
TABLE OF CONTENTS

DIVISIONS	PAGES
DIVISION 03	
SECTION 03 10 00 – CONCRETE FORMWORK	8
SECTION 03 20 00 – CONCRETE REINFORCEMENT	7
SECTION 03 30 00 – CAST-IN-PLACE CONCRETE	11
SECTION 03 35 00 – CONCRETE FLOOR FINISHING	2
DIVISION 04	
SECTION 04 20 00 – UNIT MASONRY	19
DIVISION 05	
SECTION 05 12 00 – STRUCTURAL STEEL	12
SECTION 05 31 00 – STEEL DECK	4
DIVISION 21	
SECTION 21 01 01 – GENERAL REQUIREMENTS	7
SECTION 21 05 00 – COMMON WORK RESULTS	6
SECTION 21 05 30 – SUPPORTS AND ANCHORS	3
SECTION 21 10 00 – PORTABLE FIRE EXTINGUISHERS	2
DIVISION 22	
SECTION 22 05 00 – COMMON WORK RESULTS	11
SECTION 22 05 30 – SUPPORTS AND ANCHORS	4
SECTION 22 05 93 – TESTING, ADJUSTING AND BALANCING	4
SECTION 22 07 19 – PIPING INSULATION	6
SECTION 22 08 00 – COMMISSIONING	6
SECTION 22 11 13 – NATURAL GAS PIPING	4
SECTION 22 11 19 – PLUMBING SPECIALTIES	6
SECTION 22 14 13 – PLUMBING PIPING	13
SECTION 22 40 00 – PLUMBING FIXTURES AND TRIM	3
DIVISION 23	
SECTION 23 01 01 – GENERAL REQUIREMENTS	11
SECTION 23 05 00 – COMMON WORK RESULTS	15
SECTION 23 05 30 – SUPPORTS AND ANCHORS	6
SECTION 23 05 93 – TESTING, ADJUSTING AND BALANCING	12
SECTION 23 07 13 – DUCT INSULATION	6
SECTION 23 07 16 – EQUIPMENT INSULATION	6
SECTION 23 08 00 – COMMISSIONING	9
SECTION 23 21 13 – HYDRONIC PIPING	9
SECTION 23 31 00 – DUCTWORK	18
SECTION 23 33 00 – AIR DUCT ACCESSORIES	9
SECTION 23 74 00 – PACKAGED OUTDOOR AIR HANDLING UNITS	11

DIVISION 25

SECTION 25 01 01 – GENERAL REQUIREMENTS	11
SECTION 25 05 00 – COMMON WORK RESULTS	15
SECTION 25 08 00 – COMMISSIONING	7
SECTION 25 09 23 – DIGITAL CONTROLS SYSTEM	42

DIVISION 26

SECTION 26 03 00 – ELECTRICAL WORK GENERAL REQUIREMENTS	16
SECTION 26 03 05 – BASIC ELECTRICAL MATERIALS AND METHODS	14
SECTION 26 03 10 – DEMOLITION AND REVISIONS	3
SECTION 26 03 15 – ELECTRICAL WORK TESTING	4
SECTION 26 03 20 – ELECTRICAL WORK COMMISSIONING	6
SECTION 26 04 25 – CONDUCTOR 0-1000 VOLTS	5
SECTION 26 05 04 – FIRE STOPPING	3
SECTION 26 05 06 – RENOVATIONS	4
SECTION 26 05 30 – GROUNDING AND BONDING	2
SECTION 26 05 33 – RACEWAYS FOR ELECTRICAL SYSTEMS	6
SECTION 26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS	3
SECTION 26 05 60- DISCONNECT SWITCHES	1
SECTION 26 05 66 – WIRING FOR MECHANICAL WORK	2
SECTION 26 06 35 – WIRING DEVICES	3
SECTION 26 08 05 – BUILDING INTERIOR LIGHTING	11
SECTION 26 08 15 – EXIT LIGHTS	2
SECTION 26 24 13 – SWITCHBOARDS	3
SECTION 26 24 16 – PANELBOARDS	3

DIVISION 27

SECTION 27 09 65 – FIRE ALARM SYSTEM	13
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DIVISION 28

SECTION 28 13 25 – DOOR HARDWARE WIRING	1
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END OF TABLE OF CONTENTS

PART 1 : GENERAL

1.1 WORK INCLUDED

- a. Comply with Division 1, General Requirements and all documents referred to therein.
- b. Provide all labour, materials, plant and equipment to complete the concrete formwork indicated on the drawings and specified herein.

1.2 RELATED WORK SPECIFIED ELSEWHERE

- a. Concrete Reinforcement, Section 03 20 00.
- b. Cast-in-Place Concrete, Section 03 30 00.
- c. Concrete Floor Finishes, Section 03 35 00.
- d. Structural Steel, Section 05 12 00, for anchor assemblies, bolts and the like to be cast into concrete.

1.3 REFERENCE STANDARDS, CODES AND ACTS

- a. Conform to the latest edition of the Ontario Building Code Regulations 350/06 as amended by O. Reg. 423/06, and as amended by O. Reg. 205/08m and any applicable acts of any authority having jurisdiction and the following (latest editions):
 1. A23.1 Concrete Materials and Methods of Concrete Construction.
 2. A23.2 Methods of Test for Concrete
 3. O86.1 Engineering Design in Wood (Limit States Design).
 4. CAN/CSA-O325.0 Construction Sheathing.
 5. CSA S269.3 Concrete Formwork
- b. Where there are differences between the specifications and drawings and the codes, standards or acts, the most stringent shall govern.
- c. Standards referenced by the Standards noted above are to apply even if they are not included in the list.

1.4 TOLERANCES

- a. Perform forming operations and place hardware so that finished concrete will be within the tolerances set out in A23.1 and as listed below:
 1. For areas designated as architectural concrete, tolerances are to be one-half of the allowable tolerances set out in A23.1.

2. Variations in building lines which result in extension of the building over lot lines or restriction lines will not be permitted.
- b. These tolerances are acceptable with regard to structural requirements. Interfacing tolerances may not be compatible with the above. Review and coordinate interfacing tolerances so that the various elements come together properly.

1.5 DESIGN

- a. Formwork and Re-shoring.
 1. Design formwork and re-shoring to safely support vertical and lateral loads until they can be supported by the structure. Design formwork for loads and lateral pressures recommended in CSA S269.1.
 2. Design and provide shoring and bracing to excavations to safely withstand any lateral pressures to which they may be subjected.
 3. Some of the reinforced concrete members designated on the drawings are not structurally stable until walls and slabs intersecting with them have been constructed and the concrete has reached at least 70% of the specified strength.
 4. Design shores for these slabs and walls to safely support the total vertical and lateral loads until the walls and slabs are complete and have reached 70% of their specified strength. Design the shores so that they can be unloaded gradually.

1.6 SUBMITTALS

- a. Submittal Procedures: Section 01 33 00
- b. Shop Drawings for Formwork and Re-shoring
 1. The structural drawings shall not be reproduced, in whole or in part, for use as shop drawings.
 2. Well in advance of construction, submit to the Consultant drawings showing the complete design of the slab formwork and re-shoring systems stamped by a qualified Professional Engineer licensed in the Province of Ontario.
 3. As a minimum, show the following:
 - .1 Stripping schedule;
 - .2 Sequence for installing re-shores;
 - .3 Number of slabs re-shored at any given time; and
 - .4 Formwork details related to stripping and re-shoring.
 - .5 Show for all architectural concrete, formwork form tie locations and form joint locations and construction pour line locations.
 4. Submit a written proposal for review by the Consultant as to how the specified cambers are to be achieved, in the field.
- c. Opening information

1. Submit drawings of the structure showing formed holes, recesses and sleeving required under all Sections.
- d. Surveys
 1. Submit surveys showing position of formwork, cast-in-place inserts and structural elements in their as-built condition.
 2. As a minimum include the following:
 - .1 Elevation and location of centerline with respect to grids of all footings;
 - .2 Location of centerline of all columns with respect to grids at each floor level;
 - .3 Location with respect to grids and horizontal alignment of all concrete walls at all floor levels;
 - .4 Vertical alignment (plumbness) of all columns and walls at all floor levels;
 - .5 Elevation of slab formwork and slabs at all columns, walls, centre of bays, midway between columns along gridlines and at cantilever ends, at points of maximum camber on all floor levels at the following times:
 - a. Before concrete placement.
 - b. After concrete placement, prior to removal of any formwork and re-shores from below.
 - c. Between 7 and 14 days after removal of all re-shores immediately above and below the subject floor.
 - .6 Location and alignment of edge of slabs with respect to grids at all floor levels;
 - .7 Location and elevation of cast-in-place hardware at all levels; and
 - .8 All surveys submitted must clearly indicate the date when the survey was actually carried out
- e. As-Built Drawings
 1. Mark on a complete set of final reproducible drawings any changes, additions or deletions that occur during construction as a result of the Contractor's work, change orders, or for any other reason.

PART 2 : PRODUCTS

2.1 MATERIALS

- a. Forms
 1. Formwork lumber: plywood and wood formwork materials shall conform to O86.1 and CAN/CSA - O325.0.
 2. Sheathings for exposed surfaces: New, Douglas Fir Plywood not less than 18 mm ($\frac{3}{4}$ ") thick, concrete form grade, sanded one side, conforming to CAN/CSA-O325.0.
- b. Waterstops:
 1. T/O Footing to B/O Wall (Internal Type):

2. Provide and install 9" Flat Ribbed PVC Waterstop (Type 785 Greenstreak by Sika, Type 11C by Durajoint, or approved equivalent)
Construction and Control Joints (Internal Type):
Provide and install 9" Flat Ribbed PVC Waterstop (Type 785 Greenstreak by Sika, Type 11C by Durajoint, or approved equivalent)
 3. Expansion Joints (Internal Type):
Provide and install 9" Ribbed Center Bulb PVC Waterstop (Type 696 Greenstreak by Sika, Type 7C by Durajoint, or approved equivalent)
 4. Construction and Control Joints (External Type):
Provide and install 9" Base Seal PVC Waterstop (Type 771 Greenstreak by Sika, Type 61 by Durajoint, or approved equivalent)
 5. Expansion Joints (External Type):
Provide and install 9" Base Seal PVC Waterstop (Type 938 Greenstreak by Sika, Type 62 by Durajoint, or approved equivalent)
- c. Dovetail anchor slots: minimum 0.6 mm thick galvanized steel with insulation filled slots.

PART 3 : EXECUTION

3.1 CONCRETE WORK AT EXISTING STRUCTURE

- a. Before proceeding with any work in or adjacent to the existing structure, verify that conditions are as indicated on the drawings. If they are not, do not proceed until the Consultant has given instructions.
- b. Protect and support existing services that may interfere with the work.

3.2 FORMWORK

- a. General
 1. Erect, support, brace, and maintain formwork to safely support vertical and lateral loads until they can be supported by the structure.
 2. All falsework erection shall be supervised by the Professional Engineer responsible for its design.
- b. Construction
 1. Form footing sides unless footings are shown to be placed against undisturbed soil.
 2. Where shown, camber formwork such that hardened concrete, prior to stripping of forms, is cambered as shown. Maintain beam depth and slab thickness from cambered surface.
 3. Camber slabs and beams 1 in 500 of span unless shown otherwise.
 4. Mark building, grid or other lines on forms to permit the accurate positioning of reinforcing steel.

5. Construct templates and supports to rigidly fix reinforcing dowels in the forms prior to concreting.
 6. Provide suitable markers to indicate the location and configuration of continuing concrete members so that dowels can be positioned accurately in relation to their position in the continuing members.
 1. Set anchor bolts, templates, steel connection units, hardware, or other inserts into the forms and secure them rigidly so that they do not become displaced during concreting. Set and secure these items to the tolerances specified and required in the appropriate Sections.
 7. Do not use petroleum or paraffin based form oils on forms in contact with concrete to be coated with Silicone Rubber Roofing System.
- c. Sleeves, Chases and Formed Openings
1. Form sleeves, chases and openings except where such items are specified to be formed or sleeved by the appropriate trade.
 2. All openings, sleeves, chases are not necessarily shown on the structural drawings nor are their sizes or locations shown. Refer to architectural, mechanical and electrical drawings and specifications for openings and sleeving requirements not shown, located and dimensioned on the structural drawings.
 3. No sleeves, chases and openings through structural members shall be formed without the Consultant's approval.
 4. Exposed Concrete Forms
 - .1 Make joints of forms sufficiently tight to prevent leakage of concrete fines at corners of exposed beams, walls and columns or at the corners of exposed edges of slabs, and other concrete exposed to view in the finished building.
 - .2 Provide 25 mm (1") chamfer strips at all exposed edges of concrete and 18 mm (¾") v-joints at control joints.
 - .3 Form panels for exposed concrete may be reused 3 times, providing the tie holes are reused and panels are not damaged in a way that will cause visual defects.

3.3 STRIPPING OF FORMS AND RESHORING

- a. Where forms are stripped from horizontal or sloping members before concrete has reached its specified 28 day strength, re-shore the members so that they can safely support their own load plus construction loads. In addition, ensure that the stripped member is of sufficient strength to safely carry its own weight over the area stripped out at any instant, together with any superimposed construction loads.
- b. As a minimum conform to requirements of S269.1 and the following:
 1. Re-shores in the lower storeys shall be capable of safely carrying the full weight of the concrete and formwork posted to them prior to the removal of the first storey of shores supported by the ground or slab on grade.

2. After re-shores are removed from the first storey, the design and provision of re-shores may be based on the assumption that each shored or re-shored flexural member shares load in relation to its achieved strength, provided the flexural member has attained at least 70% of its specified 28 day strength.
3. Install re-shores so that they are supported on members which can safely support the re-shore load.
4. As a guide, under specified curing conditions, 70% of the 28 day strength should be attained 7 days after concreting in normal weather and 14 days after concreting in "Cold Weather".
5. Base decision to strip forms upon satisfactory results of 7 day concrete cylinder tests and on site curing conditions.
6. Stripping and re-shoring shall proceed simultaneously so as not to leave an area greater than 9 sq.m., unsupported by either formwork or re-shoring at any instant. Install re-shores tight to construction above and below so that they will not significantly shorten under load, but take care not to preload the construction below or raise the construction above by over-tightening.
7. Maintain re-shoring or formwork in place for a minimum of 28 days or for such longer time as may be required to ensure that the concrete has reached its specified 28 day strength.
8. Do not strip within one and a half bays of a construction joint until new concrete beyond the construction joint has reached 70% of its specified 28 day strength.
9. Provide and install adequate shoring to safely support horizontal or inclined members after the 28 day specified strength is achieved where superimposed loads exceed design loads.
10. Side forms for vertical members may be stripped as soon as the concrete is sufficiently strong to stand unsupported and safely resist imposed loads.
11. Do not strip forms until the post-tensioning and grouting of ducts has been satisfactorily completed.

3.4 CONSTRUCTION JOINTS

- a. Obtain approval from the Consultant for location and details of construction joints not shown.

3.5 CONTROL JOINTS

- a. Construct control joints at the locations indicated and in accordance with the details shown.
- b. Construct clean expansion joints free of foreign material, likely to impair the proper operation of the joint.

- c. Provide a non-extruding joint filler in expansion joints for the full area between adjacent concrete members. Anchor the filler material to one of the adjacent members or between concrete members and adjacent members of other materials.
- d. Where shown, provide waterstops in expansion joints.

3.6 WATERSTOPS

- a. Install waterstops to provide continuous water seal. Do not distort or pierce waterstop to hamper performance. Do not displace reinforcement when installing waterstops. Tie waterstops rigidly in place.
- b. Splice in accordance with the manufacturer's printed instructions and as follows. Only straight heat sealed butt joints permitted in field. Shop weld corners and intersections.
- c. Where waterstops are noted to be installed into existing work, sawcut appropriately sized slots into the new work and grout waterstops into the slots. Make waterstops continuous for the full length of the joint. Splice waterstops so that the waterstopping action will not be interrupted.

3.7 SEPARATION/CLOSURE STRIPS

- a. Maintain bays containing separation/closure strips and each adjacent bay fully formed and shored until the strip is complete, and has reached its 28 day specified strength. Ensure that the forms and shores are designed so that no settlement of the forms occur during the period that the strip is open.

3.8 QUALITY CONTROL

- a. Quality Control: As specified in Section 01 45 00 Quality Requirements.
- b. Implement a system of quality control to ensure that the minimum standards specified herein are attained.
- c. Bring to the attention of the Consultant any defects in the work or departures from the Contract Documents which may occur during construction. The Consultant will decide upon corrective action and give recommendations in writing.
- d. The Consultant's general review during construction and inspection and testing by Independent Inspection and Testing Companies reporting to the Consultant are both undertaken to inform the Owner of the Contractor's performance and shall in no way augment the Contractor's quality control or relieve the Contractor of contractual responsibility.

3.9 NOTIFICATION

- a. Prior to commencing significant segments of the work, give the Consultant and Independent Inspection and Testing Companies appropriate notification so as to afford them reasonable opportunity to review the work. Failure to meet this requirement may be cause for the Consultant to classify the work as defective.

3.10 INSPECTION AND TESTING

-
- a. Inspection and Testing: As part of Section 01 45 00 Quality Requirements.
 - b. The Owner will appoint an Independent Inspection and Testing Companies to make inspections or perform tests as the Consultant directs. The Independent Inspection and Testing Companies shall be responsible only to the Consultant, and shall make only such inspections or tests as the Consultant may direct. Contractor will pay for services from Cash Allowances.

3.11 DEFECTIVE MATERIALS AND WORK

- a. Where evidence exists that defective work has occurred or that work has been carried out incorporating defective materials, the Consultant may have tests, inspections or surveys performed, analytical calculations of structural strength, made and the like, in order to help determine whether the work must be corrected or replaced. Tests, inspections or surveys or calculations carried out under these circumstances will be made at the Contractor's expense, regardless of their results, which may be such that, in the Consultant's opinion, the work may be acceptable.
- b. All testing shall be conducted in accordance with the requirements of the Ontario Building Code, except where this would, in the Consultant's opinion, cause undue delay or give results not representative of the rejected material in place. In this case, the tests shall be conducted in accordance with the standards given by the Consultant.
- c. Materials or work which fails to meet specified requirements may be rejected by the Consultant whenever found at any time prior to final acceptance of the work regardless of previous inspection. If rejected, defective materials or work shall be promptly removed and replaced or repaired to the satisfaction of the Consultant, at no expense to the Owner.

END OF SECTION

PART 1 : GENERAL

1.1 WORK INCLUDED

- a. Comply with Division 1, General Requirements and all documents referred to therein.
- b. Provide all labour, materials, plant and equipment to complete the concrete reinforcement work indicated on the drawings and specified herein.

1.2 RELATED WORK SPECIFIED ELSEWHERE

- a. Concrete Formwork, Section 03 10 00.
- b. Cast-in-Place Concrete, Section 03 30 00.

1.3 REFERENCE STANDARDS, CODES AND ACTS

- a. Conform with the latest Ontario Building Code Regulations 350/06 as amended by O.Reg. 423/06 and any applicable acts of any authority having jurisdiction and the following (latest editions):
 - 1. RSIC Reinforcing Steel Institute of Canada (RSIC), Manual of Standard Practice.
 - 2. A23.1 Concrete Materials and Methods of Concrete Construction
 - 3. A23.2 Methods of Test for Concrete.
 - 4. A23.3 Design of Concrete Structures.
 - 5. CSA G30.5 Welded Steel Wire Fabric for Concrete Reinforcement
 - 6. CSA-G30.18 Carbon Steel Bars for Concrete Reinforcement
 - 7. W186-M1990 Welding of Reinforcing Bars in Reinforced Concrete Construction.
 - 8. Ontario Provincial Standard Specification (OPSS) 1442 Material Specifications for Epoxy Coated Steel Reinforcement for Concrete.
 - 9. Ontario Provincial Standard Specification (OPSS) 1443 Material Specifications for Organic Coatings for Steel Reinforcement.
- b. Where there are differences between the specifications and drawings and the codes, standards or acts, the most stringent shall govern.
- c. Standards referenced by the Standards noted above are to apply even if they are not included in the list.

1.4 TOLERANCES

- a. Perform fabrication and setting so that completed work will be within the tolerances set out in A23.1.
- b. These tolerances are acceptable with regard to structural requirements. Interfacing tolerances may not be compatible with the above. Review and coordinate interfacing tolerances so that the various elements come together properly.

1.5 SAMPLES AND ASSISTANCE

- a. Samples: As found in Section 01 33 00 – Submittal Procedures
- b. General
 - 1. Supply samples of all materials and the following, the cost of which shall be paid for by this trade.
- c. Reinforcement
 - 1. Provide the Independent Inspection and Testing Company access to the reinforcement fabricator's plant. Inform the Independent Inspection and Testing Company of the period during which fabrication will be undertaken.
 - 2. Cut samples of reinforcing steel designated by the Independent Inspection and Testing Company from steel shipped to jobsite. Replace cut reinforcement or splice where permitted by the Independent Inspection and Testing Company.
- d. Support Accessories
 - 1. Provide samples of support accessories (chairs, bolsters, spacers) which are intended to be used.

1.6 SUBMITTALS

- a. Submittal Procedures: Section 01 33 00
- b. Shop Drawings for Reinforcement
 - 1. Reproduction of the structural drawings, to serve as shop drawings, will be permitted. Cost of reproduction to be paid for by this section. Any identification or reference to the Owners or Consultants is to be removed from all structural drawings which are used as shop drawings.
 - 2. Prepare reinforcement placing drawings and bar lists taking into account all openings and recesses shown on the architectural, structural, mechanical and electrical drawings, and on the sleeving shop drawings.
 - 3. Completely dimension openings, recesses and sleeves, and relate to suitable grid lines and elevation datum.
 - 4. Prepare placing drawings to a minimum scale of 1:50 in a clear complete manner that will permit placing of reinforcement to be performed without reference to contract drawings.
 - 5. Detail reinforcement in accordance with the contract documents, A23.1 and detailing standards in RSIC Manual of Standard Practice.
 - 6. As a minimum, show the following:
 - .1 Bar sizes, spacing, location and quantities of reinforcement, and welded wire fabric.

-
- .2 Identification of each bar with a code mark corresponding to the bar lists.
 - .3 Detail sections to fully illustrate placement of reinforcement at areas such as openings, change of levels, spandrel, stairs and wherever else required.
 - .4 Large scale detail sections at areas of steel concentrations such as at intersections of beams and columns, column splices or wherever else required.
 - .5 Placing sequence for reinforcement such as intersections of beams and beams, slabs and beams and within flat and two-way slabs.
 - .6 Minimum clearances between reinforcement and minimum concrete protection to reinforcement.
 - .7 Location and embedment of dowels.
 - .8 Location, number and type of support accessories, including support bars suitably sized and spaced to rigidly support the weight of reinforcement and construction load.
7. Submit code marks or symbols used on reinforcement of each manufacturer so that Consultant may identify grades and sizes of reinforcement.
- c. Shop drawings for Welding Reinforcement
- 1. Submit drawings showing, as a minimum, the following: locations, elevations and size of welds, welding procedures and techniques, stamped as approved by the Canadian Welding Bureau.
- d. Shop Drawings for Mechanical Splices
- 1. Submit drawings showing, as a minimum, the following: location, elevations and size of splices, materials and procedures.
- e. Certificates
- 1. Canadian Manufacture: Provide Consultant with certified copy of reports of reinforcing steel showing physical and chemical analysis minimum (1) week prior to commencing work.
 - 2. Submit code marks or symbols used on reinforcement of each manufacturer so that Consultant may identify grades and sizes of reinforcement.
- f. Substitutions
- 1. Substitution of different size bars permitted only upon written approval of Consultant.
- g. As-Built Drawings
- 1. Mark on a complete set of final reproducible drawings any changes, additions or deletions that occur during construction as a result of the Contractor's work, change orders, or for any other reasons.

PART 2 : PRODUCTS

2.1 MATERIALS

- a. Reinforcing Steel: Only deformed reinforcing steel manufactured to CSA Standards of G30 Series and to the material specification shown on the drawings.
- b. Epoxy Coating for Reinforcement: An electrostatic application of epoxy protective coating conforming to requirements of OPSS 1442 and 1443.
- c. Welded Steel Wire Fabric: conforming to G30.5, with a minimum guaranteed yield point of 400MPa. Provide in flat sheets only.
- d. Chairs, bolsters, bar supports, spacers: to A23.1. In the case of concrete exposed to view or weather the accessories shall be such that no metal is permitted to come closer than 40 mm (1 5/8") from a formed face and 50 mm (2") from a trowelled surface. Use precast concrete supports for exposed concrete beams and soffits and concrete cast against soil/rock.
- e. Tie wires and Support Accessories for Epoxy Coated Reinforcement: epoxy coated to requirements of MTO.

PART 3 : EXECUTION

3.1 FABRICATION

- a. Fabricate reinforcement in accordance with A23.1 and the RSIC Manual of Standard Practice.
- b. Identify with a tag each bundle of bars with a code mark corresponding to that appearing on the bar list.
- c. Bend reinforcement once only and at room temperature. Do not straighten or rebend reinforcement. Do not use bars with kinks or bends not shown on the drawings.
- d. Replace bars which develop cracks or splits.
- e. Welding in accordance with current C.S.A. Standard W186. Welders to be fully certified by the C.W.B. for this type of welding.

3.2 PLACING

- a. Prior to concreting, accurately place reinforcement, support and secure against displacement, as indicated on reviewed placing drawings and in accordance with A23.1. Tack welding of reinforcement to secure in place will not be permitted.
- b. Set column anchor bolts and wall dowels prior to concreting with wooden templates or other approved means.
- c. Do not drive or force reinforcement into fresh concrete.
- d. Secure reinforcement in walls using sufficient spacers on each face to maintain the requisite distance between reinforcement and column or wall face and so that vertical bars are plumb.
- e. Where toppings are placed on waterproof membranes, vapour barriers and the like, prevent reinforcement or tie wire contacting these items.

- f. Preassemble column and beam cages as necessary. Do not "spring" or bend ties and stirrups in order to place longitudinal reinforcement.
- g. Pre-tie reinforcement for footings and lower into place so as not to disturb the soil at founding elevation.
- h. Provide splices only where shown on the Contract Drawings. No other splices will be permitted without approval of the Consultant.

3.3 FIELD BENDING

- a. Do not field bend reinforcement except where indicated or authorized in writing by Consultant.
- b. When field bending is authorized, bend without heat, applying a slow and steady pressure.
- c. Replace bars which develop cracks or splits.

3.4 EPOXY COATED REINFORCEMENT

- a. Provide epoxy coated reinforcement where shown on the drawings.
- b. All systems for handling, transporting and storing coated bars shall be such that the coating shall not be damaged. Prevent bar to bar abrasion and excessive sagging. Do not drop or drag bars. Store on suitable non-metallic supports.
- c. During and after the installation of the bars into their location in the deck, repair all damaged portions of the coating with patching material conforming to OPSS 1443. Any damaged accessories shall also be repaired.
- d. Repair all damaged areas of the coated reinforcing steel and metallic accessories before any rusting occurs. The Consultant may require that damaged bars be replaced instead of being repaired. If infrequent and small damaged areas do rust, completely remove the rust by an approved method before the areas are repaired.
- e. The cutting of coated bars by burning will not be permitted.
- f. Do not weld coated bars.

3.5 WELDED WIRE FABRIC

- a. Where no reinforcement is shown, provide 152 x 152 MW18.7/MW18.7 welded wire fabric at mid-depth in slabs on grade or walks or toppings 60 mm (2½") in thickness or greater, unless noted otherwise on drawings.
- b. Lap ends and sides of fabric not less than 300 mm (12").

3.6 CONSTRUCTION JOINTS

- a. Obtain approval from the Consultant for details of construction joints not shown.
- b. Continue reinforcement through the joint in its normal position. Add additional reinforcement across the joint as shown or directed.

3.7 QUALITY CONTROL

- a. Quality Control: As specified in Section 01 45 00 Quality Requirements.
- b. Provide a system of quality control to ensure that the minimum standards specified herein are attained.
- c. Bring to the attention of Consultant any defects in the work or departures from the Contract Documents which may occur during Construction. The Consultant will decide upon corrective action and give recommendations in writing.
- d. The Consultant's general review during construction and inspection and testing by Independent Inspection and Testing Companies reporting to the Consultant are both undertaken to inform the Owner of the Contractor's performance and shall in no way augment the Contractor's quality control or relieve the Contractor of contractual responsibility.

3.8 NOTIFICATION

- a. Prior to commencing significant segments of the work, give the Consultant and Independent Inspection and Testing Companies appropriate notification so as to afford them reasonable opportunity to review the work. Failure to meet this requirement may be cause for the Consultant to classify the work as defective.

3.9 INSPECTION AND TESTING

- a. Inspection and Testing: As part of Section 01 45 00 Quality Requirements.
- b. The Owner will appoint an Independent Inspection and Testing Companies to make inspections or perform tests as the Consultant directs. The Independent Inspection and Testing Companies shall be responsible only to the Consultant, and shall make only such inspections or tests as the Consultant may direct. Contractor will pay for services from Cash Allowances.
- c. When defects are revealed, the Consultant may request, at the Contractor's expense, additional inspection or testing to ascertain the full extent of the defect.
- d. Tests on Reinforcing Steel by Independent Inspection and Testing Companies.
 - 1. A series of specimens for each grade and size of reinforcing steel contained in any 100 tonnes (100 tons) of steel shipped may be tested. A series of tests will include two bars for each test required of each size and grade of steel used. Reinforcing steel tests will be made in accordance with CSA Standards G30 Series.
 - 2. Non-destructive tests may be made on welded reinforcement.

3.10 DEFECTIVE MATERIALS AND WORK

- a. Where evidence exists that defective work has occurred or that work has been carried out incorporating defective materials, the Consultant may have tests, inspections or surveys performed, analytical calculations of structural strength made, and the like, in order to help determine whether the work must be replaced. Tests, inspections or surveys or calculations carried out under these circumstances will be made at the Contractor's expense, regardless of their results, which may be such that, in the Consultant's opinion, the work may be acceptable.
- b. All testing shall be conducted in accordance with the requirements of the Ontario Building Code, except where this would, in the Consultant's opinion, cause undue delay or give results

not representative of the rejected material in place. In this case, the tests shall be conducted in accordance with the standards given by the Consultant.

- c. Materials or work that fails to meet specified requirements may be rejected by the Consultant whenever found at any time prior to final acceptance of the work regardless of previous inspection. If rejected, defective materials or work shall be promptly removed and replaced or repaired to the satisfaction of the Consultant, at no expense to the Owner.

END OF SECTION

PART 1 : GENERAL

1.1 WORK INCLUDED

- a. Comply with Division 1, General Requirements and all documents referred to therein.
- b. Provide all labour, materials, plant and equipment to complete the cast-in-place concrete work indicated on the drawings and specified herein.

1.2 RELATED WORK SPECIFIED ELSEWHERE

- a. Concrete Formwork, Section 03 10 00.
- b. Concrete Reinforcement, Section 03 20 00.
- c. Concrete Floor Finishes, Section 03 35 00
- e. Grouting beneath base plates bearing on masonry, Section 04 20 00 – Unit Masonry.
- f. Lifting of structural steel plates for inspection of grouting, Section 05 12 00.
- g. Damp Proofing and Water Proofing, Section 07 10 00

1.3 REFERENCE STANDARDS, CODES AND ACTS

- a. Conform to the latest edition of the Ontario Building Code Regulations 350/06 as amended up to and including O. Reg. 423/06, and as amended by O. Reg. 205/08, any applicable acts of any authority having jurisdiction and the following (latest edition):
 1. Ontario Provincial Standard Specification (OPSS) 1303 Material Specification for Air Entraining and Chemical Admixtures for Portland Cement Concrete.
 2. A23.1 Concrete Materials and Methods of Concrete Construction
 3. A23.2 Method of Test for Concrete
 4. A23.3 Design of Concrete Structures
 5. ANSI/ACI 347 or, CAN/CSA - S269.3-M92 Concrete Formwork
- b. Standards referenced by the Standards noted above are to apply even if they are not included in the list.

1.4 TOLERANCES

- a. Perform placing operations so that completed work will be within the tolerances set out in A23.1 and as listed below:
 1. For areas designated as architectural concrete, tolerances are to be one half of the allowable tolerances set out in A23.1.

- b. Variations in building lines which result in extension of the building over lot lines or restriction lines will not be permitted.
- c. These tolerances are acceptable with regard to structural requirements. Interfacing tolerances may not be compatible with the above. Review and coordinate interfacing tolerances so that the various elements come together properly.

1.5 CONCRETE MIX DESIGN

- a. Design of Mix
 - 1. Design the mix in accordance with A23.1 so that concrete will be homogeneous, uniformly workable, readily placeable into corners and angles of forms and around reinforcement by methods of placing and consolidation employed on the work, but without permitting materials to segregate or excessive free water to collect on the surface. The concrete, when hardened, shall have the qualities specified.
 - 2. Specified Strength: As called for on drawings. Where walls are integral with columns such as foundation walls, cast walls and columns with concrete of the higher specified strength.
 - 3. Modulus of Elasticity (E): For each concrete mix design, the actual Modulus of Elasticity, at all times during construction, is to be not less than $4,500 \sqrt{f_c}$ MPa.
 - 4. Water Cement Ratio, Cement Content, Slump and Air Content: As called for on the drawings. These requirements are for concrete at the point of placing.
 - 5. Fly Ash: Do not use fly ash in concrete that will be exposed to view nor in concrete that will be exposed to freeze-thaw cycles or de-icing chemicals.
 - 6. Use of calcium chloride is not permitted.
 - 7. Demonstrate the following by previous performance, and on site tests:
 - 1. Segregation, loss of fines, moisture and the like, will not occur during methods of conveying and placing to be employed on site.
 - 2. Concrete will not break down or be otherwise adversely affected by high frequency vibration.
 - 3. Concrete shall be finishable with a machine steel trowel to a smooth hard surface suitable to receive resilient flooring.
 - 4. Design of concrete in conjunction with water content, placing, finishing, curing and protection to be used on site shall be such as to minimize shrinkage.

1.6 SAMPLES AND ASSISTANCE

-
- a. General
 - 1. Supply samples of all materials and the following, the cost of which shall be paid for by this trade.
 - b. Concrete Test Cylinders
 - 1. Cooperate in the execution of the concrete cylinder testing program. Furnish concrete required, protect specimens against injury and loss, and assist in the sampling and storage of specimens.
 - 2. Sample concrete, cast cylinders and store in accordance with A23.1 where directed by the Consultant. High density concrete to be tested twice as often as specified in A23.1.
 - 3. For all Portland cement concrete compressive strength tests, 100 x 200mm (4 x 8 inch) or 150 x 300mm (6 x 12 inch) cylinders shall be used.
 - 4. Provide sufficient field curing storage facilities so that cylinders representing the various areas can be safely stored in locations representing the curing conditions for those areas. Move the field-cured cylinder storage facilities from area to area as the work progresses.
 - c. Soil Inspection
 - 1. Assist the geotechnical investigation agency in making their inspections or tests.

1.7 **SUBMITTALS**

- a. Administrative Requirements: Section 01 33 00 – Submission procedures as amended by this article.
- b. Surveys
 - 1. Submit surveys in accordance with Section 03 10 00, Concrete Formwork.
- c. Certificates
 - 1. Prior to beginning work and when any change in materials or source of supply is proposed, provide the following certificates prepared by an approved inspection company. The cost of this work shall be borne by the Contractor.
 - .1 Certification that aggregates and cements proposed for the work comply with requirements of specifications and A23.1.
 - .2 Certification that compressive strength, water-cement ratio, slump, entrained air content and other specified properties will be met, using the proposed mixes.
 - .3 Give proportions by dry weight of cement, coarse and fine aggregate, type and amount of admixture or air entraining agents, and water-cement ratio, for the mix proposed for each class of concrete. Provide separate mix designs when pump mixes and mixes containing pea gravel are

proposed. Describe in detail on the mix design summary the location(s) where each class of concrete is to be placed in the structure.

- d. Well in advance of construction, submit complete details of placing and compaction procedures for sloping roofs, including details of construction and placing of top forms and top form panel.
- e. Submittal requirement for trial batch of high density concrete with representative test data. (Six cores minimum). Include certification of heavy weight aggregate. Following review by consultant confirmation of stock piled heavy weight ore at batching plant will suitable storage precautions.

PART 2 : PRODUCTS

2.1 MATERIALS

- a. Concrete: Conform to A23.1.
- b. Cement Type: GU Normal Portland Cement.
- c. Cement Type for Architectural Concrete:
 - 1. To be from same batch and plant for all exposed work, Type GU, normal.
 - 2. 2 Aggregates for all Architectural Concrete to be from same area of same quarry to minimize variation in colour, etc. Ensure aggregate contains no iron
- d. Nominal Size of Coarse Aggregate:
 - 1. 5 mm to 20 mm. Use pea gravel (5 mm to 10 mm) where concentration of reinforcement requires the use of a smaller diameter aggregate.
 - 2. For high density concrete coarse aggregate to be clean, crushed, graded high quality hematite with a minimum specific gravity of 4.5. Fine aggregate to be crushed ore fines of hematite, ilmenite or magnetite compatible with the remainder of the mix to obtain the required design. Aggregates to be non-reactive, low absorption.
 - 3. Pit run gravel will not be acceptable for this project.
- e. Admixtures: Air entraining agents, water reducing admixtures, or super plasticizers that have been tested and approved for use by The Ministry of Transportation of Ontario.
- f. Curing Compound: Conform to A23.1.
- g. Grout Beneath Base Plates: Non-shrink flowable grout In-Pakt or approved equivalent having a compressive strength at 28 days of at least 35 Mpa (5ksi). Where grout is exposed to view or weather, use non-ferrous grout.

PART 3 : EXECUTION

3.1 PLACING CONCRETE

- a. Conform to the requirements of A23.1 and the following:
 - 1. Immediately before placing concrete, clean forms and reinforcement of foreign matter.
 - 2. During hot weather conditions, do not use concrete mixed more than 1 hour after introduction of mixing water or 1½ hours during other periods.
 - 3. Allow 24 hours minimum to elapse after placing concrete in columns, piers or walls before placing concrete in beams or slabs supported thereon.
 - 4. Remove concrete spilled onto forms around hoisting equipment before depositing concrete in these areas.
- b. Pumping Concrete
 - 1. Pumping or pneumatic placing of concrete shall only be used if the velocity of discharge is reduced to a point where no separation or scattering of the concrete occurs, and the consistency of the mix has been designed to allow such a system with no adverse effects on the quality of concrete.

3.2 CURING CONCRETE

- a. General
 - 1. Cure all concrete in accordance with A23.1, except as specified herein.

3.3 PROTECTION

- a. General
 - 1. Conform to the requirements of A23.1 and the following to protect freshly deposited concrete from freezing, abnormally high temperatures or temperature differentials, premature drying, and moisture loss for a period of time necessary to develop the specified properties of the concrete.
- b. Cold Weather Concreting
 - 1. Between the 15th of October of any year and the 15th of April of the following year, provide on hand and ready for use all equipment necessary for adequate cold weather protection and curing before concrete placement is begun.
 - 2. When fresh concrete is to be cast against existing concrete, prevent the loss of heat by extending the protection for the fresh concrete at least 600 mm (24") over the existing.
 - 3. Insulate, or enclose within the protective housing, tie rods, reinforcement or metal which projects from the concrete being protected.

4. Construct enclosures tight and safe for wind and snow loadings.
5. Maintain housing, enclosures and supplementary heat in place for entire period of protection, except that sections may be temporarily removed as required to permit placing additional forms or concrete provided the uncovered concrete is not permitted to freeze. Make up time lost from the required period of protection at the required temperature before protection is discontinued and removed.
6. Locate heating units to avoid heating concrete locally or drying it excessively. Avoid high temperature and dry heating within enclosures.
7. Take particular care to maintain edges and corners of concrete at the required temperature owing to their greater vulnerability to freezing.
8. Provide sufficient insulation, and heat as necessary, to prevent freezing of frost susceptible soil which lies against structural elements; in particular protect soil beneath footings and behind foundation walls until the building is completed.
9. For cold weather protection requirements for placing concrete slabs on grade, see also SLABS ON GRADE clause.

c. Hot Weather Concreting

1. When rate of moisture evaporation exceeds 1.0 kg/m² per hour, employ the following measures in addition to the requirements of A23.1
 - .1 Use ice as mixing water to lower the concrete temperature.
 - .2 Dispatch ready-mix trucks and organize work to keep mixing time to a minimum. Minimize exposure of mixing trucks to the hot sun while waiting.
 - .3 Provide adequate personnel and organize work to keep placing time to a minimum.
 - .4 Place concrete in layers thin enough and areas small enough so that the time interval for placing is reduced and compaction will ensure complete union of adjacent portions.
 - .5 With formed concrete, reliance shall not be placed on the forms alone to provide curing. Spray formwork with water to keep it tight and free from cracking.

d. Protection of Completed Work

1. At all times during the work, protect exposed concrete, exposed masonry and other exposed members from staining or becoming coated with concrete leakage due to continuing concreting operations. Members which become coated may be classed as defective by the Consultant.
2. Protect exposed members from staining due to rusting of reinforcement projecting beyond construction joints.

3. Take suitable measures to prevent spalling and cracking damage occurring to the structure due to water freezing in expansion joints, small holes, slots, depressions and take suitable measures to prevent damage occurring to foundations and the like due to frost action in the soil or backfill.
4. The application of deicing salts on completed work is not permitted.

3.4 EXAMINATION

- a. Examine and obtain all necessary measurements of previously executed and existing work which may affect the work of this section prior to commencing operations.
- b. Report any discovered discrepancies to the Consultant so that instructions can be given for the necessary remedial action.
- c. Examine Mechanical and Electrical drawings for required housekeeping pads for supply and installation by this Section.

3.5 ADDITIONAL REQUIREMENTS FOR NON-ARCHITECTURAL CONCRETE

- a. Footings
 1. If suitable bearing strata is not found at the elevations shown, footings may have to be increased in size and not necessarily lowered.
 2. Soils Report forms part of the Contract Documents.
 3. Found footings on naturally consolidated undisturbed soil capable of safely supporting the allowable bearing capacities shown on the drawings within acceptable limits of settlement.
 4. Founding elevations shown are based upon the geotechnical investigation.
 5. Founding elevations and allowable bearing capacities must be verified by the geotechnical Consultant before footing concrete is placed.
 6. If, upon excavating to the elevations shown, the required soil bearing capacities are not achieved, or if they are achieved at a higher elevation, inform the Consultant who will provide instructions as to how to proceed.
 7. Note actual footing founding elevations on the reproducible as-built drawings.
 8. Construct footings in a particular area commencing from the lowest footing elevation and proceeding to the higher elevations.
 9. Proceed in a similar manner for continuous footings.
 10. Remove water, disturbed soil and 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.

11. During cold weather, prevent soil adjacent to and beneath all footings from freezing. Do not pour footings on frozen soil or soil which has been allowed to freeze and thaw. If the soil at 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.
12. Where excavations for mechanical or electrical services, pits adjacent foundations and the like encroach upon a 1 in 1 slope between corners of footings and bottom corners of excavations, lower footings a suitable amount so as not to exceed the 1 in 1 slope at no extra cost to the Owner.

3.6 CONSTRUCTION JOINTS

- a. Obtain approval from the Consultant for location and details of construction joints not shown.
- b. The maximum length of a concrete slab pour shall be 30 m (100'-0).
- c. The maximum length of a concrete foundation wall pour shall be 15 m (50').
- d. The maximum height of a concrete pour shall be 5 m (15'-0), except where walls are 1'-4" thick, in which case the maximum height of a concrete pour shall be 6 m (20'-0").

3.7 WATERSTOPS

- a. Maintain waterstops in position during placing of concrete. Support the waterstops during the progress of the work to ensure the proper embedment in the concrete. Equally divide the symmetrical halves of the waterstops between the concrete pours at the joints. The centre axis of the waterstops shall coincide with the joint openings at the plane of installation of the waterstop. Ensure maximum density and imperviousness of the concrete by thoroughly working it in the vicinity of all joints.
- b. Place concrete around waterstops by careful working, routing, and vibrating to ensure that all air pockets have been eliminated.

3.8 SLABS-ON-GRADE

- a. General
 1. Do not place concrete slabs-on-grade until the specified sub-floor material has been placed, inspected and approved.
 2. Do not place concrete on a frozen sub-grade, or on one that contains frozen materials.
 3. Do not place concrete on a sub-grade that has been frozen and thawed until the sub-grade has been reviewed by the Consultant and approved. If, in the Consultant's opinion, the safe bearing capacity of the sub-grade has been

reduced to below 25 kPa (500psf), remove the affected materials and replace with compacted granular fill at no additional cost to the Owner.

4. Place 200 mm (8") of 19 HL-8 coarse aggregate over the sub-base. Thoroughly roll and consolidate to the lines and levels required. Refer also to the geotechnical report for other requirements.
5. Place a bond breaker, minimum 1 layer of building paper 3mm (1/8") masonite 10mm (3/8") asphalt impregnated fibre board (A.I.F.B.), between edges of slab on grade and abutting surfaces.
6. Upon approval of the placement of the sub-floor material and setting of reinforcement, place and consolidate concrete and finish and cure as specified herein.

3.9 TREATMENT OF FORMED SURFACES NOT DESIGNATED AS ARCHITECTURAL CONCRETE

- a. Do work in accordance with A23.1 and as follows:
 1. Remove traces of form lining compound from concrete surfaces which may affect the bonding of following surface application.
- b. Provide smooth form finish to concrete surfaces exposed to public view and surfaces to receive plaster, damp-proofing, moisture resistant membrane and the like.
- c. Interior surfaces for the following air plenums and stairwells to be left exposed following hand rubbing. Fill plug openings flush with grout. Surface to be smooth free from all surface fins projections over three millimeters

3.10 REINFORCED BLOCK LINTELS

- a. Supply and place concrete for reinforced block lintels in accordance with the requirements of this specification and as shown on the drawings.

3.11 OPENINGS THROUGH COMPLETED MEMBERS

- a. Do not cut openings through completed members without the Consultant's approval.
- b. Where the location of openings is approved, locate the reinforcement by x-ray, cover meter or other positive means as required by the Consultant and adjust the location of the opening so that no reinforcement is cut unless specifically approved otherwise in writing by the Consultant.

3.12 MAKING GOOD

- a. Where directed by the Consultant make good temporary openings left in concrete construction around pipes, ducts and the like using a mortar of the same proportions as the surrounding work. Reinforce mortar with welded wire fabric where openings exceed 75 mm (3"). Roughen existing surfaces to receive mortar or apply suitable bonding agent such that mortar will be securely bonded to existing concrete.

3.13 GROUTING BENEATH BASE PLATES

- a. Grout beneath plates bearing on concrete with an approved non-shrink flowable grout. Conform to the manufacturer's directions for mixing and placing grout. Completely fill voids below plates. Fill voids left by shims after shims are removed.
- b. During cold weather, preheat base plates and footings and maintain temperature at minimum 12 degrees C. for 6 days after grouting.
- c. Refer to Section 05 12 00 Structural Steel for lifting of baseplates to determine adequacy of grouting. If defects are found, more base plates will be raised.
- d. Where openings are shown to be cut into the existing structure, drill at corners and saw cut remainder such that saw cuts do not extend into structure to be retained. Overcutting may require major structural strengthening.

3.14 QUALITY CONTROL

- a. Quality Control: As specified in Section 01 45 00 Quality Requirements.
- b. Implement a system of quality control to ensure that the minimum standards specified herein are attained.
- c. Bring to the attention of the Consultant any defects in the work or departures from the Contract Documents which may occur during Construction. The Consultant will decide upon corrective action and give his recommendations in writing.
- d. The Consultant's general review during construction and inspection and testing by independent inspection and testing agencies reporting to the Consultant are both undertaken to inform the Owner of the Contractor's performance and shall in no way augment the Contractor's quality control or relieve the Contractor of contractual responsibility.

3.15 NOTIFICATION

- a. Prior to commencing significant segments of the work, give the Consultant and independent inspection and testing agencies appropriate notification so as to afford them reasonable opportunity to review the work. Failure to meet this requirement may be cause for the Consultant to classify the work as defective.

3.16 INSPECTION AND TESTING

- a. Inspection and Testing: As part of Section 01 45 00 Quality Requirements.
- b. Appointment of Independent Inspection and Testing Companies: The Owner will appoint an Independent Inspection and Testing Companies to make inspections or perform tests as the Consultant directs. The Independent Inspection and Testing Companies shall be responsible only to the Consultant, and shall make only such inspections or tests as the Consultant may direct. Contractor will pay for services from cash Allowances.
- c. When defects are revealed, the Owner may request, at the Contractor's expense, additional inspection or testing to ascertain the full extent of the defect.

d. Tests on Concrete Materials

1. Cement and Aggregates: The Consultant may make tests on these materials as deemed necessary during the work.
2. Concrete Strength: Cylinder testing will be carried out in accordance with A23.1 and as follows: Three companion laboratory cured concrete standard compression test cylinders; two tested at 28 days and one tested at 7 days, constitute a strength test. During the placing of concrete in cold weather three additional field cured test cylinder will be made and tested at 7 days. The results of the 7 day tests related to curing procedure shall be the basis to strip soffit forms from horizontal or inclined members. Testing for high density concrete to be twice that, required by A23.1.
3. Grout under Baseplates: At least one strength test may be made each day that grout is placed under baseplates.

e. Inspection of Soil

1. Soil at footing founding elevations will be inspected.

3.17 DEFECTIVE MATERIALS AND WORK

- a. Where evidence exists that defective work has occurred or that work has been carried out incorporating defective materials, the Consultant may have tests, concrete coring, inspections or surveys performed, analytical calculations of structural strength made and the like in order to help determine whether the work must be repaired or replaced. Tests, inspections or surveys or calculations carried out under these circumstances will be made at the Contractor's expense, regardless of their results, which may be such that, in the Consultant's opinion, the work may be acceptable.
- b. All testing shall be conducted in accordance with the requirements of the Ontario Building Code, except where this would in the Consultant's opinion cause undue delay or give results not representative of the rejected material in place. In this case, the tests shall be conducted in accordance with the standards given by the Consultant.
- c. Materials or work which fails to meet specified requirements may be rejected by the Consultant whenever found at any time prior to final acceptance of the work regardless of previous inspection. If rejected, defective materials or work shall be promptly removed and replaced or repaired to the satisfaction of the Consultant, at no expense to the Owner.

END OF SECTION

1.0 GENERAL

1.1 WORK INCLUDED

- .1 Comply with Division 1, General Requirements and all documents referred to herein.
- .2 Provide all labour, materials, plant and equipment to complete the concrete floor finishes work indicated on the drawings and specified herein.
- .3 Provide surface treatment 'sealer' - penetrating, chemical-type formulation hardener and sealer as scheduled in the Room Finish Schedule.

1.2 RELATED WORK SPECIFIED ELSEWHERE

- .1 Concrete Formwork, Section 03 10 00.
- .2 Concrete Reinforcement, Section 03 20 00.
- .3 Cast-in-Place Concrete, Section 03 30 00.

1.3 REFERENCE STANDARDS, CODES AND ACTS

- .1 Conform with the 2006 Ontario Building Code Regulations 350/06 as amended by O. Reg. 423/06, and as amended by O. Reg. 205/08 and any applicable acts of any authority having jurisdiction and the following (latest editions):
 - .1 A23.1 Concrete Materials and Methods of Concrete Construction.
 - .2 A23.2 Methods of Test for Concrete.
 - .3 ACI 302.1 Guide for Concrete Floor and Slab Construction.
- .2 Where there are differences between the specifications and drawings and the codes, standards or acts, the most stringent shall govern.

1.4 SUBMITTALS

- .1 Section 01 33 00: Submittal Procedures.
- .2 Product Data: Provide data on concrete hardener, compatibilities, and limitations.
- .3 Maintenance Data: Provide data on maintenance renewal of applied coatings.

1.5 WARRANTIES

- .1 Floors
 - .1 The Contractor hereby warrants all floor surfaces finished under this Section for a period of two years against dusting, disintegrating, and/or other defects within the control of the Contractor.

1.6 QUALIFICATIONS

- .1 The "foreperson" or "lead-hand" supervising the placement consolidation, finishing and curing of the concrete shall be certified under an industry recognized concrete finishing program, such as the ACI Concrete Flatwork Finisher/Technician Certification Program.

1.7 MOCK-UP

- .1 Provide mock-up of floor finish as directed by architect.
- .2 Construct mock-up area under conditions similar to those which will exist during actual placing, 5m long by 5m wide, with coatings applied.
- .3 Locate where indicated.

-
- .4 Mock-up may remain as part of the Work after review and acceptance by Consultant.

1.8 DELIVERY STORAGE AND HANDLING

- .1 Deliver, store, protect and handle products to site.
- .2 Deliver materials in manufacturer's packaging including application instructions.

1.9 ENVIRONMENTAL REQUIREMENTS

- .1 Temporary Lighting: Minimum 200 W light source, placed 2.5m above the floor surface, for each 40 sq.m of floor being finished.
- .2 Temporary Heat: Ambient temperature of 10 degrees C minimum.
- .3 Ventilation: Sufficient to prevent injurious gases from temporary heat or other sources affecting concrete.

1.10 COORDINATION

- .1 Coordinate the work with concrete floor placement and concrete floor curing.

END OF SECTION

PART1:GENERAL

1.1 GENERALREQUIREMENTS

- a. Refer to, and be governed by, the requirements of Division 1.

1.2 SCOPE OF THEWORK

- a. Masonry: Supply all labour and materials for mortar, brick, concrete block, glass block, and reinforcement as required. Build in all control joints, chases and openings as required by other trades.
- b. Cavity Weep Hole Vents: Supply and install all cavity weep hole vents.
- c. Lintels: Build in all loose steel angles and/or plates over all openings in masonry walls. Lintel steel is specified under Section 05 12 00, Structural Steel. Provide reinforced block lintels where steel lintels cannot be used.
- d. Anchors: Build in all anchors, bolts and rods supplied by other trades for attaching their work, including anchors and straps for door frames and other work.
- e. Insulation: Install rigid insulation boards as required to form cavity walls and insulated masonry walls as supplied and specified under Division 07, Insulation. See Division 07 for supply and installation of insulation along top of walls to fill in metal deck flutes.
- f. Flashing Membranes: Supply and install all flashing membranes.
- g. Control Joint Filler and Back-Up: Supply and install all control joint and expansion joint filler.
- h. Deflection Filler: Supply and install all deflection filler above all non-bearing masonry partitions.
- i. Cutting and Patching: Perform all cutting required in masonry work. Attend upon and make good after other trades have completed work affecting the installation of masonry. Do all jobbing required and properly protect all masonry during the construction period.
- j. Fire Separations: Rooms requiring fire separations are shown on drawings. Method of sealing openings through masonry fire separations are covered in Part 3 of this Section. Materials for fire separations are shown in 2.01 A. of this Section.
- k. Lateral Support: Provide lateral support as detailed on the drawings.
- l. Air Vapour Barrier: Install all air/vapour barrier components as specified in Section

07 26 00, Air Vapour Barrier.

- m. Dovetail Anchor Slots: Supply dovetail anchor slots for installation under Section 03 30 00, Cast-In-Place Concrete.

1.3 RELATED SECTIONS

- a. Work performed by Others which is related to Work of this Section:

- .1 Section 03 30 00: dovetail anchor slots in concrete, reinforcing steel, cast-in-place concrete
- .2 Section 05 12 00: masonry anchors at steel structure
- .3 Section 05 12 00: lintel/shelf angles
- .4 Section 05 50 00: lateral support clips
- .5 Section 07 26 00: vapour retarder and air barrier
- .6 Section 07 21 16: cavity wall insulation
- .7 Section 07 62 00: flashing and sheet metal
- .8 Section 07 92 10: sealants
- .9 Section 09 91 13: painting

- b. Supply of Work which is installed by this Section:

- .1 Section 03 30 00: to furnish reinforcing steel for masonry lintels and reinforced masonry walls
- .2 Section 05 12 00: to furnish bearing plates
- .3 Section 05 12 00: to furnish masonry anchors at steel structure
- .4 Section 05 12 00: to furnish lintels

1.4 EXAMINATION

- a. Examine work of all Divisions affecting work of this Division and report any defects or discrepancies to the Consultant.

1.5 NOTICE TO OTHER TRADES

- a. Notify all other trades when materials that are to be set in masonry will be required and where the exact location of provisions will be.
- b. In the event of failure to properly locate openings, chases, or materials to be set, do all cutting and repairing necessary to the complete satisfaction of the Consultant.

1.6 COLD WEATHER REQUIREMENTS

- a. No masonry shall be laid when the temperature of the outside air is below 4°C. unless means, approved by the Consultant, are provided to heat and maintain the temperature of masonry materials and protect the complete work from freezing. Materials and completed work not adequately protected from freezing shall be removed from Site on the direction of the Consultant.

- b. Protection shall consist of heating and maintaining the temperature of the masonry materials to at least 4°C but not more than 22°C and maintaining an air temperature above 4°C on both sides of the masonry for a period of at least 72 hours. Protection to conform to CAN3-S304-M84 (R1997).
- c. When air temperature is less than 5°C (40°F), mix mortar as specified in the applicable standard.

1.7 QUALITY ASSURANCE

- a. Requirements of Regulatory Agencies
 - 1. Construct masonry as required by jurisdictional authorities.
 - 2. Before commencing masonry work, verify that site conditions will allow construction of masonry within required limitations for wall heights, wall thicknesses, openings, bond, anchorage, lateral support, and compressive strengths of masonry units and mortars.
 - 3. Construct masonry fire rated assemblies, which are validated by ULC, or NRC fire tests, in complete accordance with the test design specification. Fire rated assemblies constructed otherwise shall be approved only on presentation of affidavits that they are acceptable to the authorities having jurisdiction.
- b. Source Quality Control
 - 1. Employ an approved independent inspection and testing company to select at random and test five masonry units of each following type to determine if they meet specified requirements.
Each type of brick, in accordance with CANS-A82.2.
Each type of concrete masonry unit, in accordance with CSA Standard A165 Series – 94.
 - 2. Provide mortar for samples as required for testing.
 - 3. Retest masonry units resubmitted for units that have failed to meet specified requirements as determined by previous testing. Incorporate in the Work only masonry units produced of the same materials and in the same manner as those meeting specified requirements as determined by testing.
- c. Pre-Qualification
 - 1. Execute work of this Section only by a Subcontractor who has adequate plant equipment and skilled tradesmen to perform it expeditiously, and is known to have been responsible for similar satisfactory installations to that specified during a period of the immediate past five (5) years.

1.8 STANDARDS

- a. All work under this Section shall be carried out in accordance with Part 4, Section 4.3 of the current Ontario Building Code and C.S.A. A371-M94, CAN3-S304-M84 and CSA- A370-M94.
- b. Reference standards quoted in Contract Documents refer to:
 - ASTM A153/A153M, Specification for Zinc-Coating (Hot-Dip) on Iron and Steel Hardware. ASTM B370-81, Specification for Copper Sheet and Strip for Building Construction.
 - A653 Standard, Specification for Steel Sheet, Zinc-coated (Galvanized) or Zinc- Alloy-Coated (Galvannealed) by Hot-Dip Process.
 - CAN/CSA-A82.1-M87 (R1992), Burned Clay Brick. CAN/CSA-A5-93, Portland Cement.
 - CAN3-A82.2-M78 (R1992) Methods of Sampling and Testing Brick. CSA Standard A165 Series 1994, Concrete Masonry Units.
 - CSA-A370-M94, Connectors for Masonry.
 - CSA-A371-M94, Masonry Construction for Buildings.
 - CSA Standard CAN/CSA-G30.18-M92, Billet-Steel Bars for Concrete Reinforcement. CAN3-S304-M84 (R1997), Masonry Design for Buildings. CSA Standard A82.56-M1976, Aggregate for Masonry Mortar.
 - CSA Standard A179-94, Mortar and Grout for Unit Masonry.
 - CSA W186 (latest edition), Welding of Reinforcing Bars in Reinforced Concrete Construction.

1.9 FIELD QUALITY CONTROL

- a. An inspection and testing company will be selected to inspect and report on masonry installed by this Section as required by jurisdictional authorities and as directed.
- b. The inspection and testing company will inspect and report on compressive strength of mortar samples as laying of masonry progresses. Provide six 50mm cubes of mortar from samples taken randomly at the site, for each test, as directed.
- c. Payment for inspection and testing will be made from cash allowance specified in Section 01 21 00, Allowances.

1.10 SYSTEM DESCRIPTION

- a. Tolerances
 - 1. Lay masonry to tolerances specified in CSA-A371-94.
 - 2. Level within 6mm (W') in any bay or 6M (20'0") maximum distance, and

- 13mm
(%) in 12M (40'0") or more.
- 3. Located from position shown, and from related position of columns, walls and partitions within 13mm (%) in any bay or 6M (20'0") maximum distance and
19mm (W) in 12M (40'0") or more.
- 4. Wall cross-section dimensions within -6mm (W') and +13mm (%).
- 5. With joints to dimensions indicated but in no case more than 13mm (%).

1.11 SCAFFOLDING

- a. Erect, maintain, and disassemble all scaffolding required for the performance of this trade's work in accordance with the provisions of the Construction Safety Act.

1.12 WALL HEIGHTS

- a. Unless shown otherwise, all masonry walls and partitions shall be constructed full height from floor or sub-floor to the underside of the structural deck above. Saw cut masonry to roof slopes ensuring tight joint to deck above. All masonry partitions are to be completely sealed with non-combustible, compressible, deflection filler as detailed on the drawings. Provide lateral support as detailed.

1.13 DELIVERY, STORAGE AND HANDLING

- a. Deliver products to the place on site as directed, and to meet installation schedule.
- b. Handle and store cementitious materials protected against moisture.
- c. Handle and store all mortar materials to prevent contamination by foreign materials, and damage by freezing or excessively high temperatures.
- d. Isolate masonry units from contact with ground and other materials until laid, to prevent staining.
- e. Ensure that moisture content of concrete masonry units is maintained within specified limits from time of shipment from plant to time of installation.
- f. Cover masonry unit stockpiles while stored to prevent exposure to weather. Keep water out of all holes and reglets in units during freezing weather.
- g. Handle and store masonry units to prevent soiling and chipping.
- h. Cement, lime and other packaged materials shall be delivered in original, unbroken and undamaged packages with maker's name and brand distinctly marked thereon and after delivery, stored in weathertight sheds until use on the

project is required.

1.14 CONCRETE FILLED BLOCK

- a. Fill first core of concrete blocks adjacent to door jambs solid with concrete.
- b. Fill voids of concrete block with 20 MPa concrete where shown on Structural and Architectural Drawings. Use metal lath strip in horizontal joint to prevent concrete from falling into lower blocks.

1.15 SUBMITTALS

- a. Samples
 1. Submit duplicate samples of all materials to be incorporated in the work in accordance with Division 1, including special brick shapes.
 2. Refer to Section 01 33 00, Submittals, for requirements to incorporate all components that are the responsibility of this Section in constructing a sample section of a typical exterior wall assembly and including showing use of masonry, jointing, coursing, mortar colour and texture.
 3. Coordinate work of sample installation with related work of other Sections. b.

Shop Drawings

1. Submit shop drawings of masonry reinforcement and special brick units.

c. Test Reports

1. Submit current test reports on all materials listed for the approval of the Consultant prior to final ordering.

d. Affidavits

1. Submit affidavits by an approved independent testing laboratory stating that materials supplied are in accordance with the specifications, if requested.

1.16 PRICES

a. Unit Prices

1. Provide in the Form of Tender all required unit prices as requested.
2. Include all labour, equipment, materials and applicable taxes in the unit prices so that each unit price represents the cost for the completion of the work.

PART 2: PRODUCTS

2.1 CONCRETE BLOCK

- a. Unless otherwise noted, all concrete block shall conform to C.S.A.-165 Series 94, having a fire rating as shown on the drawings based on National Research Council Fire Study No. 25 (1970) and National Building Code Supplement (1990). Block shall be as manufactured by Richvale York Block Inc., Lafarge Construction Materials, Permacon Group, or approved alternate.
- b. Concrete block classifications shall be as follows:
 - 1. For use where interior concrete block units will not be exposed to view shall be H/15.0/A/M or S/15.0/A/M. Concrete block with 3rd facet designations of B, C, or D, but of equal compressive strength, may be substituted on approval by the Consultant.
- c. All concrete blocks shall be metric modular size and of thickness called for on drawings.
- d. Provide bullnose block on all exposed external corners, at interior walls and at exposed corners at all door and view window jambs.
- e. Provide 100% solid block where shown on drawings and where required by jurisdictional authorities.
- f. Provide lintel blocks for fabrication of lintels.
- g. Exposed concrete block shall be uniform in texture and dimension and shall be free of spalled or broken edges, corners or other defects detrimental to appearance.
- h. Provide partitions with fire resistance ratings as shown on the drawings to meet all ULC certification.
- i. Block Types:
 - 1. "Standard Block" (d x 190 mm x 390 mm) Provide bullnose edge block at exposed window jamb and sill openings (soldier course)

2.2 WALL, COLUMN AND PARTITION REINFORCEMENT

- a. Concrete block reinforcement shall be Dur-O-Wal DA3200 or Blok-Lok BL-10. Hot dip galvanized after fabrication, widths, approx. 50mm less than nominal block thickness, prefab corners and tees conforming to current CSA G30.3-M1983 (R1991) cold-drawn steel wire for concrete reinforcing.

Reinforcement shall be ladder type having two parallel side rods 3.66mm dia. welded to 3.66mm cross rods forming a ladder design with cross rods spacing not exceeding 400mm o.c. Side rods shall be notched or knurled. Design ladder reinforcement to allow placement of side rods at the center-line of both face shells of the concrete block. Cross rods are to be designed without a drip feature.

- b. All block reinforcement, wall (veneer) ties and anchors shall be hot dip galvanized after fabrication to ASTM A 153-82 and CSA G164-M92.

2.3 MORTAR

- a. Masonry cement shall conform to current C.S.A. Standard CAN/CSA-A8-M93. Ensure that water and aggregate used in mortar will not cause efflorescence.
- b. Sand shall conform to current C.S.A. Standard A179-94, per Table 1 (aggregate gradation).
- c. Water shall be potable, taken from municipal water mains without intermediate storage in any vessel.
- d. Mortar mixes shall be prepared as defined in the current Ontario Building Code.
- e. For all exterior masonry, use type "N" mortar, proportion by volume shall be 1:1:6 (portland cement/lime/sand) in accordance with C.S.A. standard A179-94. Betomix 1-1-6 by Daubois is an acceptable product or approved alternate.
- f. For all interior non-load bearing masonry, use type "N" mortar per proportion specification A179-94. Mortar strength to be minimum 3.5 MPA job site tested after 28 days.
- g. For all load bearing masonry, use type "S" mortar per proportion specification A179-94. Mortar strength to be minimum 8.5 MPA job site tested after 28 days.
- h. Colour shall be to approved samples as manufactured by Harcross Pigments, or approved alternate.
- i. Use no antifreeze liquids, salts or other substances to lower freezing point of mortar.
- j. Integral mortar waterproofer shall be Omicron as manufactured by the Master Builders Company Limited or approved metallic sterate type.

2.4 VENEER TIES AND ANCHORS

- a. All material to be stainless steel.

- b. To Concrete Block — Fero Slotted Type 1 or Blok Lok BL-507 with 3/16" (4.76mm) V-tie.
Length of embedment in block is 6mm maximum less than block width.
- c. To Concrete — Fero Raptie or Blok Lok BI-407 with two 1/4" diameter x 1 3/8" PowersTapper stainless steel screws, with 3/16" (4.76mm) V-tie.

2.5 CAVITY WEEP HOLE VENTS

- a. Polyvinyl chloride Goodco Brick vents or approved equal.

2.6 FLASHING MEMBRANES

- a. Flashing membrane to be P.V.C., 0.508mm (20 mil.) thickness, as manufactured by National Concrete Accessories, Lexsuco Canada Limited, Bakor TWF or approved alternate.
- b. Flashing membrane adhesive to be clear, synthetic rubber resin as recommended by the flashing membrane manufacturer.

2.7 CONTROL JOINTS

- a. Joint Filler: Sealtight Rescor premoulded closed cell polyvinyl chloride foam as manufactured by W.R. Meadows, Unifoam R1009 as manufactured by J.E. Goodman, or approved alternate.
- b. Refer to Section 07 92 10, Caulking, for control joint caulking and back up materials.
- c. Copper weatherstrip bellows shall be 570 gm copper sheet formed to profiles shown.

2.8 MIXES

- a. Mix mortars as specified in CSA Standard A179. Use only dry aggregate. Test for bulking to determine accurate proportioning.
- b. Incorporate plasticizing admixture with mortar in exterior walls. Mix mortar in accordance with its manufacturers' specifications and with CSA Standard A179.
- c. Match colour of mortar to concrete masonry units where exposed to view by incorporation of suitable cement and aggregate.
- d. Match colour of mortar for face brick to existing mortar joints.
- e. Use grey mortar unless specified otherwise.

- f. Parging: use Type "N" mortar with integral water-proofing.
- g. Mortar materials shall be measured either by weight or by volume and the methods of measurement shall be such that the proportions can be controlled with an error of not over 2%.

2.9 GROUT

- a. Non-Shrink grout for structural steel base plates: grout as manufactured by C.C. Chemical Limited, or N-S Grout by the Euclid Chemical Company, or M-Bed by Sternson Ltd.
- b. Grout for reinforced masonry: course grout with Portland cement and course sand, to meet specification requirements of CSA A179, with maximum slump of 200mm and minimum compressive strength at 28 days of 12.0 mpa.

PART 3: EXECUTION

3.1 PREPARATION

- a. Furnish, install and maintain safe and adequate scaffolding, centering and other equipment necessary for the proper execution of the work. During erection, walls shall be properly braced.
- b. All equipment for mixing and transporting the mortar and units shall be clean and free from set mortar, dust or other foreign matter.
- c. Ensure that steel and concrete surfaces are ready to receive masonry and that there are no protuberances or sharp edges which may tear or puncture the membrane flashing.
- d. Protection
 - 1. Provide waterproof protection over construction surfaces at mixing areas to prevent deposit on them of mortar and mortar materials.
 - 2. Cover exposed tops of masonry walls when laying is not in progress and until protected by completed construction. Cover with non-staining waterproof material to overhang top edges of wall by 600mm minimum and secured to prevent dislodgement.
 - 3. Protect exposed external corners of masonry with materials which will not damage or soil finished surfaces.
 - 4. Protect all finished surfaces from mortar droppings.
 - 5. Take particular care to protect faces of concrete unit masonry from mortar droppings and smears as laying proceeds.
 - 6. Turn over or cover scaffolds and mortar boards at completion of each day's work to avoid staining of finished surfaces by splashed rain.

e. Shelf Angles:

Install shelf angles supplied by Section 05 12 00, Structural Steel. Level, adjust and secure angles permanently in place.

3.2 LAYING MASONRY- GENERAL

- a. Lay masonry to meet specified requirements of CSA-A370-94 and CSA-A371-94, unless otherwise specified.
- b. Lay masonry, plumb, level and true to line, in running bond, with vertical joints of alternate courses in line (interior partitions to extend to underside of roof deck or to structure above), properly jointed to connecting work (except for stack bond), vertical and horizontal joints of equal and uniform thickness. Constantly check levels and coursing with a graduated "storey" rod. All corners to be square unless shown otherwise on drawings. Minimize cutting of units.
- c. Distribute exposed masonry of varying colours, textures, and tones over wall area to produce a homogeneous blend. Discard units which are too contrasting in appearance to achieve satisfactory blending.
- d. Use chipped and blemished units only where concealed. Do not use defective or broken units. Do not lay concrete units with markedly smooth face that will appear slick where exposed to view, whether painted or not.
- e. Maintain bracing of walls and piers continuously during construction until structure provides support.
- f. Lay each hollow unit in full bed of mortar for face shells. Butter vertical joints full. When laying closure units butter vertical units already in place and ends of units being placed.
- g. Stop off horizontal runs of walls by racking back a half unit in each horizontal course: do not tooth.
- h. Wet clay and shale masonry units before placing. Wet faces of masonry in place before laying new masonry. Ensure that units have no water adhering to their surfaces when laid; but shall be wet only to ensure that complete hydration takes place during hot drying weather, and when unit absorption rates are greater than 0.11 ml/sq.cm/minute, so that the initial rate of absorption does not exceed above rate when laid.
- i. All solid concrete block units shall receive full head and bed mortar joints.
- j. Bond units at intersection of walls by overlapping units using full masonry bond or by pre-fabricated "tee" metal reinforcing.

- k. Spread mortar only so far ahead that it remains plastic when masonry is laid. Use ample mortar on closures. Shove closure unit into place carefully so that adjoining masonry is not disturbed.
- l. No masonry unit shall be shifted or re-aligned after being laid. If necessary to do so, remove unit, clean off and re-lay with fresh mortar.
- m. Where new masonry abuts fully set masonry clean existing surfaces and dampen to obtain bond.
- n. Build in flashing membranes as indicated on drawings. Separate wall construction from foundations using two piece installation method. Flush surfaces smooth with mortar masonry against which flashing rests to ensure that it is not punctured.
- o. Build in all anchors, plugs, lintels, ties, inserts, flashings, reinforcement, window and door frames, etc., filling hollow metal door frames with cement mortar.
- p. Built-In Items
 - 1. Verify that built-in items specified in other Sections are available for building in before laying of masonry commences. Cooperate in the setting and aligning of built-in items and provide for later installation of items which are installed by other Sections, to avoid cutting, fitting, and patching.
 - 2. Build-in precast concrete sills. Incorporate spacers at underside of units where required to maintain 10mm (3/8") mortar joint.
 - 3. Build masonry around pressed steel door frames supplied and set as specified in other Sections. Ensure that anchors are well-secured and that frames are true and plumb. Completely fill frames with mortar as each course is laid. Maintain protective frame covering and ensure that no mortar is left on frame faces.
- q. Tolerances - to standards referenced herein.
- r. Use only dry and unfrozen materials.
- s. Remove sections of masonry which have been frozen before laying of masonry continues.
 - 1. Lay precast sill, cap, coping and trim units with a consistent 10mm (3/8") mortar bed. Where units laid do not have spacers incorporated, set sill units on lead wedges to provide proper spacing.
- u. Joints:
 - 1. Make joints of uniform thickness with vertical joints from course to

-
- course maintained plumb.
 2. Provide full bed and head joints for shear walls.
 3. When laying is resumed on walls previously laid with mortar either partially or totally set, remove loose units and mortar from top and adjoining surfaces. Remove mortar completely when masonry is removed and replaced with new.
 4. Form tooled concave joints wherever exposed to view, whether behind cabinets, fittings, and wall accessories, or not. When mortar has become "thumb- print" hard, tool joints and clean off burrs with trowel or burlap. Use a tool with a bearing surface of 550mm minimum length on horizontal joints to avoid uneven depressions.
 5. Trowel point joints in unparged masonry in contact with earth.
 6. Rake out joints of masonry exposed to view to provide for caulking at juncture of interior and exterior walls with columns. at interior with exterior walls intersections of walls and partitions where joint reinforcement is installed. at caulked joints where indicated typically.
 7. Cut joints off flush where thin-set tile will be applied, and where treatment is not otherwise specified.
 8. Ensure that no mortar protrudes from joints on wall surfaces to which insulation will be applied.
- v. Cope, cut and split concrete masonry units with power-driven abrasive discs. Cut units wherever electrical outlets, grilles, and pipes occur. Allow 3.2mm (1/8") clearance around items which are incorporated in walls.

3.3 LAYING BRICKWORK

- a. Brickwork to be laid in running bond with soldier courses, header courses and rowlock courses as shown or noted on drawings.
- b. All brick joints to be struck off flush and tooled concave.
- c. Coursing to be 3 brick + 3 joints = 200mm.
- d. Wetting of brick units to conform to standards listed herein.

3.4 LAYING CONCRETE BLOCKWORK

- a. Lay each hollow unit in full bed of mortar for inner and outer face shells. Butter vertical joints full. When laying closure units, butter vertical units already in place and ends of units being placed. In addition, the webs shall be laid in a full bed in all courses of piers where adjacent to cells that are to be reinforced or filled with concrete grout. Where walls or partitions abut concrete columns or beams build block tight to concrete and fill all voids with mortar and build in metal anchors.
- b. Extend walls and partitions to underside of structural deck or structural members, as applicable, except where otherwise noted on Drawings.

Incorporate both lateral support and deflection space at termination of walls as required by this Section. Where walls terminate at bottoms of steel joists, close space at joists to deck or slab with metal lath on one side of joist or with 16mm (5/8") thick fire rated, non-gypsum based board secured to each side of joists, if infilling with masonry is impractical; and to meet Mondelez requirements. Ensure that construction at joists completely closes and seals space.

- c. Provide solid masonry units immediately above all sound block (CB-4) panel locations.
- d. Incorporate a deflection space between tops of non- load-bearing walls and partitions and structure to prevent transference of structural loads to masonry.
- e. Fill deflection space with Firestop at Fire-rated walls to seal space.
- f. Coordinate laying of masonry with installation of lateral support specified in this Section.
- g. All cutting of concrete block shall be done with a masonry saw.
- h. Surface variation of walls shall be to C.S.A. Standard A224-1970 except where glazed tile finish is required variation shall be maximum of 6mm in 2450mm.
- i. Align webs of concrete unit masonry vertically and with thick ends on top.
- j. Do not wet concrete block.
- k. Do not expose open cells, cores or frogs of masonry units to view.
- l. Render masonry with two 6.4mm (Ye) thick coats of parging mortar where indicated on Drawings.

3.5 CAVITY WALL

- a. Lay up inner (concrete block) 4 courses ahead of outer brick or masonry units, setting reinforcing in place and striking off all mortar flush on cavity side.
- b. Install membrane flashings along bottom of cavity wall, continuous full width across any steel structure projecting through or into cavity, across heads or lintels of doors, windows, louvres or any other openings through wall, under sills and all other areas, indicated on drawings so that all moisture in cavity space will be diverted to the exterior. Lap and seal all joints in flashing, extend flashing a maximum of 200mm beyond each side of openings, carry through full width of brick or block facing, across cavity and insulation, up cavity face of inner block at least 200mm and 100mm into block at coursing.

- c. Coordinate with the installation of the air/vapour barrier system as specified in Section 07 26 00, Air Vapour Barrier.
- e. Lay up face brick, striking off all mortar flush on cavity side. Provide weep and vent holes spaced 600mm o.c. maximum, over all flashings and at the top of all cavity walls. Weep and vent holes to be as called for in 2.07 of this Section.
- f. In the cavity air space, provide at each cavity weep hole/vent located over cavity flashing membranes, 150mm (6") high mounds of cavity mortar dropping control materials as described in item 2.18 of this Section.

REMOVE SURPLUS MORTAR, MORTAR DROPPINGS, CHIPS AND DIRT. FROM THE CAVITY AIR SPACE KEEPING CAVITY PERFECTLY CLEAN AT ALL TIMES.

3.6 REINFORCING

- a. Concrete block walls, including interior partitions and inner wythe of cavity walls, shall have continuous masonry reinforcing in every second block course vertically starting at first joint above floor. Stop reinforcing at each side of all masonry control joints. Lap ends of reinforcement at least 200mm (8") at splices.
- b. Place reinforcement additionally in courses 200mm (8"), 400mm (16") and 810mm (32") above and below openings, and extending 600mm (24") beyond jambs of openings.
- c. Where changes in wall thickness occur, extend reinforcement of lesser width 450mm (18") beyond changes of width.
- d. Wherever walls and partitions intersect one another, or each other, continue reinforcement through. Do not carry reinforcement through intersections where lateral support anchors are installed or at intersections of walls and partitions with solid piers.
- e. Brick facing shall be tied to inner block of the exterior cavity wall with stainless steel v-ties reinforcement spaced no greater than 600mm o.c. horizontally and 400 mm o.c. vertically.

3.7 MASONRY ANCHORS

- a. Use dovetail anchors for slots at concrete construction.
- b. Use adjustable anchors at steel structure.
- c. Keep masonry a minimum of 12.7mm (W) clear of faces of structural members or as indicated on Drawings, and fill space with glass fibre board, leaving space for caulking at joints exposed to view or the weather.

Bed anchors solidly in mortar joints.

- e. Coordinate with Section 03 30 00, Cast-in-Place Concrete, to ensure that dovetail anchor slots in concrete are located correctly. Assist in their installation if requested.

3.8 TYING

- a. Dovetail anchors to be installed at 400mm centers in dovetail anchor slots.
- b. Fero Ties or Blok Loc ties to be installed at 600mm vertical spacing and 800mm horizontal spacing when connecting veneer to plywood, concrete and concrete block masonry or as per manufacturer's recommendations.
- c. Fero Ties or Blok Loc ties to be connected to structural steel at 800mm centers in predrilled holes or as per manufacturer's recommendations.
- d. Fero ties or Blok Loc ties to be connected to metal studs at 600mm centers or as per manufacturer's recommendations.
- e. Veneer ties shall be installed within 200mm of all door and window openings, edges of masonry panels and control joints, at 400mm centers.

3.9 MORTAR

- a. Mortar materials shall be measured either by weight or by volume and the methods of measurement shall be such that the proportions can be controlled with an error of not over 2%.
- b. Mix mortar in accordance to C.S.A. Standard A179-94 proportioned and mixed to suit location and type of masonry.

3.10 SEAL AT DUCTS, PIPES AND DECK

- a. Neatly seal with masonry and mortar to within 19mm (W) around all ducts, sleeves, conduits, pipes and structural members which penetrate through masonry walls or partitions, maintaining the required fire resistance rating of the fire separation.
- b. Fill in open flutes of structural deck along top of all block walls serving as fire separations. Leave cut block openings in block walls where required to leave clearances for deflection of structural members. In fire separation walls, these openings will be sealed in accordance with Section 07 27 00, Firestopping.

At service and structural penetrations through masonry fire-rated separations, and at the joint between the top of masonry fire-rated separations and structural deck above, seal all penetrations and joints in accordance with Section 07 27 00, Firestopping.

3.11 CONTROL JOINTS

- a. Incorporate vertical shrinkage control joints in walls of which concrete masonry units are a part.
- b. Install control joints at junctions of walls and columns, at intersections of unit concrete masonry load-bearing walls, and wherever indicated on Drawings, and otherwise in walls with no openings, at a maximum spacing of 10m (30'-0") o.c. Carry joints full height of walls.
- c. Ensure complete vertical separation through walls incorporating control joints. Make control joints 9.5mm (3/8") wide, rake back 19mm (3/4") at junctures with concrete, and leave joints free and clear for caulking, as specified in Section 07 92 10, Joint Sealing.
- d. Construct control joints of standard block and fill void between block with 20 MPa concrete grout to form a continuous key full height of joint. Maintain separation between walls on each side of joint by installation of continuous building paper between concrete key and block on one side of joint.
- e. Saw cut all masonry at control joints.
- f. Control joints in the exterior width of cavity walls to be completely free of mortar.

3.12 EXPANSION JOINTS

- a. Incorporate expansion joints in walls where indicated on Drawings.
- b. Build in metal bellows with joints between lengths lapped a minimum of 50mm (2") and flanges anchored in joint between wythes.
- c. Maintain expansion joints free of mortar with temporary filler when laying masonry. Pack joints full height with glass fibre board compressed to 50% of original thickness.
- d. Leave clean space in joints for caulking as specified in Section 07 92 10, Joint Sealants.

3.13 BLOCK PARTITION LATERAL SUPPORT

- a. All interior masonry partitions must have adequate lines of lateral support at vertical or horizontal intervals of 36 times the thickness of the wall. Door openings may not occur between vertical lines of lateral support.
- b. Vertical lines of lateral support may be provided by intersecting masonry walls which are connected by prefabricated masonry reinforcing "T's" or "L's" or by block bonding; or by structural steel bracing members connected to the wall with fasteners spaced at not more than 4 times the nominal wall thickness. Horizontal

lines of lateral support may be provided by floor or roof structure connected to the masonry partitions with metal clips spaced at not more than 10 times the nominal wall thickness (2000mm maximum).

- c. Lateral support clips are specified in Section 05 50 00, Metal Fabrications.
- d. Coordinate with Section Metal Fabrications to ensure that lateral supports are located correctly. Assist in their installation if requested.

3.14 THROUGH WALL METAL FLASHING

- a. Install metal flashing at locations indicated on Drawings.
- b. Coat surface of metal in contact with masonry with two coats of bituminous paint. c. Lap joints between lengths of flashing a minimum of 100mm (4") and seal with lap cement.

3.15 FIRE SEPARATIONS

- a. Construct fire separation walls tightly to construction at perimeter, and without openings or voids.
- b. Do not reduce the thickness of masonry fire separations to less than the thickness indicated for the required fire separation rating.

3.16 FIRE PROTECTION

- a. Install masonry fire protection of structural steel columns as indicated on Drawings, for fire ratings indicated.
- b. Completely enclose structural steel columns with masonry for their entire length. Do not fill webs.

3.17 GROUTED REINFORCED MASONRY

- a. Incorporate reinforcing steel and construct masonry to meet specified requirements of CSA-A371-94 and CAN3-S304-M84 (R1997), and as indicated on structural Drawings
- b. Fill first core of concrete blocks adjacent to door jambs solid with concrete.
- c. Fill voids of concrete block with 20 MPa concrete where shown on Consultants' Drawings. Use metal lath strip in horizontal joint to prevent concrete from falling into lower blocks.

3.18 CLEAN-UP

- a. Point all holes in masonry (except weepers) and cut out all defective joints to a

depth of 13mm (½") and repoint with mortar.

- b. Patch damaged masonry walls which have been rejected.
- c. Thoroughly clean all exposed masonry of exterior and interior walls of all dirt, stains and excess mortar with stiff brushes and solution of tri-sodium phosphate and water. Scrapers may be used only where necessary with prior approval by the Consultant. Work from the top of wall towards bottom, completing work without interruption. Do not use wire brushes for cleaning masonry.
- d. Should specified cleaning methods be insufficient, proceed with other methods only with approval.
- e. Protect adjacent materials, construction and finished surfaces from damage while cleaning.
- f. Ensure that all efflorescence and mortar deposits are removed from all exposed masonry surfaces.
- g. Masonry work shall be left in a finished condition satisfactory to the Consultant.
- h. Excess brick remaining at the completion of work shall be stockpiled on site in a location designated by the Owner.
- i. Remove all equipment, surplus materials and debris immediately after completion of the work.

END OF SECTION

PART 1 : GENERAL

1.1 WORK INCLUDED

- a. Comply with Division 1, General Requirements and all documents referred to therein.
- b. Provide all labour, materials, plant and equipment to complete the structural steel work indicated on the drawings and specified herein.

1.2 RELATED WORK SPECIFIED ELSEWHERE

- a. Concrete Reinforcement: Section 03 20 00.
- b. Grouting beneath column bases on concrete members: Section 03 30 00.
- c. Cast-in-Place Concrete: Section 03 30 00.
- d. Grouting beneath base plates bearing on masonry: Section 04 20 00 – Unit Masonry.
- e. Reinforcement of edges of openings in metal deck that are not larger than 450 mm (18") in roof deck and 300 mm (12") in floor deck: Section 05 31 00.

1.3 REFERENCE STANDARDS, CODES AND ACTS

- a. Conform with the latest edition of the Ontario Building Code, Regulation 350/06 as amended by O. Reg. 423/06, and as amended by O. Reg. 205/08, and any applicable acts of any authority having jurisdiction and the following, except as specifically varied herein (latest editions):
 1. ASTM A36/A36M Standard Specification for Structural Steel.
 2. ASTM A108 Standard Specification for Steel Bars, Carbon, Cold Finished, Standard Quality.
 3. ASTM A307 Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
 4. ASTM A325M Standard Specification for Structural Bolts for Structural Steel Joints.
 5. ASTM A490M Standard Specification for High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints.
 6. ASTM A496 Standard Specifications for Steelwire, deformed, for concrete reinforcement
 7. CAN/CSA-G40.20 General Requirements for Rolled or Welded Structural Quality Steel
 8. CAN/CSA-G40.21 Structural Quality Steels.
 9. CAN/CSA-G164-M92 Hot Dip Galvanizing of Irregularly Shaped Articles.
 10. CAN/CSA-S16.1 Limit States Design of Steel Structures.

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| 11. | CSA-S136 | Cold Formed Steel Structural Members. |
| 12. | CSA-W47.1 | Certification of Companies for Fusion Welding of Steel Structures. |
| 13. | W59-M1989 | Welded Steel Construction (Metal Arc Welding). |
| 14. | CISC/CPMA 1-73a | Quick-Drying, One-Coat Paint for Use on Structural Steel. |
| 15. | CISC/CPMA 2-75 | Quick-Drying, Primer for use on Structural Steel |
- b. Where there are differences between the specifications and the drawings and the standards, codes or acts, the most stringent shall govern.

1.4 **TOLERANCES**

- a. Conform to erection tolerances specified in CSA-S16.1.
- b. Interfacing tolerances may not be compatible with the above. Review and coordinate interfacing tolerances so that the various elements come together properly.
- c. Fabricating, preparation and coating systems shall be such that they minimize the effects of galvanizing, bending, cambering and the like, on the alignment of the completed members.
- d. The as fabricated and erected straightness tolerances of architecturally exposed steel members shall not exceed 1/2 of the standard camber and sweep tolerances specified in G40.21.

1.5 **DESIGN CRITERIA**

- a. All loads, forces and reactions, shown on the drawings or noted in the specifications are service loads (unfactored), unless noted otherwise.
- b. Design and detailing of joists, connections, etc., to be in accordance with CAN/CSA- S16.1. Service loads must be factored for Limit States Design. Top chords of joists to have each top chord angle not less than 38 side for hot rolled angles or not less than 50 for cold formed angles. Minimum weight 13.4 kg/m.
- c. Typical connections details are shown on the drawings for guidance only. Design and submit for approval suitable bolted or welded connections. In general, bolted connections should be designed as bearing connections with threads included in the shear plane.
- d. The shear capacity of all beam and girder connections shall be not less than the shear capacity of the section acting as a simple beam loaded uniformly to its moment capacity over the same span nor less than that shown on the drawings, whichever is greater.
- e. Design joist and bridging members in accordance with applicable reference standards for the uniform loadings shown on the drawings with due allowance for local bending moments and for any additional concentrated and/or line loads for the support of mechanical units and/or masonry walls. Design OWSJ such that total load deflection does not exceed L/240 and live load deflection does not exceed L/360 under design service loads.

- f. Refer to mechanical drawings for number of, approximate location, and weight of suspended mechanical units and piping runs. Final location will be determined during the shop drawing stage.
- g. Where tie joists (t.j.) and/or square end joists are shown on the drawings, extend the complete bottom chord to connect to column or beam.
- h. Provide additional bottom chord bridging to ensure adequate bottom chord compression capacity where stress reversal may occur due to net uplift, or cantilever action.
- i. Note that the roof systems are sloped for drainage, which requires attention to detailing and fabrication.
- j. Typical bearing stiffeners for beams continuous over columns are shown on the drawings. Design suitable stiffeners at other locations of concentrated loads, as required to suit the connection design.
- k. Working points for vertical braced frames are column/beam centerline intersection and column centerline with base plate.
- l. In general, design connections of beams to HSS columns as double header angles or structural tees.
- m. Refer to drawings for special joist ends or web configuration to allow clearance for mechanical duct work.

1.6 **QUALIFICATIONS**

- a. Fabricator, erector and all subcontractors performing structural steel work shall be certified under the requirements of Division 1, or Division 2.1 of W47.1.
- b. Professional engineers responsible for the design of steel connections, joist systems and the like shall be insured in accordance with section 74(1) of Regulation 941 of the Ontario Professional Engineers Act. The alternative in section 74(2) is not acceptable.

1.7 **DESIGN**

- a. General
 - 1. Design connections and the like for the loads shown or implied in accordance with requirements of S16.1 and the following:
- b. Connections
 - 1. Use types of shop or field connection shown, or in the absence of such indication, use most appropriate type of connection.
 - 2. Design connections to safely withstand the combined primary effects of axial forces, shear, moment and torque and any secondary effects due to welding.
 - 3. Design connections between columns, beams, girders, trusses and braces, and

between such members as spandrel angles and beams, hangers, stiffeners, etc., and their supporting members be they steel or concrete.

4. Design bracing member connections for field adjustability to maximum construction tolerances.
5. Design connections that are exposed to weather so that moisture, foreign matter, and the like cannot be trapped or gain entry to the interior of hollow built-up members.
6. Design and detail connections so as not to encroach upon architectural clearance lines or finishes.
7. Design connections that are to be cast into concrete to provide for the maximum deviation that can occur in erection and based upon the following:
 - .1 Specified steel erection tolerances,
 - .2 Maximum permissible tolerances in the location of inserts cast into concrete, specified in Section 03 10 00.
- c. Design calculations shall be carried out by or under the direct supervision of a qualified Professional Engineer licensed in the Province of Ontario, with a minimum of 5 years Canadian experience in the design of structural steel work, connections including design of weldments, or joist systems, as appropriate.
- d. Colour Coding
 1. Use a colour coding technique to aid in the shop and field identification of all different grades of steel. Each member used shall bear its particular colour code.

1.8 **SUBMITTALS**

- a. Refer to Section 01 33 00
- b. Qualifications of Professional Engineer
 1. Submit a curriculum vitae of each professional engineer who will be responsible for steel work, connections, joist systems and the like, verifying the minimum experience requirements outlined in section titled Qualifications.
 2. Submit proof of adequate liability insurance coverage for each professional engineer who will be responsible for the steel work.
- c. Shop, Erection and Setting Drawings
 1. Professional engineer responsible for the structural steel work, connections, joist systems and the like shall either:
 - .1 Seal and sign each shop drawing submitted, or
 - .2 Submit a sealed and signed letter prior to commencement of shop drawing preparation stating that he has been retained by the steel fabricator to carry out the design of steel connections, joist systems and the like AND shall submit a second letter after shop drawing preparation is complete stating that

the design of the steel work for which he is responsible has been completed in accordance with the contract documents and relevant building codes and standards.

2. All shop drawings submitted must clearly indicate the initials of the individual who checked the shop drawings before they were submitted for review.
 3. Reproduction of the structural drawings, to serve as erection or setting drawings, will be permitted. Cost of reproduction to be paid for by this section. Any identification or reference to the Owners or Consultants is to be removed from all structural drawings which are used by the fabricator and erector.
 4. Submit structural steel shop, erection, and setting drawings for review by the Consultant.
 5. Shop drawings shall be submitted in complete packages so that individual parts and the assembled unit can be reviewed together. This section and the applicable drawings used in the development of the shop drawings shall be clearly referenced on each shop drawing to facilitate review. Detail member marks shall be cross referenced on the erection drawings to facilitate a quick identification of the members.
 - .1 As a minimum, show the following:
 - a. layout;
 - b. member sizes;
 - c. connection details;
 - d. bearing details;
 - e. splice locations and details;
 - f. holes;
 - g. camber;
 - h. finishes;
 - i. grades of steel;
 - j. bolt material;
 - k. architectural clearance lines and finishes where connections and the like may encroach with other work;
 6. Prepare setting drawings showing dimensions and details for setting structural steel bearings, anchorages, assemblies and the like where they interface with other building components.
 7. Co-ordinate structural steel shop and erection drawings with shop drawings of other interfacing work.
 8. Submit all non-prequalified welding procedures, stamped as approved by the Canadian Welding Bureau and correlated to the appropriate shop and erection drawings.
 9. Furnish Inspection Company with a copy of each shop, erection, and setting drawing bearing the Consultant's shop drawing stamp marked reviewed.
- d. Calculations
1. Submit calculations bearing the seal and signature of a qualified Professional Engineer licensed in the Province of Ontario and such further proof as may be

necessary to show that non-standard connections and the like conform to the requirements set forth herein.

e. Erection Procedures

1. Erection procedures and temporary bracing are the sole responsibility of the Contractor.
2. Well in advance of erection, submit procedures, methods, sequences of erection, temporary shoring and guying, and equipment proposed for use in erecting structural steel and bearing the seal and signature of a qualified licensed Professional Engineer licensed in the Province of Ontario.

f. Substitution

1. If the Contractor wishes to make substitutions for steel materials or sizes indicated, submit proposals with the tender with calculations for review by the Consultant.

g. As-Built Drawings

1. Mark on a complete set of final reproducible drawings any changes, additions, or deletions that occur during construction as a result of the Contractor's work, change orders or for any other reason.

h. Mill Test Reports

1. Submit to the Consultant copies of mill test reports covering chemical and physical properties of steel used in this work, including mill test reports for all structural bolts.

i. Colour Code

1. Submit colour code proposed to identify various grades of structural elements.

j. Non-destructive Testing

1. Submit all in-house non-destructive testing results of shop and field work together with inspector/technician certification status and test procedures used.

PART 2 : PRODUCTS

2.1 MATERIALS

- a. Provide only Canadian manufactured new materials in accordance with the Reference Standards. Where sections identified are not available from Canadian mills, provide new American materials of strength and quality noted.

2.2 STRUCTURAL STEEL

- a. Structural wide flange and welded wide flange shapes (W, WWF) to conform to CAN/CSA-G40.20/G40.21 grade 350W.

- b. Angles, channels (L, C) and plates to conform to CAN/CSA-G40.20/G40.21 grade 300W.
- c. Hollow structural sections (HSS) to conform to CAN/CSA-G40.20/G40.21 grade 350W, class H.
- d. Anchor Bolts: In accordance with CSA Standard G40.21M-300W (Galvanized bolts at exterior columns).
- e. Concrete Anchors: Shall be Nelson, flux filled deformed bar anchors, type D2L, or approved equivalent. Studs shall be made from ASTM A-108 cold rolled, deformed wire meeting the mechanical properties of ASTM A-496 and shall be welded per the manufacturer's recommendations.
- f. Shop Paint: to CISC/CPMA 1-73a for steel not exposed to weather or view. No lead based paints allowed.
- g. Shop Paint: to CISC/CPMA Standard 2-75 for interior steel exposed to view. No lead based paints allowed.
- h. Hot dip galvanizing: to CSA G164, minimum zinc coating of 600 g/m² for all steel outside the building vapour barrier including connection material and inserts.
- i. Zinc-rich paint: Galvafruid as supplied by W. R. Meadows Limited or approved equivalent.

PART 3 : EXECUTION

3.1 FABRICATION

- a. Provide holes up to 15 mm (5/8") in diameter, as required, to permit the attachment of other materials.
- b. Provide drain holes in closed sections to prevent water build-up during erection.
- c. Splices, other than those shown, shall not be permitted in members without Consultant's approval. If approval is given to permit welded splices, they shall be non-destructively tested at no extra cost to the Owner.
- d. Unless noted otherwise on the drawings, provide a 10 mm (3/8 inch) cap plate for all hollow built-up members. Cap plate is to be continuously seal welded to built-up member.
- e. Seal all hollow built-up members exposed to weather with continuous seal welds, incorporating structural welds where shown or required.
- f. Where masonry walls are shown built into structural steel columns and beams, provide and install masonry anchors on columns at 600 mm (24") on centers and anchors on beams at 1500mm (5'-0") on center.
- g. Thickness of baseplates 100 mm or greater is nominal and allows for a maximum reduction of 6 mm for milling to the requirements of CAN S16.1.
- h. Openings

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1. No openings through structural steel members will be permitted without the Consultant's approval.
- i. Architecturally Exposed Steel
1. Perform fabrication with special care and necessary straightening to maintain the condition of the material as described herein.
 2. Show clearly the required fabrication tolerances on shop drawings. Show the required tolerances for setting embedded items on erection drawings.
 3. Make copes, mitres and butt cuts in surfaces exposed to view within the closest possible tolerances consistent with structural shop equipment and practice. Plan erection sequence so that these tolerances can be maintained.
 4. All exposed edges of plates shall be universal mill or guided flame cut. Exposed cut edges of beam flanges shall be guided flame cut. Cut surfaces shall be equal in smoothness to a mill finish.
 5. Except as otherwise shown on the drawings, all shop and field assembly shall be done by welding.
 6. Form and weld all joints exposed to weather to exclude water by the use of "seal" welds.
 7. Exposed welds, except filler welds and concealed welds where clearances or fit of other items may so necessitate, shall be ground smooth and otherwise finished flush and even with adjacent surfaces. Grinding is not required for well formed fillet welds.
 8. Grind bevel welds smooth, forming neat, well-made corners.
 9. Grind smooth any welds on structural steel members in the finished building that are within the reach of the public.
- j. All structural steel to be fabricated in accordance with CAN/CSA-S16.1.

3.2 ERECTION

- a. Carry out erection operations, including installation of any temporary guying and shoring required, ensuring that the existing structure or members already erected are not loaded in excess of their safe load carrying capacity.
 1. Temporary bracing must be adequate to restrict lateral drift per storey to 1/500 under maximum design wind load during construction.
 2. During erection, forces or reactions in the steel frame members and their connections might exceed those on which the design is based. Determine the magnitude of such erection forces and reactions and take such measures as are necessary to ensure that the safety and stability of the structure is maintained until the entire structure, including floor and roof slabs is complete.

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3. Nuts on bolts shall be prevented from working loose by use of lock washers, lock nuts, jam nuts, thread burring or other approved methods.
 4. Report to the Consultant where members cannot be erected within the specified tolerances without modification or special procedures. Take corrective measures to the Consultant's approval.
 5. Erection tolerances in accordance with CAN/CSA-S16.1. Take particular care in the erection of architecturally exposed members.
- b. Bearing on Concrete or Masonry
1. Set steel baseplates and bearing assemblies true and level at the proper elevation so that upon grouting, they will have full bearing.
 2. Unless a specific method is shown, leveling devices or steel shimming may be used to support bases prior to grouting. Subsequent to grouting, loosen the leveling devices so that all load passes through the entire area of the bases. Remove the steel shims so that the resulting voids can be fully grouted.
- c. Lintels
1. Unless a reinforced block or concrete lintel is noted, provide loose steel lintels, to the details shown, over openings and recesses including those for mechanical or electrical services in masonry walls or partitions.
- d. New Steel Work to the Existing Building
1. Before proceeding with any work at the existing building, verify that existing members being connected are of the size and section indicated on the drawings. If they are not, inform the Consultant immediately. Do not proceed until the Consultant has given instructions.
 2. Make site measurements as required to verify dimensions of existing work before proceeding with the work. The Contractor shall be responsible for extra costs incurred due to proceeding without verifying site dimensions.
 3. Adequately shore existing structure to ensure that no movements or damage occurs until the permanent structure shown is installed.

3.3 PROTECTION

- a. Cleaning Steel
1. Clean all unexposed structural steel in accordance with requirements of SSPC-SP3 Power Tool Cleaning, to remove loose mill scale, rust, oil, dirt and other foreign matter.
 2. Clean structural steel exposed to view or steel outside the building vapour barrier in accordance with SSPC-SP6 Commercial Blast Cleaning.
 3. Clean surfaces within 50 mm (2") of any field weld location of materials that would

prevent proper welding or produce objectionable fumes while welding is being done.

4. After inspection and before leaving the shop, clean all architecturally exposed steel work exposed in the finished work by grit-blasting of all mill scale, rust, weld slag or flux deposit and other foreign matter, to a Commercial Bright finish as required by CISC/CPMA 2-75.

b. Painting

1. Do not paint metal items that are to be encased in concrete and surfaces that are to have concrete placed against them.
2. Except where steel is to be galvanized, immediately after cleaning, apply a shop coat paint to all steel work, except as follows, to dry surfaces by spray, to a minimum dry film thickness of 2 mils (50 µm). Allow to dry in dust free areas.
3. Upon completion of erection, clean with mechanical brush and apply primer to welds, bolts and at locations where original primer is damaged.
4. Additional Requirements for Architecturally Exposed Steel:
 - .1 Apply one additional shop coat of paint as specified to parts of shop coated steel surfaces that will be inaccessible after erection.
 - .2 After erection and immediately after grinding welds, etc. touch up and paint with one coat of same paint as shop coat, all damaged and abraded spots, including any unpainted areas. Completely remove anti-spatter coating, if used before field touch-up painting.

c. Galvanizing

1. In accordance with CAN/CSA-G164, fully galvanize structural steel lintels, masonry shelf angles and other steel materials outside the building vapour barrier including connection material and inserts.
2. Where galvanizing process distorts the members, submit procedures for review by the Consultant and make good to tolerances noted in the contract documents.

d. Cold Weather Protection - During cold weather, protect members from damage due to water freezing in confined areas.

e. Corrosion

1. Protect milled surfaces to prevent corrosion prior to erection.

3.4 QUALITY CONTROL

a. Quality Control: As specified in Section 01 45 00 Quality Requirements.

b. Visual Inspection

1. As a minimum, carry out visual inspection of all shop and field welds in accordance with CSA W59.

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- c. Non-Destructive Testing
1. Non-destructive testing to be carried out by radiography, magnetic particle or ultra sonic methods, whichever is more appropriate.
 2. In addition to visual inspection, the Contractor is to include the following requirements for non-destructive testing (NDT):
 3. Any deficient welds identified by means of NDT, shall be repaired at the Contractor's expense.
 4. Welds found deficient in dimensions, but not in quality may be enlarged by additional welding. Any weld found deficient in quality shall be removed by chipping or gouging and the weld shall be remade.
 1. Include for full NDT of all shop welded connections in the first two trusses fabricated.
 2. Include for full NDT of all shop welded splices.
- d. General
1. Bring to the attention of the Consultant any defects in the work or departures from the Contract Documents which may occur during construction. The Consultant will decide upon corrective action and give recommendations in writing.
 2. The Consultant's general review during construction and inspection and testing by Independent Inspection and Testing Companies reporting to the Consultant are both undertaken to inform the Owner of the Contractor's performance and shall in no way augment the Contractor's quality control or relieve the Contractor of contractual responsibility.

3.5 NOTIFICATION

- a. Prior to commencing significant segments of the work, give the Consultant and Independent Inspection and Testing Companies appropriate notification so as to afford them reasonable opportunity to review work previously completed. Failure to meet this requirement may be cause for the Consultant to classify the work as defective.

3.6 INSPECTION AND TESTING

- a. Inspection and Testing: As part of Section 01 45 00 Quality Requirements.
- b. The Owner will appoint an Independent Inspection and Testing Companies to make inspections or perform tests as the Consultant directs. The Independent Inspection and Testing Companies shall be responsible only to the Consultant, and shall make only such inspections or tests as the Consultant may direct. Contractor will pay for services from cash Allowances.
- c. When defects are revealed, the Consultant may request, at the Contractor's expense,

additional inspection or testing to ascertain the full extent of the defect.

- d. Inspection and testing may include the non-destructive testing of the full butt welds.

3.7 DEFECTIVE MATERIALS AND WORK

- a. Where evidence exists that defective work has occurred or that work has been carried out incorporating defective materials, the Consultant may have tests, inspections or surveys performed, analytical calculations of structural strength made and the like in order to help determine whether the work must be replaced. Tests, inspections or surveys or calculations carried out under these circumstances will be made at the Contractor's expense, regardless of their results, which may be such that, in the Consultant's opinion, the work may be acceptable.
- b. All testing shall be conducted in accordance with the requirements of the Ontario Building Code, except where this would, in the Consultant's opinion, cause undue delay or give results not representative of the rejected material in place. In this case, the tests shall be conducted in accordance with the standards given by the Consultant.
- c. Materials or work that fail to meet specified requirements, may be rejected by the Consultant whenever found at any time prior to final acceptance of the work regardless of previous inspection. If rejected, defective materials or work shall be promptly removed and replaced or repaired to the satisfaction of the Consultant, at no expense to the Owner.

END OF SECTION

PART 1: GENERAL

1.1 WORK INCLUDED

- a. Supply and install all steel deck, closures.

1.2 RELATED WORK SPECIFIED ELSEWHERE

- a. Structural Steel – Section 05 12 00.
- b. Roofing, Flashing and Sheet Metal – Division 7.

1.3 APPLICATION STANDARDS

- a. Conform with the Ontario Building Code, Regulation 350/06 as amended by O. Reg. 423/06, and as amended by O. Reg. 206/08, and any applicable acts of any authority having jurisdiction and the following, except as specifically varied herein (latest editions):
 - 1 S136 Cold Formed Steel Structural Members.
 - 2. W47.1 Certification of Companies for Fusion Welding of Steel Structures.
 - 3. W59 Welded Steel Construction (Metal Arc Welding).
 - 4. Manufacturing Standards, Canadian Sheet Steel Building Institute.
- b. Where there are differences between the specifications and the drawings and the standards, codes or acts, the most stringent shall govern.

1.4 SHOP DRAWINGS

- a. Examine all drawings forming a part of this contract and conform to the requirements of all such drawings.
- b. Prepare shop drawings to supplement the Consultant's drawings. Report any discrepancies in the Contract Drawings to the Consultant. Make allowances for openings where these are not detailed on the drawings.
- c. Shop drawings shall show the position, extent, type and arrangement of the units, their relationship to other materials, depths, thicknesses, connections and accessories.
- d. The Consultant's review of shop drawings will not relieve the Contractor from his responsibility for ensuring that his work is complete, accurate and in accordance with the drawings and specifications.
- e. Examine the Mechanical and Electrical Drawings to establish the number, size and location of all openings through the deck.
- f. Submit shop drawings in accordance with the General Conditions.

1.5 **COORDINATION**

- a. Co-ordinate the work of this Section with the scheduling in accordance with the General Conditions.
- b. Co-ordinate the work of this Section with the work of Section 05 12 00, "Structural Steel" to ensure a continuous erection procedure.
- c. Supply and erect steel deck at such a rate and in proper sequence so that the schedule is maintained.

1.6 **STORAGE & HANDLING**

- a. Exercise care in storing, handling and placing the steel deck units to prevent damage likely to impair the adequacy or appearance of the material in the finished structure.
- b. Replace or correct damaged material to the approval of the Consultant.

PART 2: PRODUCTS

2.1 **MATERIALS**

- a. Steel Sheets: for the fabrication of deck sections, metal closures, straps and flashings in accordance with A.S.T.M. Standard A653M SQ Grade 230.
- b. Zinc Coating: All exterior deck and roof deck Class Z275 applied before forming by a hot dipping process for roof deck. All interior composite deck ZF75 (Vicwest Galvanneal) unless otherwise noted on plans.
- c. Metal Roof Deck: 38 mm (1-1/2") deep with flutes centred at 150 (6") o.c. minimum galvanneal core thickness .048" manufactured in accordance with C.S.S.B.I. Standards. P-3606 by CANAM, or as otherwise noted on Structural Drawings.
- d. Composite Floor/Roof Deck: manufactured in strict accordance with CSSBI Standards: and meeting the required ULC Fire Resistance Rating F904 for 2 hr. unprotected deck 3" (75 mm) deep – minimum core thickness 0.91 mm HB306 Galvanneal Vickwest or approved equal.
- e. Finishing Channels: 1.52 mm (0.060") (minimum) thickness.
- f. Flashing Sheets: 1.22 mm (0.048") (minimum) thickness.
- g. Deck Edge Supports: Steel angle 40x40x3 (1-1/2" x 1-1/2" x 1/8"), or as otherwise noted on Structural Drawings.

2.2 **FABRICATION**

- a. Provide sheet steel cover plates as noted on the drawings and to cover gaps where deck units abut or change direction.

- b. Provide steel angle 40x40x3 deck edge supports to close between deck units and spandrel members, and deck edge supports (as required) to maintain the integrity of the diaphragms.

PART 3: EXECUTION

3.1 EXAMINATION

- a. Examine and obtain all necessary measurements of previously executed work which may affect the work of this section.
- b. Report any discovered discrepancies to the Consultant so that instructions can be given for any remedial action.

3.2 ERECTION

- a. Erection of steel deck shall be performed by the erection forces of the manufacturer. Sub-letting of the erection of these materials will not be allowed without the prior written consent of the Consultant.
- b. Place and align units in their final position on the supporting steel structure prior to making permanent connections.
- c. Provide any temporary connection of the deck to the supporting structural steel to prevent displacement of the deck due to construction operations, wind forces, etc., which may result in a hazardous condition.
- d. Provide permanent connection of the new steel deck to the supporting steel structure as per Structural drawings.

Ensure that welds penetrate through deck and flashing sheets where double thickness occurs.
- e. Exercise care to avoid burning through joist chords. Damaged joist chords will be repaired under the direction of the Engineer at no additional cost to the Owner.
- f. Clinch all male and female side laps mechanically at 450 o.c. (18") maximum, unless noted otherwise on drawings.
- g. Cut and reinforce, where necessary, all holes through the roof deck where secondary structural framing is not specifically shown around the openings. Exact location of openings will be established on site by the trades concerned.
- h. Install all flashing plates, closures and finishing channels.
- i. If low flute of deck does not 'close' with perimeter angle, provide continuous L 40 x 40 x 3 welded to vertical leg of perimeter angle to provide welding base for deck.
- j. Clean the new deck of all debris, welding rods, oil and grease or other materials likely to have a harmful effect on the application of the roofing system.

3.3 FIELD PAINTING

- a. Field paint with compatible zinc rich paint, all welds, burns, scratches or other defects of the zinc finish of the deck units for the roof system.

3.4 REPAIR AND MAKE GOOD

- a. Just prior to installation of roofing, review all areas of roof deck for damage which affects the structural capacity or performance of the roofing system.
- b. Repair and make good all such damage to restore the deck.

3.5 FIELD QUALITY ASSURANCE

- a. All welding to be carried out by experienced 'deck' welders holding current C.W.B. certification for 'deck' welding and currently employed by a Division 1 or 2 company.

3.6 CLEAN-UP

- a. Remove any excess materials, debris from site.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Read and conform to:
 - .1 The Contract CCDC 2-2008, Stipulated Price Contract as amended,
 - .2 Division 1 requirements and documents referred to therein.
- .2 This Section applies to and governs the work of all Sections of Division 21.
- .3 The technical Sections of this Division are generally divided into units of work for the purpose of ready reference. The division of the work among subcontractors is not the Consultant's responsibility and the Consultant assumes no responsibility to act as an arbiter and/or to establish subcontract limits between any Sections of the work.
- .4 The specifications are integral with the drawings which accompany them. Neither is to be used alone. Any item or subject omitted from one but implied in the other is fully and properly required.
- .5 Wherever differences occur in the tender documents, the most onerous condition governs. Base the bid on the most costly arrangement.

1.2 DEFINITIONS

- .1 The following are definitions of words found in this specification and on associated drawings under this Division:
 - .1 "Concealed" locations hidden from normal sight in furred spaces, shafts, ceiling spaces, walls, and partitions.
 - .2 "Exposed" mechanical work normally visible to building occupants.
 - .3 "Furnish" (and its derivatives) has the same meaning as the term "Supply".
 - .4 "Install" (and its derivatives) - receive, store and handle at the site, mount and support and connect all required services. Includes adjustment and calibration, testing, commissioning, inspection by authorities having jurisdiction and documentation.
 - .5 "Provide" (and its derivatives) - supply, install in place, connect the associated required services ready for operation, adjust and calibrate, test, commission, warrant, and document. Includes inspection by authorities having jurisdiction.
 - .6 "Supply" (and its derivatives) purchase and deliver to the site for installation. Includes submittals, manufacturer's field inspection and warranty.
 - .7 "Wet" locations exposed to moisture, requiring special materials and arrangement.

1.3 WORK INCLUDED

- .1 Products and methods mentioned or shown in the Contract Documents complete

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- with incidentals necessary for a complete operating installation. Provide all tools, equipment and services required to do the work.
 - .2 Cutting and patching of new or existing work
 - .3 Identification of piping and valves
 - .4 Take such measures and include in Bid Price for the proper protection of the existing building and its finishes at all times during alterations and construction of the new addition. Coordinate this protective work with all trades.
 - .5 Take measures to prepare and execute a fire watch plan during construction period when the sprinkler system is not operational.
 - .6 Verify the correct operation of each sprinkler zone provided and/or altered and obtain the Owner's approval prior to starting and/or returning to operation.

1.4 SUBMITTALS

- .1 Approval Drawings: Prepare and submit stamped sprinkler drawings necessary for approval to authority having jurisdiction and obtain two (2) copies of approved drawings for retention by Consultant prior to commencement of work under this Division.
- .2 Shop Drawings: Prepare and submit two (2) copies of stamped shop drawings indicating the relocation/alteration and addition of sprinkler heads for each individual zone to the Consultant for review. The Consultant will return one copy, marked with comments and his review stamp as he deems appropriate. Prepare the necessary number of copies of the returned set and distribute to the Owner, the Prime Consultant, the General Contractor, the site, and to subcontractors and suppliers.
 - .1 Clearly indicate manufacturer's and supplier's names, catalogue model numbers, details of construction, accurate dimensions, capacities, and performance. Prior to submission check and certify as correct, shop drawings and data sheets. Do not order equipment until a copy of the shop drawings, reviewed by Consultant, has been returned to Contractor.
 - .2 Clearly indicate the sprinkler zone, hazard type, pipe routing, location of sprinkler heads, type of sprinkler heads, method of support and anchor point forces and locations for each piece on shop drawings.
 - .3 The Consultant will not review shop drawings that fail to bear the Contractor's stamp of approval or certification.
 - .4 Read the following in conjunction with the wording on the shop drawing review stamp applied to each and every drawing submitted:
 - .1 *"This review by the Consultant is for the sole purpose of ascertaining conformance with general design concept. This review shall not mean that the Consultant approves the detail design inherent in the shop drawings, responsibility for which shall remain with the Contractor submitting same, and such review shall not relieve the Contractor of his responsibility for errors or omissions in the shop drawings or of his responsibility for meeting all requirements of the Contract Documents. The Contractor is responsible for dimensions to be confirmed and correlated at the*

job site, for information that pertains solely to fabrication processes or to techniques of construction and installation and for coordination of the work of all sub trades."

- .3 As-Built Records: Prepare and submit complete as-built records prior to Substantial Performance of the Contract. Refer to paragraph 3.3 and to Division 1 for requirements.
- .4 Requests for Shut-Down: Obtain permission for systems shut-down and/or service interruption from the Owner prior to disruption of any system or service in use by the Owner. Employ the Owner's standard form of request where available. Refer to Division 1 for additional requirements.
- .5 Requests for Start-up: Obtain permission from the Owner to start-up or to return to service any item of equipment, system or service installed new or previously shut-down. Refer to Division 1 for additional requirements.
- .6 Contractor's Material and Test Certificates: Prepare and submit certificates for each system installed. Where certificates are prescribed by regulations, codes or standards ensure they conform to the requirements of those documents (eg. NFPA-standards). Include a copy of each certificate in the Operation and Maintenance manual. Certificates shall include the following:
 - .1 description of the system (description and type),
 - .2 description of the tests conducted, and results observed, including re-testing, where necessary,
 - .3 description of any corrective measures undertaken,
 - .4 description of materials used (pipe and fittings),
 - .5 list of witnesses for each test conducted,
 - .6 date system left ready for service,
 - .7 signature of installing Contractor.
- .7 Maintenance Data and Operating Instructions
 - .1 Submit three (3) copies of Operation and Maintenance Manual individually bound in hard backed three-ring binders.
 - .2 Ensure the binder spines have typewritten lettering as follows:
OPERATION & MAINTENANCE MANUAL
for
TCDSB St. Antoine Daniel Catholic School
"Insert date of submission"
Division 21 00 00
 - .3 Provide a list of names, addresses and telephone numbers of equipment suppliers, installing contractors, general contractors, architect and Consultant. Include special telephone numbers for service departments on normal and emergency call basis.
 - .4 Provide descriptive literature (shop drawings) of each manufactured item. Include a bill of material with purchase order numbers and vendor's identification of equipment orders for each item.
 - .5 Include copies of start-up reports and checklists and all certificates issued with respect to this contract.
 - .6 Ensure operating instructions include the following:
 - .1 General description of each fire suppression system altered as part of this project.

- .2 Step by step procedure to follow in putting each piece of equipment into service.
- .7 Ensure maintenance instructions include the following:
 - .1 Manufacturer's maintenance instructions for each item of mechanical equipment installed under this Division. Instructions shall include installation instructions, parts numbers and lists, name of supplier and maintenance instructions.
 - .2 Summary list of each item of mechanical equipment.
 - .3 Equipment directory indicating name, model, serial number and nameplate data of each item of equipment supplied, and system with which it is associated.
 - .4 Copy of valve directory.
- .8 As-Built Records: Prepare and submit complete as-built records prior to Substantial Performance of the Contract. Refer to Division 1 for requirements.

1.5 QUALITY ASSURANCE

- .1 Conform to minimum requirements or better of provincial and local codes, where existing, and to requirements of local inspection authorities for execution of work under this Division.
- .2 Ensure materials supplied under this Division conform to minimum requirements and recommendations or better of applicable standards of the following:
 - .1 NFPA National Fire Protection Association
 - .2 OBC Ontario Building Code
 - .3 OFC Ontario Fire Code
 - .4 OFM Ontario Fire Marshall
- .3 Use latest editions and amendments in effect on date of bid call subject to requirements of OBC.
- .4 Arrange and pay for permits and inspections by authorities having jurisdiction, required in the undertaking of this Division. Make modifications required by authorities.
- .5 All tradesmen employed on the project shall hold valid trade certificates/licenses and shall make a copy available for review by the Consultant and/or Owner when requested.

1.6 JOB CONDITIONS

- .1 Visit site and examine existing conditions which may affect work of this Division.
- .2 Examine all Contract Documents to ensure that work of this Division may be satisfactorily completed.
- .3 Notify Consultant upon discovery of conditions which adversely affect work of this Division. No allowance will be made after letting of contract for any expenses incurred through failure to do so.
- .4 Submission of a bid confirms that the Contract Documents and site conditions are accepted without qualifications, unless exceptions are specifically noted in the Bid.

1.7 WARRANTY

- .1 Refer to General Conditions.
- .2 Arrange with each manufacturer/supplier to extend warranties as necessary to coincide with warranty period or those periods specified.

2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- .1 Ensure materials and equipment provided under this Division are new and free from defects and bear labels of approval as required by codes referred to in this Division and/or by inspection authorities.
- .2 Ensure manufacturers and suppliers of equipment or materials under this Division determine if their products are composed of any hazardous materials. If they are, the products are suitably labeled and supplied with Material Safety Data sheets. Obtain the Owner's approval in writing to bring hazardous materials onto the site prior to doing so.
- .3 When utilizing any products that are hazardous, keep Material Safety Data sheets on file at the job site and present them to anyone requesting this information. When transferring hazardous materials from original container into other containers, provide Workplace Labels on such containers.

2.2 ACCEPTABLE PRODUCTS

- .1 First item named or specified by catalogue number meets specifications regarding performance, quality of material and workmanship, and is acceptable to the Consultant.
- .2 Items, other than first named, meeting specifications regarding quality of materials and workmanship are acceptable to the Consultant, only, if they also meet performance and/or capacities specified and can be accommodated within the space allotted.
- .3 General approval indicated by inclusion of other manufacturers named is subject to final review of shop drawings, performance data and test reports.

2.3 EQUIVALENTS AND ALTERNATIVES

- .1 Suppliers wishing approval for additional equipment items or alternatives as equivalent to those specified **must submit complete description, technical and performance data to the Toronto Catholic District School Board's (TCDSB) Procurement Services Department Representative at least twelve (12) working days prior to Bid closing date.** Such equivalent equipment, if accepted, to conform to specifications with regard to all details, accessories, modifications, features and performance. Deviations from specifications must be stated in writing at time of submission for approval.
- .2 Bid Prices shall include only products specified or approved equivalents.

2.4 SUBSTITUTIONS DURING PROGRESS OF WORK

-
- .1 Refer to Section 01 25 00.

2.5 CONSULTANT'S REVIEW

- .1 The consultants will review and evaluate unsolicited alternatives and substitutions proposed by the Contractor. Such review and evaluation work will be undertaken by the Consultant on an additional fee basis. The Contractor shall reimburse the Owner for all costs associated with such reviews and evaluations.
- .2 The Contractor shall also reimburse the Owner for any and all costs incurred in updating Contract Documents to reflect such changes.

3 EXECUTION

3.1 RELATIONSHIP WITH OTHER TRADES

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

3.2 INSTALLATION REQUIREMENTS

- .1 The Consultant's drawings and instructions govern the location of all items. Prepare fully coordinated installation drawings prior to installation.
- .2 Install equipment neatly to the satisfaction of the Consultant. Unless noted otherwise install products and services to follow building planes. Ensure installation permits free use of space and maximum headroom.
- .3 Do not use powder activated tools except as permitted by the Prime Consultant and the Owner's workplace health and safety policies.

3.3 CONTRACT DRAWINGS

- .1 The drawings of this Division are performance drawings and indicate general arrangement of the work. They are diagrammatic except where specific details are given.
- .2 Obtain accurate dimensions from the architectural and structural drawings, or by measurement. Location and elevation of services are approximate. Verify them before construction is undertaken.
- .3 Make changes where required to accommodate structural conditions, (beams, columns, etc.). Obtain Consultant's approval before proceeding.
- .4 Adjust the location of materials and/or equipment as directed without adjustment to contract price, provided that the changes are requested before installation and do not affect material quantity. **Note that sprinkler heads and/or piping may be relocated up to 10 feet (3 m) in any direction without a change to the contract price.**
- .5 Note that the layout and orientation of the ceiling outlets on the architectural reflected ceiling drawings may differ from that shown on the mechanical drawings. Make the installation in accordance with the latest architectural ceiling drawings. Provide the equipment as specified and/or shown on the documents of this Division.

- .6 The drawings of this Division are intended for tender pricing. The quantities and quality to be included in the bid price shall be based on the layout and specifications as shown on the mechanical documents. If there is a difference in quantity between the architectural and drawings of this Division, base the contract price on the greater quantity.
- .7 Prepare installation (construction) drawing to reflect the latest architectural ceiling layout.

3.4 EXTRAS AND CREDITS

- .1 Accompany all price submissions requested by Consultant for extra work, or work to be deleted, with a complete cost breakdown as follows:
 - .1 Materials, quantities and unit costs including any applicable contractors trade discount clearly identified.
 - .2 Labour hours and unit costs.
 - .3 Total materials and labour costs.
 - .4 Overhead and profit mark-ups in accordance with the General Conditions of the Contract.

3.5 INSTRUCTION

- .1 Instruct and familiarize Owner's operating personnel with the various mechanical systems. Arrange instruction for each system separately.
- .2 Provide instruction for each system on two separate occasions, coordinated with the Owner's staff operating schedule, in order that interested personnel may arrange to attend.
- .3 Ensure each instruction period includes, but is not limited to the following;
 - .1 a classroom seminar with operating manuals, product and system drawings and such other audio/visual aids as may be appropriate,
 - .2 instruction during the classroom seminar by the manufacturer's representative regarding the proper operating and maintenance procedures for each item of equipment,
 - .3 demonstration of the proper operating procedures for each item of equipment,
 - .4 explanation of the purpose and function of all safety devices provided,
 - .5 demonstration of all measures required for safe and proper access for operation and maintenance.
- .4 Provide a period of follow-up instruction (on two occasions) approximately one month after completing Owner's instruction to clarify and reinforce earlier instructions.
- .5 Submit a letter from the Owner's management staff indicating the instruction has been given satisfactorily to the Consultant prior to substantial completion of the project.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 21 01 01.

1.2 COMMON WORK RESULTS

- .1 Section 21 05 00 applies to and governs all work of Division 21.

1.3 REFERENCE STANDARDS

- .1 Provide all work in accordance with requirements of Regulatory Agencies and conform to:
 - .1 Local and district by-laws, regulations and published engineering standards.
 - .2 the Ontario Building Code as amended,
 - .3 Regulations for Construction Projects under The Occupational Health and Safety Act.
 - .4 Fire Code made under the Fire Marshal's Act.
- .2 Conform to following CSA Standards:
 - .1 CSA B242 Groove and Shoulder Type: Mechanical Pipe Couplings.
 - .2 CAN1-B149.1 Natural gas and propane installation code.
 - .3 CSA B64.1 Manual for the Selection and Installation of Backflow Prevention Devices
 - .4 CSA B64.1 Manual for the Maintenance and Field Testing of Backflow Prevention Devices.
- .3 Conform to following National Research Council Canada publications:
 - .1 National Building Code of Canada and Supplements to National Building Code of Canada
 - .2 National Fire Code of Canada.
- .4 Provide work where indicated in conformance with guide Specification of the Victaulic System for Building Services, G-100.
- .5 Conform to following National Fire Protection Association standards;
 - .1 NFPA 13 - Installation of Sprinkler Systems.
 - .2 NFPA 14 - Installation of Standpipe, Private Hydrants, and Hose Systems.
 - .3 NFPA 10 - Standard for Portable Fire Extinguishers.

1.4 SUBMITTALS

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

2 PRODUCTS

2.1 1 PIPING SPECIALTIES

- .1 Cast brass, pressure, copper to copper unions shall be used with seamless copper tubing smaller than 3" (75 mm).
- .2 Cast brass flanges shall be used with seamless copper tubing, type L for tubing

- 3" (75 mm) and larger.
- .3 Dart type, 125 lb. (860 kPa) black malleable iron unions shall be used with all steel pipe for piping 2-1/2" (65 mm) and smaller.
- .4 Slip-on, 150 lb. (1000 kPa) carbon steel flanges with 1/16" (4 mm) raised face shall be used with all steel pipe for piping larger than 2-1/2" (65 mm).
- .5 Gaskets for joining flanged steel pipe shall be 1/16" (4 mm) Cranite ring type gaskets.
- .6 Piping specialties including backflow preventers, strainers, valves etc. shall be line size unless indicated otherwise on drawings.

2.2 ADHESIVES, SEALANTS, PAINTS AND COATINGS

- .1 Adhesives, Sealants, Paints and Coatings: Use only low VOC emitting materials meeting following criteria;
 - .1 Paint for Mechanical Identification: maximum VOC emission of 250g/L
 - .2 Touch-Up Paint: maximum VOC emission of 250g/L
 - .3 Zinc-Rich Primer: maximum VOC emission of 250g/L
 - .4 Adhesives for Mechanical Identification: maximum VOC emission of 70g/L
 - .5 Sealants for service penetrations: maximum VOC emission of 650g/L clear and 350 g/L pigmented
 - .6 Sealants for Firestopping: max. VOC emission of 650g/L clear and 350 g/L pigmented
 - .7 Acrylic Sealant for supports and anchors: maximum VOC emission of 250g/L
 - .8 Insulation Vapour Barrier Lap Adhesive: maximum VOC emission of 80g/L
 - .9 Insulation Joint Sealer: maximum VOC emission of 250g/L
 - .10 Insulation Vapour Barrier Mastic: maximum VOC emission of 400g/L
 - .11 Flame Retardent Adhesive: maximum VOC emission of 650g/L clear and 350 g/L pigmented

3 EXECUTION

3.1 INSPECTION

- .1 Inspect installed work of other trades and verify that such work is complete to point where work under this Division may properly commence.
- .2 Verify that work of this Division may be executed in accordance with pertinent codes and regulations, specifications, drawings, and referenced standards.
- .3 Review drawings and verify dimensions at the site. Report discrepancies immediately to Consultant before proceeding with any construction work or shop drawings.

3.2 PREPARATION

- .1 Existing services and equipment shall be relocated or removed to suit new construction and renovation work.
- .2 Services that are no longer required shall be removed or cut back and capped to

- the satisfaction of Consultant.
- .3 Obtain written authorization from Consultant for renovation work that is not specifically indicated.
- .4 Where modifications or connections to existing systems require shutdown of the system the Contractor shall submit a request for system shutdown describing the system or part to be shutdown, the duration of the shutdown, the work planned and steps to be taken to reinstate the system to full operation. The request shall be submitted in the format stipulated by the Owner.
- .5 All work required to prepare systems for shutdown and/or re-instatement, such as draining, chemical treatments, and re-filling shall be included in the Bid Price.

3.3 PIPING INSTALLATION - ABOVE GROUND

- .1 Cooperate with other trades whose work affects or is affected by work of this Division to ensure satisfactory installation and to avoid delays. Provide all materials to be built-in such as sleeves, anchors, etc., together with accurate dimensions or templates, promptly.
- .2 Layout all work accurately, installing piping parallel to lines of building.
- .3 Install piping, wherever possible, in partitions and above ceiling. Do not install piping in outside walls unless so shown on drawings. Wrap uninsulated piping in masonry walls with building paper.
- .4 Install concealed piping close to building structure to minimize furring dimensions.
- .5 Provide adequate space around piping to facilitate application of insulation.
- .6 Use dielectric couplings where piping of dissimilar metals connect.
- .7 Where piping passes through concrete floors, or walls, sleeves shall be sized to permit the pipe to expand freely without binding or crushing pipe insulation.
- .8 Where branch pipes are welded into main without the use of "T" connections, torch cut openings must be cut true, bevelled and filed smooth. Branch pipes must not be allowed to project inside of main pipe. Openings must not be cut large enough to permit entry of welding metal and slag within the pipe.

3.4 PIPING JOINTS

- .1 Make joints in piping installed under this Division using persons familiar with the particular materials being used and in accordance with NFPA Standards, manufacturer's instructions, and as specified herein.
- .2 Use only welder and/or brazer operators, with a valid identification card, as issued under The Boiler and Pressure Vessels Act, to make joints in Registered Piping Systems.
- .3 Carefully ream joints in threaded pipe and paint with approved graphite type joint sealer on male connections only. Make connections with proper wrench to suit pipe size. Where leaks occur, the joint shall be disassembled and corrected if possible, or replaced. Over-tightening, caulking or peening will not be acceptable.
- .4 When using Victaulic Grooved Piping Method: make joints in grooved piping with couplings and gaskets in accordance with Victaulic Company of Canada Ltd, General Catalogue G-100, latest edition. Cut or roll grooves using tools

- specifically designed for that purpose.
- .5 Use butt welding and/or schedule 40 carbon steel welding fittings to join sections of steel piping with welding ends.

3.5 FLUSHING AND CLEANING

- .1 Flush water mains in accordance with procedures established by NFPA 24.
- .2 Thoroughly flush all other piping installed by this Division.
- .3 Remove, clean and replace all strainers in systems after flushing.
- .4 Thoroughly clean and lubricate all equipment and leave all items in perfect order ready for operation.

3.6 ELECTRICAL WIRING

- .1 Conform to requirements of Division 26 for all wiring included in Division 21, including pre-wired equipment provided by Sections under Division 21.
- .2 Ensure that all pre-wired electrical equipment is CSA approved. Arrange and pay for special approval where this is not possible.
- .3 Coordinate all wiring requirements with other Divisions. Line voltage wiring from power distribution panels to starters and from starters to motors will be provided under Division 26. All other field wiring for equipment shall be included under Division 21.

3.7 EQUIPMENT TESTING AND INSPECTION

- .1 Test operation of equipment installed under this Division according to instructions in appropriate articles of this Division. Make any required adjustments or replacements to ensure equipment is operating as intended. Retest equipment requiring adjustment or replacement.
- .2 Pay all fuel consumption charges for equipment under testing and during commissioning.
- .3 Arrange and pay for inspections by authorities as required by code and complete any changes or alterations required by such inspections.
- .4 Conduct tests in the presence of:
 - .1 Authorized inspector(s) for authorities having jurisdiction.
 - .2 The Consultant.
 - .3 The Owner's Representative.
- .5 Notification must be given at least 48 hours in advance of tests being conducted, to all persons required to be present.

3.8 PIPING SYSTEMS TESTING AND INSPECTION

- .1 Prior to tests, isolate all equipment or other parts which are not designed to withstand test pressures.
- .2 Test all piping at the completion of roughing-in, before connecting to existing systems, and prior to concealment.
- .3 Make tests, that are required by any authority having jurisdiction, in the presence

- of the authority's authorized inspector and shall be certified by him.
- .4 Conduct tests in the presence of:
 - .1 Authorized inspector(s) for authorities having jurisdiction.
 - .2 The Owner's Representative
- .5 Notification must be given at least 48 hours in advance of tests being conducted, to all persons required to be present.
- .6 Repair all leaks exposed during testing and retest. If defects in pipe or fittings are discovered in the system, they shall be removed and replaced.
- .7 Certify tests not required by authorities having jurisdiction.

3.9 PROTECTION

- .1 Protect finished and unfinished work by tarpaulins, or other covering, from damage due to execution of work under this Division.
- .2 Repair to satisfaction of Consultant, damage to building resulting from failure to provide such protection.

3.10 CUTTING AND PATCHING

- .1 Include cutting and patching as required in execution of work under respective Sections of this Division.
- .2 Holes through the structure will not be permitted without written approval of the Consultant. Any and all openings required through the completed structure must be clearly and accurately shown on a copy of the relevant structural drawing(s). Exact locations, elevations and size of the proposed opening must be identified well in advance of the need for the work.
- .3 All sleeved or formed openings through the structure must be shown on sleeving drawings and must be approved by the Structural Consultant prior to construction.
- .4 The Contractor shall conduct exploratory work including x-ray of the existing structure, shall mark the location of embedded reinforcements, anchors, conduits and piping on exposed surfaces of adjacent floors and/or walls and shall pay all associated costs.
- .5 Reinforcing shall not be cut or modified without prior approval of the Structural Consultant. Should reinforcement be cut without such prior approval, the cost of any additional reinforcement deemed necessary by the Structural Consultant shall be the responsibility of this Contractor.
- .6 Alternative imaging techniques are subject to the approval of the Structural Consultant.
- .7 Ensure that cutting and patching of roofs and reinforced concrete structures is executed by specialists familiar with the materials affected, and is performed in a manner to neither damage nor endanger the work. Coordinate and supervise such cutting and patching.
- .8 Maintain the integrity of fire rated assemblies where they are pierced by ducts and pipes.
- .9 Make good surfaces affected by this work and repair finish to satisfaction of Consultant.
- .10 Stop work immediately upon discovery of any hazardous material and report

discovery to the Owner and Consultant. Obtain instruction prior to proceeding with the work.

3.11 SUPPORT AND ATTACHEMENT

- .1 Support piping and equipment from load bearing structures such as beams, joists, reinforced concrete slabs and concrete block walls, and do not support from or attach to steel roof deck and/or wall or ceiling finishes.

3.12 DISSIMILAR METALS

- .1 Separate dissimilar metals in order to prevent galvanic corrosion.
- .2 Provide gaskets or shims of approved materials to avoid electrolytic action.
- .3 Use dielectric unions and/or flanges where piping of dissimilar metals are connected.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 21 01 01.

1.2 SECTION INCLUDES

- .1 Pipe and equipment hangers and supports.

1.3 REFERENCES

- .1 ASME B31.5 - Refrigeration Piping and Heat Transfer Components.
- .2 ASTM F708 - Design and Installation of Rigid Pipe Hangers.
- .3 MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
- .4 MSS SP69 - Pipe Hangers and Supports - Selection and Application.
- .5 MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices.
- .6 UL 203 - Pipe Hanger Equipment for Fire protection Service.

1.4 SUBMITTALS

- .1 Section 21 01 01: Procedures for submittals.
- .2 Shop Drawings: Indicate system layout with location and detail of trapeze hangers.
- .3 Product Data: Provide manufacturers catalogue data including load capacity.
- .4 Design Data: Indicate load carrying capacity of trapeze, multiple pipes, and riser support hangers.
- .5 Manufacturer's Installation Instructions: Indicate special procedures and assembly of components.

1.5 REGULATORY REQUIREMENTS

- .1 Conform to CSA B-51 for support of piping.

2 PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

- .1 Manufacturers:
 - .1 Anvil
- .2 Sprinkler Piping:
 - .1 Conform to CSA B-51 and ASME B31.9.
 - .2 Hangers for Pipe Sizes 1/2" to 1-1/2" (13 to 38 mm): Carbon steel, adjustable swivel, split ring.
 - .3 Hangers for Cold Pipe Sizes 2" (50 mm) and Over: Carbon steel, adjustable, clevis.
 - .4 Hangers for Hot Pipe Sizes 2" to 4" (50 to 100 mm): Carbon steel, adjustable, clevis.
 - .5 Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.

2.2 ACCESSORIES

- .1 Hanger Rods: galvanized, carbon steel continuous threaded.
- .2 Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

3 EXECUTION

3.1 INSTALLATION

- .1 Install to manufacturer's instructions and best trade practises.

3.2 INSERTS

- .1 Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- .2 Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
- .3 Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.

3.3 PIPE HANGERS AND SUPPORTS

- .1 Support horizontal piping as scheduled.
- .2 Install hangers to provide minimum 1/2" (13 mm) space between finished covering and adjacent work.
- .3 Place hangers within 12" (300 mm) of each horizontal elbow.
- .4 Use hangers with 1-1/2" (38 mm) minimum vertical adjustment.
- .5 Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- .6 Design hangers for pipe movement without disengagement of supported pipe.
- .7 Prime coat exposed steel hangers and supports. Hangers and supports located in suspended ceiling spaces are not considered exposed.

3.4 SCHEDULES

- .1 Imperial Measure (IP)

Pipe Size (in)	Rod Diameter (in)	Support Spacing (Ft)	
		Steel Pipe	Copper Tube
1/2	3/8	7	6
3/4	3/8	7	6
1	3/8	7	6
1-1/4	3/8	7	6
1-1/2	3/8	9	8

2	3/8	10	9
2-1/2	3/8	12	10
3	3/8	12	10

.2 Metric Measure (SI)

Pipe Size (mm)	Rod Diameter (mm)	Support Spacing (m)	
		Steel Pipe	Copper Tube
13	10	2.1	1.8
20	10	2.1	1.8
25	10	2.1	1.8
32	10	2.1	1.8
38	10	2.7	2.4
50	10	3	2.7
65	10	3.6	3
75	10	3.6	3

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 21 01 01

1.2 SECTION INCLUDES

- .1 Portable Fire Extinguishers
- .2 Fire Extinguisher Cabinets
- .3 Fire Extinguisher Brackets

1.3 REFERENCES

- .1 FM - Factory Mutual System - Approval Guide.
- .2 NFPA 10 - Portable Fire Extinguishers.
- .3 ULC - Fire Protection Equipment Directory.

1.4 SUBMITTALS FOR REVIEW

- .1 Section 21 01 01
- .2 Product Data: Provide manufacturers literature including general assembly, type and rating of extinguishant.

1.5 SUBMITTALS AT PROJECT CLOSEOUT

- .1 Refer to section 21 01 01
- .2 Project Record Documents: Record actual locations of components and accessories.
- .3 Maintenance Data: Include manufacturers literature, cleaning procedures, replacement parts lists, and repair data for pumps, drivers and controllers.

1.6 QUALITY ASSURANCE

- .1 Perform Work to NFPA 10
- .2 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

1.7 REGULATORY REQUIREMENTS

- .1 ULC listed and labelled
- .2 Rated and identified in conformance with CAN/ULC S508, "Rating and Fire Testing of Fire Extinguishers".

2 PRODUCTS

2.1 GENERAL

- .1 Manufacturers

- .1 National Fire Equipment
- .2 Kent

2.2 MULTI-PURPOSE DRY CHEMICAL

- .1 Type: multi-purpose (ABC) type, dry chemical
- .2 Size: 5 lb. (2.27 kg)
- .3 Rating: minimum 3A:10Bc.

2.3 CABINETS

- .1 Fully Recessed
 - .1 Tub: 18 ga. (1.3 mm) steel tub with white prime painted finish
 - .2 Door & Trim: 14 gauge (2.1 mm) stainless steel, brushed finish
 - .3 Panel: "Lexan" glass
 - .4 Size: to accommodate specified extinguisher
 - .5 Height x Width x Depth: 26-3/4" x 11-3/4" x 5-3/4"
 - .6 Window Material: Tempered Glass
 - .7 Manufacturer: DANA fire extinguisher cabinet Model #7260-DV

3 EXECUTION

3.1 INSTALLATION

- .1 Install to manufacturer's instructions.
- .2 Conform to NFPA 10.
- .3 Locate and secure cabinets plumb and level. Establish top of cabinet (inside horizontal surface) 65" (1675 mm) above finished floor.
- .4 Locate fire extinguisher in cabinet as indicated.
- .5 Install with wall mounting bracket where not installed in cabinets.

3.2 APPLICATIONS

- .1 Provide fire extinguishers where indicated and in conformance with the Ontario Fire Code and NFPA 10.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 22 01 01.

1.2 COMMON WORK RESULTS

- .1 Section 22 05 00 applies to and governs all work of Division 22.

1.3 REFERENCE STANDARDS

- .1 Provide all work in accordance with requirements of Regulatory Agencies and conform to:
 - .1 Local and district by-laws, regulations and published engineering standards.
 - .2 the Ontario Building Code as amended,
 - .3 the Ontario Gas Utilization Code as amended
 - .4 Regulations for Construction Projects under The Occupational Health and Safety Act.
- .2 Conform to following CSA Standards:
 - .1 CSA B242 Groove and Shoulder Type: Mechanical Pipe Couplings.
 - .2 CAN1-B149.1 Natural gas and propane installation code.
- .3 Conform to following National Research Council Canada publications:
 - .1 National Building Code of Canada and Supplements to National Building Code of Canada
 - .2 Canadian Plumbing Code.
- .4 The above documents or portions thereof are referenced within the work of Division 22 and shall be considered part of the requirements of this document as though fully repeated herein.

1.4 QUALIFICATIONS

- .1 Motor manufacturer: Company specializing in manufacture of electric motors for HVAC use, and their accessories, with minimum three years documented product development, testing, and manufacturing experience.
- .2 Firestop Sealant Manufacturer: Company specializing in manufacture of sealants with minimum three years documented product development, testing, and manufacturing experience.
- .3 Firestop components and assemblies shall be ULC listed and tested in accordance with ULC S115 Standard Method of Fire Test for Firestop Systems.

1.5 SUBMITTALS

- .1 Submit shop drawings in accordance with Section 22 01 01.

1.6 DELIVERY, STORAGE, AND HANDLING

- .1 Transport, handle, store, and protect products. Refer to Division 1 requirements as well.

- .2 Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

1.7 WASTE MANAGEMENT & DISPOSAL

- .1 Separate and recycle waste materials in accordance with Division 01 Waste Management and Disposal, and with the Contractor's Waste Reduction Workplan.
- .2 Place materials defined as hazardous or toxic waste in designated containers.
- .3 Ensure emptied containers are sealed and stored safely for disposal away from children.

2 PRODUCTS

2.1 PIPING SPECIALTIES

- .1 Cast brass, pressure, copper to copper unions shall be used with seamless copper tubing smaller than 3" (75 mm).
- .2 Cast brass flanges shall be used with seamless copper tubing, type L for tubing 3" (75 mm) and larger.
- .3 Strainers
 - .1 Manufacturers:
 - .1 S. A. Armstrong
 - .2 Conbraco
 - .2 In copper tubing: Class 250, wye type, bronze, screwed connection, with blind caps, and 1/32" (0.8 mm) perforated stainless steel screen.

2.2 ADHESIVES, SEALANTS, PAINTS AND COATINGS

- .1 Adhesives, Sealants, Paints and Coatings: Use only low VOC emitting materials meeting following criteria;
 - .1 Paint for Mechanical Identification: maximum VOC emission of 250g/L
 - .2 Touch-Up Paint: maximum VOC emission of 250g/L
 - .3 Zinc-Rich Primer: maximum VOC emission of 250g/L
 - .4 Adhesives for Mechanical Identification: maximum VOC emission of 70g/L
 - .5 Sealants for service penetrations: maximum VOC emission of 650g/L clear and 350 g/L pigmented
 - .6 Sealants for Firestopping: max. VOC emission of 650g/L clear and 350 g/L pigmented
 - .7 Acrylic Sealant for supports and anchors: maximum VOC emission of 250g/L
 - .8 Insulation Vapour Barrier Lap Adhesive: maximum VOC emission of 80g/L
 - .9 Insulation Joint Sealer: maximum VOC emission of 250g/L
 - .10 Insulation Vapour Barrier Mastic: maximum VOC emission of 400g/L
 - .11 Flame Retardent Adhesive: maximum VOC emission of 650g/L clear and

350 g/L pigmented

2.3 FIRESTOPPING COMPOUNDS

- .1 Manufacturer: 3M products indicated.
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Dow Corning
 - .2 John Manville
 - .3 Hilti Firestop Systems
- .3 Fire Rated Sealants: intumescent material, synthetic elasomers, capable of expanding up to 8 to 10 times when exposed to temperatures of 250°F (121°C) or higher. ULC listed and labelled.

2.4 TAGS

- .1 Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background colour. Tag size minimum 1-1/2" (40 mm) diameter. OR
- .2 Metal Tags: Brass, aluminum or stainless steel with stamped letters; tag size minimum 1-1/2" (40 mm) diameter with smooth edges.
- .3 Chart: Typewritten letter size list in anodized aluminum frame.

2.5 ACCESS DOORS

- .1 Standard:
 - .1 Minimum 12ga
 - .2 steel, prime coat painted
 - .3 heavy duty fully concealed hinges
 - .4 screwdriver operated, cam latch
- .2 Concealed (Recessed):
 - .1 Minimum 12ga.
 - .2 steel, prime coat painted
 - .3 heavy duty fully concealed hinges
 - .4 screwdriver operated, cam latch
- .3 Fire Rated:
 - .1 Access doors in fire separations or fire rated assemblies: ULC labelled.
 - .2 Refer to architectural drawings for ratings of fire separations and assemblies.
 - .3 Minimum 12ga
 - .4 steel, prime coat painted
 - .5 heavy duty fully concealed frame and hinges
 - .6 screwdriver operated, cam latch

2.6 SLEEVES

- .1 Materials: minimum schedule 20 galvanized steel or cast iron.

2.7 ESCUTCHEONS

- .1 Finish: Polished chrome

2.8 FLASHINGS AND COUNTER FLASHINGS

- .1 Thaler or equivalent mechanical/electrical flashings as recommended for specific purpose.
- .2 Stainless steel flashing sleeve, integral deck flange and EPDM seal.

2.9 PENETRATION SEALS

- .1 Manufacturer: Link-Seal
- .2 Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and nut.

3 EXECUTION

3.1 INSPECTION

- .1 Inspect installed work of other trades and verify that such work is complete to point where work under this Division may properly commence.
- .2 Verify that work of this Division may be executed in accordance with pertinent codes and regulations, specifications, drawings, and referenced standards.
- .3 Review drawings and verify dimensions at the site. Report discrepancies immediately to Consultant before proceeding with any construction work or shop drawings.

3.2 PREPARATION

- .1 Existing services and equipment shall be relocated or removed to suit new construction and renovation work.
- .2 Services that are no longer required shall be removed or cut back and capped to the satisfaction of Consultant.
- .3 Obtain written authorization from Consultant for renovation work that is not specifically indicated.
- .4 Where modifications or connections to existing systems require shutdown of the system the Contractor shall submit a request for system shutdown describing the system or part to be shutdown, the duration of the shutdown, the work planned and steps to be taken to reinstate the system to full operation. The request shall be submitted in the format stipulated by the Owner.
- .5 All work required to prepare systems for shutdown and/or re-instatement, such as draining, chemical treatments, and re-filling shall be included in this Bid Price.

3.3 PIPING INSTALLATION - ABOVE GROUND

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

- .3 Install piping, wherever possible, in partitions and above ceiling. Do not install piping in outside walls unless so shown on drawings. Wrap un-insulated piping in masonry walls with building paper.
- .4 Install concealed piping close to building structure to minimize furring dimensions.
- .5 Provide adequate space around piping to facilitate application of insulation.
- .6 Use dielectric couplings where piping of dissimilar metals connect.
- .7 Where piping passes through concrete floors, or walls, sleeves shall be sized to permit the pipe to expand freely without binding or crushing pipe insulation.
- .8 When using PVC-DWV pipe, provide for expansion and contraction of risers by using ProSet E-Z Flex Coupling in accordance with good engineering practices.

3.4 PIPING JOINTS

- .1 Make joints in piping installed under this Division using persons familiar with the particular materials being used and in accordance with Canadian Plumbing Code, manufacturer's instructions, and as specified herein.
- .2 Use 95/5 Sb.Sn (tin-antimony) solder for joining copper drainage tubing smaller than 4" (100 mm), and for joining copper water tubing installed above grade, and smaller than 4" (100 mm).
- .3 Use silver solder or Silfos for joining copper water tubing installed below grade, and all copper tubing 4 " (100 mm) and larger in size.
- .4 Carefully ream joints in threaded pipe and paint with approved graphite type joint sealer on male connections only. Make connections with proper wrench to suit pipe size. Where leaks occur, the joint shall be disassembled and corrected if possible, or replaced. Over-tightening, caulking or peening will not be acceptable.
- .5 Make joints in cast iron pipe with standard M-J joints in accordance with manufacturer's recommendations and CSA B70.
- .6 When using Victaulic Grooved Piping Method:
 - .1 Make joints in grooved piping with couplings and gaskets in accordance with Victaulic Company of Canada Ltd, General Catalogue G-100, latest edition. Cut or roll grooves using tools specifically designed for that purpose.
 - .2 Use Zero-flex or rigidlok couplings in locations where rigidity is required, in particular in mechanical rooms on coils, headers and pumps.
 - .3 Vic-Boltless couplings may be used.
- .7 Install unions or welding flanges at connections to valves, etc. to facilitate removal.
- .8 Use butt welding and/or schedule 40 carbon steel welding fittings to join sections of steel piping with welding ends.

3.5 FLUSHING AND CLEANING

- .1 Flush and sterilize domestic water mains in accordance with procedures established by AWWA Specification C601.
- .2 Flush new domestic water piping in accordance with Local and Provincial Codes.
- .3 Thoroughly flush all other piping installed by this Division.

- .4 Remove, clean and replace all strainers in systems after flushing.
- .5 Thoroughly clean all equipment and fixtures, lubricate mechanical equipment, and leave all items in perfect order ready for operation.

3.6 EQUIPMENT TESTING AND INSPECTION

- .1 Test operation of equipment installed under this Division according to instructions in appropriate articles of this Division. Make any required adjustments or replacements to ensure equipment is operating as intended. Retest equipment requiring adjustment or replacement.
- .2 Pay all fuel consumption charges for equipment under testing and during commissioning.
- .3 Conduct tests before application of external insulation and before concealment of piping or ductwork.
- .4 Arrange and pay for inspections by authorities as required by code and complete any changes or alterations required by such inspections.
- .5 Conduct tests in the presence of:
 - .1 Authorized inspector(s) for authorities having jurisdiction.
 - .2 The Owner's Representative.
- .6 Notification must be given at least 48 hours in advance of tests being conducted, to all persons required to be present.

3.7 PIPING SYSTEMS TESTING AND INSPECTION

- .1 Prior to tests, isolate all equipment or other parts which are not designed to withstand test pressures.
- .2 Test all piping at the completion of roughing-in, before connecting to existing systems, and prior to concealment, insulation or covering of piping.
- .3 Make tests, that are required by any authority having jurisdiction, in the presence of the authority's authorized inspector and shall be certified by him.
- .4 Conduct tests in the presence of:
 - .1 Authorized inspector(s) for authorities having jurisdiction.
 - .2 The Owner's Representative
- .5 Notification must be given at least 48 hours in advance of tests being conducted, to all persons required to be present.
- .6 Repair all leaks exposed during testing and retest. If defects in pipe or fittings are discovered in the system, they shall be removed and replaced.
- .7 Certify tests not required by authorities having jurisdiction.

3.8 TESTING AND BALANCING

- .1 Allow sufficient time for testing and verification prior to substantial completion. Notify Testing and Balancing Agency on completion of adjusting and balancing of systems.
- .2 Maintain systems in full operation during testing and verification.

3.9 PROTECTION

- .1 Protect finished and unfinished work by tarpaulins, or other covering, from

- damage due to execution of work under this Division.
- .2 Repair to satisfaction of Consultant, damage to building resulting from failure to provide such protection.

3.10 EXCAVATING AND BACKFILLING

- .1 Be responsible for excavation and backfilling necessary for installation of underground work under this Division.
- .2 Excavate with suitable machinery or by hand as may be necessary and as follows:
 - .1 Excavate to the depth and dimensions shown on drawings.
 - .2 Keep excavation free of water by bailing, pumping or a system of drainage as required.
 - .3 Cut and trim banks of excavation evenly, as nearly vertical as possible, and shore if required to prevent caving-in.
 - .4 Keep bottom of excavation clean and clear of loose material. Slope or grade as required.
 - .5 Provide shoring in accordance with The Occupational Health and Safety Act and Regulations for Construction Projects.
 - .6 Notify Consultant immediately in case of encountering any unstable ground, unsuitable for bearing of pipes. Consultant will decide the method of installation of pipes in unstable ground.
 - .7 Inform Consultant immediately if the excavation reveals seepage zones, springs or other unexpected sub-surface conditions which may necessitate revisions to drainage or water supply systems.
- .3 Obtain Consultant's approval prior to commencement of backfilling of trenches. Backfill the trenches carefully to prevent injury to the work and subsequent settlement and execute backfilling generally as follows:
 - .1 provide minimum 6" (150 mm) fine gravel or coarse sand bedding (Class B) or as indicated for the bottom of trenches.
 - .2 backfill above pipe bedding with granular material specified, hand tamp in layers of 6" (150 mm) thickness. Extend backfill 12" (300 mm) above pipe.
 - .3 backfill and consolidate remainder of trench depth below paved or graveled areas with granular Class "B" aggregate in 6" (150 mm) layers to an elevation to allow for thickness of Class "A" aggregate and asphalt pavement.
 - .4 backfill and consolidate remainder of trench depth below sodded or seeded areas with specified granular material or material obtained from site excavation where approved by Consultant, in 9" (225 mm) layers to an elevation 6" (150 mm) below of proposed grades in sodded/seeded areas.
 - .5 compact each layer thoroughly at optimum moisture content with approved hand or mechanical tampers to a density equal to;
 - .1 95% of Maximum Standard Proctor Density
 - Behind foundation and retaining walls on grades
 - Below sodded or seeded areas
 - .2 100% of Maximum Standard Proctor Density

- Below slabs on grade within building areas up to the underside of the crushed stone underlay
- Below paved or graveled areas
- .6 Do not puddle or flood with water for consolidating backfill. Add Water during the compaction to optimum moisture content of backfilling material.

3.11 SEALANTS & CAULKING

- .1 Fill voids around pipes:
 - .1 Seal between sleeve and pipe in foundation walls and below grade floors with penetration seals (link-seal)). Install as per manufacturer's installation instructions.
 - .2 Where sleeves pass through non-fire rated walls or floors, caulk space between pipe and sleeve with fibreglass. Seal space at each end with waterproof, fire retardant, non-hardening mastic.
 - .3 Ensure no contact between copper tube or pipe and ferrous sleeve.
 - .4 Fill future-use sleeves with easily removable filler.
 - .5 Coat exposed exterior surfaces or ferrous sleeves with heavy application of zinc rich paint (VOC content not to exceed 250 g/L).
- .2 Temporarily plug all openings during construction.

3.12 FIRESTOPPING

- .1 All openings in fire separations and fire rated assemblies for service penetrations shall be protected with ULC listed service penetration firestop systems (SP).
- .2 The service penetration firestop system shall have F and FT ratings equal to or greater than ratings specified by the Architect for the fire separation (F) and firewall (FT) joint firestop systems (JF).
- .3 All components employed in the service penetration firestop system shall conform to the ULC listing.
- .4 Contractor shall prepare and submit a schedule of service penetration firestop systems to be employed indicating the ULC listing designation, services involved, location of opening through fire separation and the components of the fire separation assembly.
- .5 Refer to architectural drawings for ratings of fire separations and assemblies.

3.13 FLASHINGS

- .1 Provide all flashing at each point where piping passes through the roof.
- .2 Coordinate this work with the roofing Trades to ensure a satisfactory installation and to avoid delays.

3.14 ESCUTCHEONS AND PLATES

- .1 Provide on pipes passing through finished walls, partitions, floors and ceilings.
- .2 Use chrome or nickel plated brass, solid type with set screws for ceiling or wall mounting.
- .3 Inside diameter shall fit around finished pipe. Outside diameter shall cover opening or sleeve.

- .4 Where sleeve extends above finished floor, escutcheon or plates shall clear sleeve extension.
- .5 Secure to pipe or finished surface, but not insulation.

3.15 PAINTING

- .1 Repair minor damage to finish of equipment with standard factory applied baked enamel finish under the appropriate Sections of this division. Replace entirely, items suffering major damage to finish if too extensive to be repaired in the opinion of the Consultant.
- .2 Apply at least one coat of corrosion resistant primer paint to supports, and equipment fabricated from ferrous metals.

3.16 SUPPORT AND ATTACHEMENT

- .1 Support and attach piping from load bearing structures such as beams, joists, reinforced concrete slabs and concrete block walls, and do not support from or attach to steel roof deck and/or wall or ceiling finishes.

3.17 DISSIMILAR METALS

- .1 Separate dissimilar metals in order to prevent galvanic corrosion.
- .2 Provide gaskets or shims of approved materials to avoid electrolytic action.
- .3 Use dielectric unions and/or flanges where piping of dissimilar metals are connected.

3.18 SERVICE CONNECTIONS

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

3.19 ADJUST AND CLEAN

- .1 Clean equipment and fixtures, lubricate mechanical equipment installed under this Division and leave items in perfect order ready for operation.
- .2 Test and adjust control devices, instrumentation, relief valves, dampers, etc., installed in this Division after cleaning of systems and leave in perfect order ready for operation.
- .3 Remove from the premises upon completion of work of this division, debris, surplus, and waste materials resulting from operations.

3.20 MECHANICAL IDENTIFICATION INSTALLATION

- .1 Degrease and clean surfaces to receive adhesive for identification materials.
- .2 Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer (VOC content not to exceed 680 g/L).
- .3 Install tags with corrosion resistant chain.

- .4 Comply with standard detail drawing plate, "Detail of Piping Identification".
- .5 Install plastic tape pipe markers complete around bare pipe to manufacturer's instructions.
- .6 Identify valves in main and branch piping with tags. Consecutively number valves in each system.
- .7 Identify piping, concealed or exposed, with stencilled painting and plastic tape pipe markers. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 6 m on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.

3.21 MECHANICAL IDENTIFICATION SCHEDULES

- .1 Consult the Owner and identify piping, ductwork and equipment as directed;
 - .1 conforming to the Owner's existing identification practices, or
 - .2 conforming to the following Pipe and Valve Identification Table:

Pipe Marker Legend	Valve Tag Legend	Primary Colour	Secondary Colour
Cold Water	CW	Green	None
Dom. Hot Water Supply	DHWS	Green	None
Dom. Hot Water Recirc.	DHWR	Green	None
Sanitary Sewer	-	Green	None
Storm Sewer	-	Green	None
Vent	-	Green	None

- .2 Where coloured PVC jacketing is specified, conform to the following schedule;

Service	Legend	Colour
Cold Water	CW	Dark Green
Dom. Hot Water Supply	DHWS	Yellow
Dom. Hot Water Recirc.	DHWR	Yellow
Sanitary Sewer	SAN	Dark Grey
Storm Sewer	STRM	Light Grey

3.22 INSTALLATION OF ACCESS DOORS

- .1 Supply access doors for access to equipment requiring service, lubrication or adjustment and all concealed valves, cleanouts, and other such equipment.

-
- .2 Turn over access doors to the appropriate general trade for installation under other Sections.
 - .3 Refer to architectural drawings for ratings of fire separations and assemblies. install fire rated access doors in fire rated partitions, walls, and ceilings.
 - .4 Access doors in ceilings shall be minimum 24" x 24" (600mm x 600mm), unless otherwise approved by the Consultant.
 - .5 Provide concealed access doors in GWB ceilings and coordinate in-fill with general trades.

END OF SECTION

1 05GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 22 01 01.

1.2 SECTION INCLUDES

- .1 Pipe and equipment hangers and supports.
- .2 Sleeves and seals.
- .3 Flashing and sealing equipment and pipe stacks.

1.3 REFERENCES

- .1 ASME B31.5 - Refrigeration Piping and Heat Transfer Components.
- .2 ASTM F708 - Design and Installation of Rigid Pipe Hangers.
- .3 MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
- .4 MSS SP69 - Pipe Hangers and Supports - Selection and Application.
- .5 MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices.
- .6 UL 203 - Pipe Hanger Equipment for Fire protection Service.

1.4 SUBMITTALS

- .1 Section 22 01 01: Procedures for submittals.
- .2 Shop Drawings: Indicate system layout with location and detail of trapeze hangers.
- .3 Product Data: Provide manufacturers catalogue data including load capacity.
- .4 Design Data: Indicate load carrying capacity of trapeze, multiple pipes, and riser support hangers.
- .5 Manufacturer's Installation Instructions: Indicate special procedures and assembly of components.

1.5 REGULATORY REQUIREMENTS

- .1 Conform to CSA B-51 for support of piping.

2 PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

- .1 Manufacturers:
 - .1 Anvil
- .2 Plumbing and Natural Gas Piping:
 - .1 Conform to CSA B-51 and ASME B31.9.
 - .2 Hangers for Pipe Sizes 1/2" to 1-1/2" (13 to 38 mm): Carbon steel, adjustable swivel, split ring.
 - .3 Hangers for Cold Pipe Sizes 2" (50 mm) and Over: Carbon steel, adjustable, clevis.
 - .4 Hangers for Hot Pipe Sizes 2" to 4" (50 to 100 mm): Carbon steel, adjustable, clevis.

- .5 Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
- .6 Wall Support for Pipe Sizes to 3" (76 mm): Cast iron hook.
- .7 Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- .8 Floor Support for Hot Pipe Sizes to 4" (100 mm): Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- .9 Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

2.2 ACCESSORIES

- .1 Hanger Rods: galvanized, carbon steel continuous threaded.
- .2 Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

3 EXECUTION

3.1 INSTALLATION

- .1 Install to manufacturer's instructions and best trade practises.

3.2 INSERTS

- .1 Provide inserts for placement in concrete formwork.
- .2 Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- .3 Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
- .4 Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.

3.3 PIPE HANGERS AND SUPPORTS

- .1 Support horizontal piping as scheduled.
- .2 Install hangers to provide minimum 1/2" (13 mm) space between finished covering and adjacent work.
- .3 Place hangers within 12" (300 mm) of each horizontal elbow.
- .4 Use hangers with 1-1/2" (38 mm) minimum vertical adjustment.
- .5 Support horizontal cast iron pipe adjacent to each hub, with 5 feet (1.5 m) maximum spacing between hangers.
- .6 Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- .7 Provide copper plated hangers and supports for copper piping.
- .8 Design hangers for pipe movement without disengagement of supported pipe.
- .9 Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

3.4 SLEEVES

- .1 Set sleeves in position in formwork. Provide reinforcing around sleeves.
- .2 Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.
- .3 Extend sleeves through floors 1" (25 mm) above finished floor level. Caulk sleeves.
- .4 Where piping or ductwork penetrates floor, ceiling, or wall, close off space between pipe or duct and adjacent work with stuffing insulation and caulk. Provide close fitting metal collar or escutcheon covers at both sides of penetration.
- .5 Install chrome plated steel escutcheons at finished surfaces.

3.5 FLASHING

- .1 Provide flexible flashing and metal counterflashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.
- .2 Flash vent and soil pipes projecting 3" (75 mm) minimum above finished roof surface with lead worked 1" (25 mm) minimum into hub, 8" (200 mm) minimum clear on sides with 24" x 24" (600 x 600 mm) sheet size. For pipes through outside walls, turn flanges back into wall and caulk, metal counterflash, and seal.
- .3 Flash floor drains in floors with topping over finished areas with lead, 10" (250 mm) clear on sides with minimum 36" x 36" (910 x 910 mm) sheet size. Fasten flashing to drain clamp device.
- .4 Seal roof, floor, shower and mop sink drains watertight to adjacent materials.
- .5 Provide acoustical lead flashing around ducts and pipes penetrating equipment rooms, installed to manufacturer's instructions for sound control.
- .6 Provide curbs for mechanical roof installations 14" (350 mm) minimum high above roofing surface. Flash and counterflash with sheet metal; seal watertight. Attach counterflashing mechanical equipment and lap base flashing on roof curbs. Flatten and solder joints.
- .7 Adjust storm collars tight to pipe with bolts; caulk around top edge. Use storm collars above roof jacks. Screw vertical flange section to face of curb.

3.6 SCHEDULES

- .1 Imperial Measure (IP)

Pipe Size (in)	Rod Diameter (in)	Support Spacing (Ft)	
		Steel Pipe	Copper Tube
1/2	3/8	7	6
3/4	3/8	7	6
1	3/8	7	6
1-1/4	3/8	7	6

1-1/2	3/8	9	8
2	3/8	10	9
2-1/2	3/8	12	10
3	3/8	12	10

.2 Metric Measure (SI)

Pipe Size (mm)	Rod Diameter (mm)	Support Spacing (m)	
		Steel Pipe	Copper Tube
13	10	2.1	1.8
20	10	2.1	1.8
25	10	2.1	1.8
32	10	2.1	1.8
38	10	2.7	2.4
50	10	3	2.7
65	10	3.6	3
75	10	3.6	3

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 22 01 01.

1.2 SECTION INCLUDES

- .1 Testing, adjustment, and balancing of piping systems.

1.3 REFERENCES

- .1 Ontario Building Code.
- .2 AABC - National Standards for Total System Balance.
- .3 NEBB - Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

1.4 SUBMITTALS

- .1 Submit name of adjusting and balancing agency for approval within 30 days after award of Contract.
- .2 Field Reports: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
- .3 Prior to commencing work, submit report forms or outlines indicating adjusting, balancing, and equipment data required.
- .4 Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Consultant and for inclusion in operating and maintenance manuals.
- .5 Provide reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side.
- .6 Include detailed procedures, agenda, sample report forms and copy of AABC National Project Performance Guaranty prior to commencing system balance.
- .7 Test Reports: Indicate data on AABC National Standards for Total System Balance forms. Submit data in S.I. Metric units.
- .8 All reports shall be prepared in electronic (computer) format using MS Word software and all tabulations shall be prepared in electronic (computer) format using MS Excel spreadsheet software. Submittals shall include three (3) copies each of hard copy printout and two (2) copies with text in ".pdf" and tabulations in ".xls" or ".xlsx" formats on CD, DVD, or USB flash drive.

1.5 PROJECT RECORD DOCUMENTS

- .1 Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.
- .2 Record actual locations of flow measuring stations.

1.6 QUALITY ASSURANCE

- .1 Perform total system balance to AABC National Standards for Field

- Measurement and Instrumentation, Total System Balance.
- .2 Maintain one copy of each document on site.

1.7 INDEPENDENT AGENCY

- .1 All work of Mechanical Testing, Adjusting and Balancing shall be undertaken by a single agency, employed under Division 23.
Other agencies may be proposed as an Alternate only, in accordance with Section 22 01 01, paragraph 2.3.
- .2 The work of the agency consists of the furnishing of all labour, materials, equipment and accessories necessary in the testing, verification and documentation of the operational performance of all equipment and systems installed under the Sections of Division 20: Mechanical.

1.8 QUALIFICATIONS

- .1 Agency: Company specializing in the testing, adjusting, and balancing of systems under this Section with minimum five years documented experience certified by AABC or prequalified as listed below.
- .2 Work shall be performed under the supervision of an AABC certified Test and Balance Engineer, an NEBB Certified Testing, Adjusting and Balancing Supervisor or a registered Professional Engineer experienced in the performance of this work and licenced at the place where the Project is located.

1.9 PRE-BALANCING CONFERENCE

- .1 Convene one week prior to commencing work of this Section.

1.10 CO-OPERATION

- .1 Co-operate with installing Contractor(s) in advising them of specific scheduling requirements for systems verification.
- .2 Provide advice to installing Contractors regarding the location and installation of devices required to permit system balancing and measurements, prior to start of the installation work.
- .3 TAB Contactor responsible for 22 05 93 and TAB Contractor responsible for 23 05 93 are required to work in conjunction with each other to achieve a fully balanced and functional HVAC system. Where two separate contractors are used, the General Contractor is responsible for coordinating this work.

2 PRODUCTS

2.1 REFERENCE STANDARDS

- .1 All equipment required for the verification of equipment and systems shall be furnished by the agency employed to conduct the Plumbing Systems Verification.
- .2 Testing and measuring equipment used in the verification of the plumbing systems shall be calibrated to give true readings within the accuracy specifications of the equipment used. A certificate of calibration from an independent testing laboratory may be required by the Consultant if there is any

- reason to suspect that the equipment used is giving erroneous readings. In such an event the verification agency shall reconduct its verifications.
- .3 All equipment used by the agency in its verification of plumbing systems remains the property/responsibility of the agency and is not included in the supply to the project.

3 EXECUTION

3.1 EXAMINATION

- .1 Verify that systems are complete and operable before commencing work. Ensure the following conditions:
- .1 Systems are started and operating in a safe and normal condition.
 - .2 Plumbing systems are flushed, filled, and vented.
 - .3 Service and balance valves are open.
- .2 Submit field reports. Report defects and deficiencies noted during performance of services which prevent system balance.
- .3 Beginning of work represents acceptance of existing conditions in the areas served.

3.2 PREPARATION

- .1 Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Consultant to facilitate spot checks during testing.
- .2 Provide additional balancing devices as required.

3.3 INSTALLATION TOLERANCES

- .1 Domestic Hot Water Recirculation Systems: Adjust to within plus or minus 10 percent of design.

3.4 ADJUSTING

- .1 Ensure recorded data represents actual measured or observed conditions.
- .2 Permanently mark settings of valves other adjustment devices allowing settings to be restored. Set and lock memory stops.
- .3 After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

3.5 DOMESTIC HOT WATER RECIRCULATION SYSTEM PROCEDURE

- .1 Adjust water systems to provide required or design quantities.
- .2 Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance.
- .3 Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.
- .4 Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

3.6 SCHEDULES

- .1 Equipment requiring testing, adjusting and balancing:
 - .1 Balancing valves
- .2 Report Forms
 - .1 Title Page:
 - .1 Name of Testing, Adjusting, and Balancing Agency
 - .2 Address of Testing, Adjusting, and Balancing Agency
 - .3 Telephone number of Testing, Adjusting, and Balancing Agency
 - .4 Project name
 - .5 Project location
 - .6 Project Architect
 - .7 Project Engineer
 - .8 Project Contractor
 - .9 Project altitude
 - .10 Report date
 - .2 Summary Comments:
 - .1 Design versus final performance
 - .2 Notable characteristics of system
 - .3 Description of systems operation sequence
 - .4 Nomenclature used throughout report
 - .5 Test conditions

3.7 PIPING SYSTEMS VERIFICATION

- .1 Review the drawings, specifications, and installed work to ensure that systems may be properly balanced in accordance with drawings. Advise the installing Contractor of any additional requirements for effective balancing.
- .2 Open all valves to full position, including coil stop valves, close bypass valves, and return line
- .3 Examine water in system to determine if it has been treated and is clean.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 22 01 01.

1.2 SECTION INCLUDES

- .1 Piping insulation.
- .2 Jackets and accessories.

1.3 REFERENCES

- .1 ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
- .2 ASTM C177 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
- .3 ASTM C195 - Mineral Fibre Thermal Insulating Cement.
- .4 ASTM C335 - Steady-State Heat Transfer Properties of Horizontal Pipe Insulation.
- .5 ASTM C449/C449M - Mineral Fibre Hydraulic-setting Thermal Insulating and Finishing Cement.
- .6 ASTM C518 - Steady-State Thermal Transmission Properties by Means of the Heat Flow Metre Apparatus.
- .7 ASTM C533 - Calcium Silicate Block and Pipe Thermal Insulation.
- .8 ASTM C534 - Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
- .9 ASTM C547 - Mineral Fibre Pipe Insulation.
- .10 ASTM C552 - Cellular Glass Thermal Insulation.
- .11 ASTM C578 - Rigid, Cellular Polystyrene Thermal Insulation.
- .12 ASTM C585 - Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
- .13 ASTM C591 - Unfaced Preformed Cellular Polyisocyanurate Thermal Insulation.
- .14 ASTM C610 - Moulded Expanded Perlite Block and Pipe Thermal Insulation.
- .15 ASTM C921 - Properties of Jacketing Materials for Thermal Insulation.
- .16 ASTM D1056 - Flexible Cellular Materials - Sponge or Expanded Rubber.
- .17 ASTM D1667 - Flexible Cellular Materials - Vinyl Chloride Polymers and Copolymers (Closed Cell Foam).
- .18 ASTM D2842 - Water Absorption of Rigid Cellular Plastics.
- .19 ASTM E84 - Surface Burning Characteristics of Building Materials.
- .20 ASTM E96 - Water Vapour Transmission of Materials.
- .21 NFPA 255 - Surface Burning Characteristics of Building Materials.
- .22 UL 723 - Surface Burning Characteristics of Building Materials.

1.4 SUBMITTALS

- .1 Product Data: Provide product description, list of materials and thickness for each service, and locations.
- .2 Manufacturer's Installation Instructions: Indicate procedures which ensure

acceptable workmanship and installation standards will be achieved.

1.5 QUALITY ASSURANCE

- .1 Materials: Flame spread/smoke developed rating of 25/50 or less to ULC S102 and ASTM E84.

1.6 QUALIFICATIONS

- .1 Applicator: Company specializing in performing the work of this section with minimum three years experience.

1.7 DELIVERY, STORAGE, AND HANDLING

- .1 Transport, handle, store, and protect products.
- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.
- .3 Store insulation in original wrapping and protect from weather and construction traffic.
- .4 Protect insulation against dirt, water, chemical, and mechanical damage.

1.8 ENVIRONMENTAL REQUIREMENTS

- .1 Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- .2 Maintain temperature during and after installation for minimum period of 24 hours.

2 PRODUCTS

2.1 GLASS FIBRE

- .1 Manufacturers:
 - .1 Manufacturer: Owens Corning Fiberglas
- .2 Other acceptable manufacturers offering equivalent products:
 - .1 Manson
 - .2 Knauf Fiber Glass
 - .3 Johns Manville
- .3 Insulation: ASTM C547; rigid moulded, noncombustible.
 - .1 'ksi' value : ASTM C335, 0.035 at 75°F (24°C).
 - .2 Minimum Service Temperature: -20°F (-28.9°C).
 - .3 Maximum Service Temperature: 302°F (150°C).
 - .4 Maximum Moisture Absorption: 0.2 percent by volume.
- .4 Vapour Barrier Jacket
 - .1 ASTM C921, White kraft paper reinforced with glass fibre yarn and bonded to aluminized film.
 - .2 Moisture Vapour Transmission: ASTM E96; 0.02 perm.
 - .3 Secure with self sealing longitudinal laps and butt strips.
 - .4 Secure with outward clinch expanding staples and vapour barrier mastic.

- .5 Tie Wire: 1.3 mm stainless steel with twisted ends on maximum 12" (300 mm) centres.
- .6 Vapour Barrier Lap Adhesive
 - .1 Compatible with insulation.
- .7 Insulating Cement/Mastic
 - .1 ASTM C195; hydraulic setting on mineral wool, VOC content not to exceed 80 g/L.
- .8 Fibrous Glass Fabric
 - .1 Cloth: Untreated; 9 oz/sq yd (305 g/sq m) weight.
 - .2 Blanket: 1.0 lb/cu ft (16 kg/cu m) density.
- .9 Indoor Vapour Barrier Finish
 - .1 Vinyl emulsion type acrylic, compatible with insulation, white colour, VOC content not to exceed 250 g/L.
- .10 Outdoor Vapour Barrier Mastic
 - .1 Vinyl emulsion type acrylic, compatible with insulation, white colour.
- .11 Insulating Cement
 - .1 ASTM C449, VOC content not to exceed 80 g/L.

2.2 JACKETS

- .1 PVC Plastic
 - .1 Jacket: ASTM C921, One piece moulded type fitting covers and sheet material.
 - .1 Minimum Service Temperature: -31°F (-35°C).
 - .2 Maximum Service Temperature: 151°F (66°C).
 - .3 Moisture Vapour Transmission: ASTM E96; 0.03 perm inches.
 - .4 Maximum Flame Spread: ASTM E84; 25 or less.
 - .5 Maximum Smoke Developed: ASTM E84; 50 or less.
 - .6 Thickness: 20 mil (0.4 mm) minimum.
 - .2 Colour: standard off-white
 - .3 Covering Adhesive Mastic
 - .1 Compatible with insulation, maximum VOC content of 50 g/L.
 - .4 Manufacturer;
 - .1 Ceel-Co 300 series
 - .2 Speedline *Smoke Safe*
- .2 Aluminum Jacket: ASTM B209.
 - .1 Thickness: 0.02" (0.40 mm) sheet.
 - .2 Finish: Smooth.
 - .3 Joining: Longitudinal slip joints and 2" (50 mm) laps.
 - .4 Fittings: 0.02" (0.40 mm) thick die shaped fitting covers with factory attached protective liner.
 - .5 Metal Jacket Bands: 3/8" (10 mm) wide; 0.01" (0.38 mm) thick aluminum.

2.3 ACCESSORIES

- .1 Adhesives and finishes shall be as recommended by the insulation manufacturer and shall comply with Section 22 01 01.2.2. Accessories such as adhesives,

- mastics and cements shall have the same properties as listed above and shall not detract from any of the system ratings specified.
- .2 Vapor retarder lap adhesive shall be water based, fire retardant
- .3 Tapes shall be of cloth reinforced aluminum, soft adhesive with minimum 2" (50 mm) width.
- .4 Tie wire shall be of 1/16" (1.5 mm) Ø stainless steel.
- .5 Fasteners shall be of 1/8" (4 mm) Ø pins, with 35 mm square clips. Clip length to suit insulation thickness.
- .6 Bands shall be 1/2" (12 mm) wide 1/4" (6mm) thick galvanized steel.
- .7 Facing shall be of 1" (25 mm) galvanized steel hexagonal wire mesh attached on both faces of insulation.

3 EXECUTION

3.1 EXAMINATION

- .1 Verify that piping has been tested before applying insulation materials.
- .2 Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

- .1 Install piping insulations to TIAC National Installation Standards.
- .2 Apply insulation materials, accessories, jackets and finishes in accordance with manufacturer' written instructions and as specified.
- .3 On exposed piping locate insulation and cover seams in least visible locations.
- .4 Insulated dual temperature pipes or cold pipes conveying fluids below ambient temperature:
 - .1 Provide vapour barrier jackets, factory applied or field applied.
 - .2 Insulate fittings, joints, and valves with moulded insulation of like material and thickness as adjacent pipe.
 - .3 Finish with glass cloth and vapour barrier adhesive.
 - .4 PVC fitting covers may be used.
 - .5 Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations.
 - .6 Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
- .5 For insulated pipes conveying fluids above ambient temperature:
 - .1 Provide standard jackets, with or without vapour barrier, factory applied or field applied.
 - .2 Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe.
 - .3 Finish with glass cloth and adhesive.
 - .4 PVC fitting covers may be used.
 - .5 For hot piping conveying fluids 140°F (60°C) or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
 - .6 For hot piping conveying fluids over 140°F (60°C), insulate flanges and unions at equipment.

- .6 Inserts and Shields:
 - .1 Application: Piping 1-1/2" (40 mm) diameter or larger.
 - .2 Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
 - .3 Insert Location: Between support shield and piping and under the finish jacket.
 - .4 Insert Configuration: Minimum 6" (150 mm) long, of same thickness and contour as adjoining insulation; may be factory fabricated.
 - .5 Insert Material: hydrous calcium silicate insulation.
- .7 Finish insulation at supports, protrusions, and interruptions.
- .8 Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapour barrier cement.

3.3 PIPE INSULATION

- .1 Insulate new or altered piping with rigid pipe insulation and re-insulate existing piping where insulation has been removed or damaged as follows:

RIGID PIPE INSULATION			
Service	Operating Temperature Range °F	Pipe Diameter in.	Insulation Thickness in.
Domestic cold water	0 to 850	All sizes	1
Domestic hot water & hot water recirculation	105 to higher	2 and smaller	1
		2-1/2 and larger	1-1/2
Storm drainage	40 to 55	All sizes	1

RIGID PIPE INSULATION (SI)			
Service	Operating Temperature Range °C	Pipe Diameter (mm)	Insulation Thickness (mm)
Domestic cold water	-18 to 454	All sizes	25
Domestic hot water & hot water recirculation	41 and higher	50 and smaller	25
		65 and larger	40
Storm drainage	4 to 13	All sizes	25

- .2 Insulate valves, flanges and pipe connections with removable / reusable insulation covers.
- .3 Wrap butt joints with a 4" (100 mm) strip of fire resistant vapour barrier jacket

-
- cemented with lagging adhesive.
- .4 Where the pipe hanger is around the insulation, provide an insulation protection shield within the pipe saddle. Coordinate with installation of hangers.
 - .5 Insulate all fittings, flanges and valves on pipes to provide equivalent insulation to that on adjoining pipe.
 - .6 Continue insulation through sleeves including specified finish.
 - .7 Cut back covering on strainers and finish off to expose removable head insulation.
 - .8 Cover expansion joints first with 24 gauge (0.7 mm) galvanized metal sleeve and then insulate to provide equivalent thickness to that on adjoining pipe.
 - .9 Protect insulation with protection saddles where insulated pipe is supported by rollers.
 - .10 Insulate pipe hangers supporting new piping carrying water at 70°F (21°C) or less to prevent condensation. Extend insulating material along hanger rod to height 4 times thickness of insulation. Seal insulation with vapour-proof sealant.
 - .11 Extend pipe insulation and covering through walls, floors, ceilings, and concrete beams, unless indicated otherwise on drawings. protect exposed insulation extending through floors with 4" (100 mm) wide strip of 18 gauge (1.3 mm) galvanized iron.
 - .12 Pack annular space between pipe sleeves and piping or pipe covering with glass fibre insulation or rockwool insulation. In fire rated assemblies use Dow Silicon RTV or other ULC listed materials. Seal exposed insulation with mastic.
 - .13 Recover exposed surfaces of insulated piping installed in exposed areas, mechanical rooms, and equipment rooms with PVC jacketing and PVC fitting covers installed in accordance with manufacturers instructions.
 - .14 Insulate and cover exposed surfaces of waste connections, traps, and valves at each lavatory and sink designated for "handicapped" or "barrier free" use with: PVC insulated fitting covers specifically designed for this application. Vinyl material is not to exceed flame spread rating of 150, and if intended to be used in high buildings, its smoke developed classification does not exceed 300. Zeston or other equivalent material. or foamed plastic type insulation finished with two coats of Armstrong Armflex or other equivalent material.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 22 01 01 and 01 91 00.

1.2 COMMISSIONING AGENT

- .1 The commissioning agent (CA) has been contracted directly by the Owner for this project. The CA has overall responsibility for planning and coordinating the commissioning process. Commissioning involves all parties to the design and construction process, including the Contractor and his sub-contractors and suppliers.

1.3 DESCRIPTION OF WORK

- .1 The purpose of the commissioning process is to provide the owner/operator of the facility with assurance that the plumbing systems have been installed according to the contract documents, and operate within the performance guidelines set out in the design intent documents and these specifications. The CA will provide the Owner with an unbiased, objective view of the system's installation, operation, and performance. The commissioning process does not take away or reduce the responsibility of the installing contractors to provide a finished product, installed and fully functional in accordance with the contract documents.
- .2 Commissioning is intended to enhance the quality of system start up and aid in the orderly completion and transfer of systems for beneficial use of owner. The CA will be the leader of the commissioning team, planning and coordinating all commissioning activities in conjunction with the design professionals, construction manager, subcontractors, manufacturers and equipment suppliers.
- .3 The General Contractor and Division 21, 22, 23, 25, 26, 27 and 28 sub-contractors are responsible for cooperating, and coordinating their work, with the CA. They shall also be responsible for carrying out all the physical activities required for installation of components and systems, and operating them during the commissioning process as required in this Section.

1.4 RELATED DOCUMENTS

- .1 Drawings and General Requirements of the contract, including General and Supplementary General Conditions, General Requirements and applicable Sections of Divisions 21, 22, 23, 25, 26, 27 and 28 apply to work of this Section.
- .2 Refer to Commissioning Specifications indicated in Appendix C.

1.5 REFERENCES

- .1 Ontario Building Code (OBC).
- .2 Ontario Fire Code (OFC).
- .3 ASHRAE Guideline 0 The Commissioning Process,

1.6 SYSTEMS TO BE COMMISSIONED

-
- .1 The following Plumbing work shall be commissioned as part of the Work of this contract;
 - .1 Domestic water supply systems
 - .2 Domestic hot water supply systems
 - .3 Domestic tempered water supply systems
 - .4 Sanitary drainage systems
 - .5 Storm drainage system
 - .6 Pipe testing

2 PRODUCTS

2.1 COMMISSIONING AUTHORITY

- .1 The commissioning authority shall consist of representatives of the following:
 - .1 Owner and the Owner's Operating and Maintenance Staff
 - .2 Architect
 - .3 Mechanical Design Engineer
 - .4 Electrical Design Engineer
 - .5 Commissioning Agent (CA)
 - .6 General Contractor
 - .7 Division 22 Subcontractor
 - .8 Testing, Adjusting and Balancing Agency
 - .9 Related Subcontractors and Suppliers.

2.2 SYSTEMS START-UP/VERIFICATION CHECKLISTS

- .1 The Appendix specification section contains the system start-up and verification checklists as listed below:
 - .1 Domestic water supply systems
 - .2 Domestic hot water supply systems
 - .3 Domestic tempered water supply systems
 - .4 Sanitary drainage systems
 - .5 Storm drainage systems
 - .6 Pipe testing

2.3 FUNCTIONAL PERFORMANCE TEST CHECKLISTS

- .1 The Appendix specification section contains functional performance test checklists as listed below:
 - .1 Domestic water supply systems cisterns
 - .2 Domestic hot water supply systems
 - .3 Domestic tempered water supply systems
 - .4 Storm drainage systems
 - .5 Sanitary drainage systems
 - .6 Pipe testing

3 EXECUTION

3.1 COMMISSIONING CONSULTANT'S RESPONSIBILITIES

- .1 The Commissioning Consultant shall:
 - .1 plan, organize and implement the commissioning process as specified herein;
 - .2 prepare the commissioning plan, ensure its distribution for review and comment;
 - .3 revise the commissioning plan as required during construction;
 - .4 chair commissioning meetings, and prepare and distribute minutes to all commissioning team members, whether or not they attended the meeting;
 - .5 in conjunction with the General Contractor, coordinate commissioning activities among all contractors, sub-trades and suppliers;
 - .6 monitor system verification checks, and ensure the results are documented as the checks are done;
 - .7 observe all start-ups and initial system operations tests and checks;
 - .8 witness all functional performance tests and document the results;
 - .9 prepare and submit a commissioning report which documents all checks and tests done throughout the commissioning process, and the results obtained from each; and
 - .10 ensure all required O&M manuals, instructions and demonstrations are provided to the owner's designated operating staff.

3.2 MECHANICAL ENGINEER'S RESPONSIBILITIES

- .1 The Mechanical Engineer will review the commissioning plan, and will participate, as appropriate, in on-site commissioning meetings.
- .2 During the acceptance phase of the commissioning process, the Mechanical Engineer may be on site to review commissioning documentation, to witness functional performance tests, and to analyze the installation and its performance.

3.3 OWNER'S RESPONSIBILITIES

- .1 The Owner will ensure the availability of operating staff for all scheduled instructions and demonstration sessions. This staff will possess sufficient skills and knowledge to operate and maintain the installation following attendance at these sessions. The owner will also ensure the appropriate involvement of the Electrical Engineer, Architect, and any other consultants as required, in the commissioning process.

3.4 GENERAL CONTRACTOR'S RESPONSIBILITIES

- .1 The General Contractor has responsibility to ensure the overall completion of the work. In this regard, he shall;
 - .1 Participate as required in the Mechanical Systems Commissioning process,
 - .2 ensure the Division 22 sub-contractor performs all assigned commissioning responsibilities as specified in 3.5,
 - .3 ensure the testing, adjusting and balancing agency performs all assigned commissioning responsibilities as specified in 3.6,
 - .4 ensure the cooperation and participation in the commissioning process of

-
- all other sub-contractors as applicable.
- .2 The General Contractor shall assign a representative to the commissioning team, and submit the person's name to the commissioning agency, within one (1) month of the award of the contract. The representative shall have the authority to make decision on behalf of the general contractor as they relate to the organization and scheduling of plumbing systems commissioning. The representative shall facilitate communications among all contractors and suppliers and other commissioning team members and shall foster the necessary cooperative action. One specific responsibility shall be to attend commissioning meetings and ensure action items arising from them are attended to as required to allow the commissioning process to proceed on schedule.
 - .3 In the event that any scheduled equipment or system start-ups or functional performance tests are terminated because the CA or the mechanical engineer discover deficient or incomplete work, or due to the non-attendance of required contractor or supplier personnel, the contractor or sub-contractor responsible for the termination shall also be responsible for paying reasonable costs of time and travel expenses of any or all of the following representatives who were physically present for the purpose of witnessing the start-up or the FPT: the CA, the mechanical engineer, the electrical engineer, and the owner. The owner may provide a statement to the General Contractor identifying the specific activity that was terminated, the scheduled date, and a list of those in attendance, along with their reasonable time and travel expense costs.

3.5 DIVISION 22 SUBCONTRACTOR'S RESPONSIBILITIES

- .1 The Division 22 sub-contractor, and all the sub-contractors and suppliers within the mechanical aspect of the project's scope, shall cooperate with the commissioning agent (CA), and other commissioning team members, to facilitate the successful completion of the commissioning process.
- .2 The contractor shall assign a representative to the commissioning team, and submit the person's name to the commissioning agency, within one (1) month of the award of the contract. The representative shall have the authority to make decisions on behalf of the mechanical contractor as they relate to the organization and scheduling of plumbing systems commissioning. The representative shall ensure communications between Division 22 contractors and suppliers and all other commissioning team members, and shall foster the necessary cooperative action. One specific responsibility shall be to attend commissioning meetings, and ensure action items arising from them are attended to as required to allow the commissioning process to proceed on schedule.
- .3 The plumbing systems sub-contractor, and all sub-contractors and suppliers, shall cooperate with the Commissioning Agency in carrying out the plumbing systems commissioning process. In this context, the plumbing systems sub-contractor shall:
 - .1 Include in his bid price the cost of participating in the commissioning process as specified herein.
 - .2 Provide instruction and demonstrations for the Owner's designated operating staff, in conjunction with the commissioning agency and mechanical engineer, and with the participation of qualified technicians

-
- from major equipment suppliers and the controls contractor.
 - .3 Include requirements for submittal data. O&M data, and training information in each purchase order or sub-contract written.
 - .4 Attend commissioning meetings scheduled by the CA.
 - .5 Notify the CA a minimum of two weeks in advance of scheduled equipment and system start-ups, so that the CA may witness system verifications, and equipment and system start-ups.
 - .6 Provide sufficient personnel to assist the CA as required during system verification and functional performance testing.
 - .7 Prior to set-up, inspect, check and confirm the correct and complete installation of all equipment and systems for which system verification checklists are included in the commissioning plan. Document the results of all inspections and checks on the checklists and sign them. If deficient or incomplete work is discovered, ensure corrective action is taken and re-check until the results are satisfactory, and the system is ready for safe start-up.
 - .8 Notify the CA a minimum of two weeks in advance, of the time for start of the TAB work. Attend the initial TAB meeting for review of the TAB procedures.
 - .9 Prepare preliminary schedule for mechanical system orientation and inspections. O&M Manual submission, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up TAB, and task completion for use by the CA. Update schedule as appropriate throughout the construction period.
 - .10 Conduct plumbing systems orientation and inspection at the equipment placement completion stage.
 - .11 Update drawings to as-built condition and review with the CA.
 - .12 Gather O&M data on all equipment, and assemble in binders as required by the
 - .13 Provide written notification to the general contractor (or construction manager) and CC that the following work has been completed in accordance with the contract documents and the equipment, systems and sub-systems are operating as required;
 - .1 plumbing equipment including all tanks, pumps, fixtures and piping systems.
 - .2 Fire-stopping in the fire-rated construction
 - .14 Provide a complete set of as-built drawings and O&M manuals to the CA.

3.6 TAB AGENCY'S RESPONSIBILITIES

- .1 With respect to plumbing systems commissioning, the TAB agency shall:
 - .1 Include costs for plumbing systems commissioning requirements in the quoted price.
 - .2 Attend commissioning meetings scheduled by the CA prior to, and during, on-site TAB work being done.
 - .3 Submit proposed TAB procedures to the CA and mechanical engineer for review and acceptance.
 - .4 Attend the TAB planning meeting scheduled by the CA. Be prepared to discuss the procedures that shall be followed in testing, adjusting and

-
- balancing the plumbing systems system.
- .5 At the completion of the TAB work, submit the final TAB report to the mechanical contractor, submittal will be to the mechanical contractor, with general contractor, CA, and mechanical engineer notified
 - .6 Participate in verification of the TAB report by the CA for verification or diagnostic purposes.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 22 01 01.

1.2 SECTION INCLUDES

- .1 Pipe and pipe fittings.
- .2 Hangers and supports.
- .3 Labelling and identification.
- .4 Valves.
- .5 Accessories

1.3 REFERENCES

- .1 CSA B149.1 Natural gas and propane installation code, as adopted.
- .2 ASME B16.3 - Malleable Iron Threaded Fittings.
- .3 ASME B36.10 - Welded and Seamless Wrought Steel Pipe.
- .4 ASTM A53/A53M - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
- .5 NFPA 31 - Installation of Oil-Burning Equipment.

1.4 SUBMITTALS

- .1 Product Data: Provide data on pipe materials, pipe fittings, valves and accessories. Provide manufacturers catalogue information. Indicate valve data and ratings.
- .2 Project Record Documents: Record actual locations of piping system, storage tanks, and system components.
- .3 Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.
- .4 Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.
- .5 Contractor's material and test certificates.

1.5 QUALITY ASSURANCE

- .1 Welding Materials and Procedures: Conform to ASME Code.
- .2 Welders Certification: To ASME SEC IX.
- .3 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- .4 Installer Qualifications: Company specializing in performing the work of this section with minimum 5 years documented experience.
- .5 Valves: Manufacturer's name and pressure rating marked on valve body.

1.6 REGULATORY REQUIREMENTS

- .1 Conform to CSA B149.1 Natural Gas and Propane installation code
- .2 Conform to ANSI B31.1 for installation of fuel oil piping.
- .3 Products Requiring Electrical Connection: Listed and classified by CSA, ULC, cUL or Special Inspection as suitable for the purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND PROTECTION

- .1 Transport, handle, store, and protect products.
- .2 Protect piping and fittings from soil and debris with temporary end caps and closures. Maintain protection in place until installation.

1.8 EXTRA MATERIALS

- .1 Provide two repacking kits for each size valve.

2 PRODUCTS

2.1 ABOVE GROUND PIPING

- .1 Steel Pipe: ASTM A53/A53M Gr. B, ERW or A106 SMLS, schedule 40.
 - .1 Fittings: ASTM B16.3, malleable iron class 150, screwed or flanged or ASTM A234/A234M, wrought carbon steel and alloy steel welding type.
 - .2 Joints: NFPA 30, threaded, flanged or welded to ANSI B31.1.
 - .1 Screwed fittings: pulverized lead paste.
 - .2 Welded fittings: butt-welding fittings to CSA W47.1.
 - .3 Flange gaskets: nonmetallic flat, to ASME B16.5.
 - .4 Unions: malleable iron, brass to iron, ground seat, to ASTM A 47/A47M.
 - .5 Bolts and nuts: to ASME B18.2.1.
 - .6 Nipples: schedule 40, to ASTM A 53/A53M.
- .2 Where piping is installed in ceilings used as return air plenums, provide seamless pipe and welding fittings.

2.2 PIPE HANGERS AND SUPPORTS

- .1 Conform to NFPA 31.
- .2 Hangers for Pipe Sizes 1" - 1-1/2" (15 to 40 mm): Malleable iron, adjustable swivel, split ring.
- .3 Hangers for Pipe Sizes 2" (50 mm) and Over: Carbon steel, adjustable, clevis.
- .4 Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
- .5 Wall Support for Pipe Sizes to 3-1/4" (80 mm): Cast iron hook.
- .6 Vertical Support: Steel riser clamp.
- .7 Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- .8 Roof support: refer to section 22 01 01 and CSA B149.1
- .9 Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

2.3 ISOLATION VALVES

- .1 2" (50 mm) and smaller: semi-steel lubricated plug valves, screwed, wrench operated. Rockwell "Nordstrum" Fig. 142, Newman-Milliken 170M.
- .2 Provide two (2) standard pattern, cast handle wrenches to operate valves.

2.4 PRESSURE REDUCING VALVES

- .1 Gas Pressure Reducing and Relief Valves: Spring loaded regulator with internal relief valve. Cast iron body, aluminum diaphragm case and orifice. For capacities refer to drawings. Fisher CS800 or approved equal as noted on drawings.

3 EXECUTION

3.1 SERVICE CONNECTIONS

- .1 Provide for new gas service complete with gas meter and regulators. Provide regulators on each line serving gravity type appliances, sized to equipment.

3.2 EXAMINATION

- .1 Verify existing conditions before starting work.
- .2 Verify that excavations are to required grade, dry, and not over-excavated.

3.3 PREPARATION

- .1 Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- .2 Remove scale and dirt, on inside and outside, before assembly.
- .3 Prepare piping connections to equipment with flanges or unions.

3.4 INSTALLATION

- .1 Install to CSA B149.1-15 as adopted.
- .2 Provide non-conducting dielectric connections wherever jointing dissimilar metals.
- .3 Route piping in orderly manner and maintain gradient.
- .4 Install piping to conserve building space and not interfere with use of space.
- .5 Group piping whenever practical at common elevations.
- .6 Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- .7 Provide clearance for installation of insulation and access to valves and fittings.
- .8 Provide flexible pipe connections at the generator.
- .9 Establish elevations of buried piping outside the building to ensure not less than 1m of cover.
- .10 Where pipe support members are welded to structural building framing, scrape, brush clean, weld, and apply one coat of zinc rich primer.
- .11 Prepare pipe, fittings, supports, and accessories not prefinished, ready for finish painting.

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- .12 Identify piping systems including underground piping.
 - .13 Install valves with stems upright or horizontal, not inverted.
 - .14 Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 22 01 01.

1.2 SECTION INCLUDES

- .1 Floor drains
- .2 Funnel Floor Drains
- .3 Trap Seal Primers
- .4 Cleanouts
- .5 Water hammer arrestors
- .6 Backflow Preventor
- .7 Wall hydrants

1.3 REFERENCES

- .1 ASME A112.21.1 - Floor Drains.
- .2 ASME A112.21.2 - Roof Drains.
- .3 ASME A112.26.1 - Water Hammer Arrestors.
- .4 PDI WH-201 - Water Hammer Arrestors.

1.4 SUBMITTALS FOR REVIEW

- .1 Product Data: Provide component sizes, rough-in requirements, service sizes, and finishes.
- .2 Shop Drawings: Indicate dimensions, weights, and placement of openings and holes.

1.5 SUBMITTALS FOR INFORMATION

- .1 Manufacturer's Instructions: Indicate Manufacturer's Installation Instructions: Indicate assembly and support requirements.

1.6 SUBMITTALS AT PROJECT CLOSEOUT

- .1 Project Record Documents: Record actual locations of equipment, cleanouts, backflow preventers, water hammer arrestors
- .2 Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.7 QUALITY ASSURANCE

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

1.8 DELIVERY, STORAGE, AND PROTECTION

- .1 Accept specialties on site in original factory packaging. Inspect for damage.

2 PRODUCTS

2.1 GENERAL

- .1 Manufacturer: Watts or Zurn Drainage model indicated or equivalent by;
 - .1 Jay R. Smith

2.2 FLOOR DRAINS

- .1 Floor Drain:
 - .1 Manufacturer:
 - .1 Watts FD-100-C
 - .2 ANSI A112.21.1; lacquered cast iron two piece body with double drainage flange, weep holes, reversible clamping collar, and round, adjustable round nickel-bronze strainer with removable perforated sediment bucket.

2.3 FUNNEL FLOOR DRAINS

- .1 Funnel Floor Drain:
 - .1 Manufacturer:
 - .1 Watts FD-100-EG
 - .2 Epoxy coated cast iron floor drain with anchor flange, weep holes, reversible clamping collar, and round, adjustable round nickel-bronze strainer with 102 x 229 oval nickle bronze funnel.

2.4 BACKFLOW PREVENTOR

- .1 Backflow Prevention Device Applications:

Type & Purpose	Description	Installed Application
Reduced Pressure Zone Assemblies	Two independent check valves with intermediate relief valve. Supplied with shutoff valves & ball type test cocks.	Make up water for hot water tank, boiler.
Double Check Valve Assemblies	Two independent check valves. Checks are replaceable for repair & testing.	Main incoming water line
Atmospheric vacuum breaker	Single float and disc with atmospheric port.	Dishwasher
Hose connection vacuum breakers	Single check with atmospheric vacuum breaker vent	Hose bibbs, service sink

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- .2 Reduced Pressure Zone Assemblies:
 - .1 Manufacturers:
 - .1 Watts Model LF909.
 - .2 A reduced pressure zone assembly shall be installed at each cross-connection to prevent back siphonage & backpressure of hazardous materials into the portable water supply.
 - .3 The assembly shall consist of a pressure differential relief valve located in a zone between two positive seating check valves.
 - .4 Back siphonage protection shall include provision to admit air directly into the reduced pressure zone via a separate channel from the water discharge channel or via a separate vent directly into the supply pipe.
 - .5 Assembly shall be constructed using lead free cast copper silicon materials.
 - .6 Assembly shall include two tightly closing shutoff valves before & after the assembly. Test cocks & a protective strainer upstream of the No. 1 shutoff valve.
 - .7 Conform to the requirements of ASSE Std 1013, AWWA Std C-511-92, CSA B64.4.
 - .3 Double Check Valve Assemblies:
 - .1 Manufacturer:
 - .1 Watts LF007
 - .2 A double check valve assembly shall be installed at each noted location.
 - .3 Two positive seating check modules with captured springs & rubber seat discs.
 - .4 Check module seats & seat disc shall be replaceable.
 - .5 Service of all internal components shall be through a single access cover secured with stainless steel bolts.
 - .6 Construction shall be lead free cast copper silicon alloy.
 - .7 Two resilient seated isolation valves, four top mounted, resilient seated test cocks.
 - .8 Conform to the requirements of ASSE Std 1015, AWWA Std C510
 - .4 Atmospheric Vacuum Breaker:
 - .1 Manufacturer:
 - .1 Watts LF288A, LF289, LFN 388
 - .2 Body: lead free cast silicon copper alloy
 - .3 Disc: Silicone
 - .4 Spill-resistant diaphragm
 - .5 Temperature Range: 82C (180F)
 - .6 Max Working Pressure: 15PSI (8.6 Bar)
 - .5 Hose Connection Vacuum Breakers
 - .1 Manufacturer
 - .1 Watts LF8
 - .2 Lead free hose connection vacuum breaker shall be constructed using lead free materials
 - .3 Copper silicon alloy body
 - .4 Conform to ANSI A112.1.3, ASSE Standard 1011

2.5 TRAP SEAL PRIMERS

- .1 Individual Traps:
 - .1 Manufacturer:
 - .1 Watts MS-810
 - .2 Brass trap seal primer with integral vacuum breaker.
 - .3 Copper sweat inlet & outlet connections.

2.6 CLEANOUTS

- .1 Interior Finished Floor Areas:
 - .1 Manufacturer:
 - .1 Zurn Z1840-6S
 - .2 12 gauge TYPE 304 stainless steel
 - .3 6" (150mm) square industrial cleanout
 - .4 Heavy duty grate. PVC Plug and bead blasted finish.
- .2 Interior Finished Wall Areas:
 - .1 Manufacturer:
 - .1 Watts WUCO
 - .2 Line type with lacquered cast iron body and round epoxy coated gasketed cover, and round stainless steel access cover secured with vandal proof stainless steel proof.
- .3 Stack Cleanouts
 - .1 Manufacturer:
 - .1 Watts CO-460-RD
 - .2 Cast iron stack cleanout with gasketed brass countersunk plug
 - .3 Stainless steel access cover
 - .4 Vandal proof stainless steel screw
- .4 Line Cleanouts
 - .1 Manufacturer:
 - .1 Watts CO-450-RD
 - .2 Epoxy coated cast iron cleanout with gasketed cover
 - .3 Stainless steel access cover
 - .4 Vandal proof stainless steel screw
- .5 Urinal Cleanouts
 - .1 Manufacturer:
 - .1 Zurn Z-1666-1
 - .2 Stainless steel access cover
 - .3 Vandal proof stainless steel screw

2.7 WATER HAMMER ARRESTORS

- .1 Manufacturer:
 - .1 Watts LF15M2
- .2 NPT solid hex lead free brass adapter end connection
- .3 Copper body lead free construction. Polypropylene piston. EPDM O-ring
- .4 Confirm to ASSE 1010, ANSI 112.26.1M, PDI WH201

2.8 WALL HYDRANT

- .1 Exterior Wall Hydrant, (NFHB):
 - .1 Watts Drainage model HY-725
 - .2 ANSI/ASSE 1019; non-freeze, self-draining type with polished nickel bronze box and cover for recessed mounting, all bronze head, seat casting and internal working parts, 3/4" (20 mm) hose thread spout, key operated, integral vacuum breaker, galvanized wall casing and hydrant key.
- .2 Interior Wall Hydrant, (H/C HB):
 - .1 Charland Thermojet Inc NL-550-TM-BV
 - .2 Wall mounted hot and cold mixer with ball valve.
 - .3 Max operating pressure: 150 PSI (1,034 kPa)
 - .4 Max operating temperature: 200F (93 C)
 - .5 Integrated check valves
 - .6 Stainless steel ball valves
 - .7 Vacuum breaker

3 EXECUTION

3.1 GENERAL

- .1 Install all products in accordance with the plumbing code and with manufacturer's instructions.

3.2 CLEANOUTS

- .1 Cleanouts shall be the same size as the pipe up to 4" (100mm) and not less than 4" (100mm) for larger pipes.
- .2 Provide cleanouts at the end of mains and branches, at changes in direction, in long straight runs and at the base of all soil stacks and rainwater leaders and where required by code.
- .3 Extend cleanouts to finished floor or wall surface.
- .4 Encase exterior cleanouts in concrete flush with grade.
- .5 Install floor cleanouts at elevation to accommodate finished floor.
- .6 Cleanouts in floors with surface membranes shall be installed with a membrane clamp and anchoring flange.
- .7 Lubricate threaded cleanout plugs with mixture of graphite and linseed oil.
- .8 Ensure clearance at cleanout for rodding of drainage system.

3.3 FLOOR DRAINS

- .1 Provide floor drains where indicated on architectural and plumbing floor plans.
- .2 Inspect locations where floor drains are shown to determine that floor is sloped appropriately. Report concerns to Consultant prior to installation of drains.
- .3 Coordinate installation with general trades.
- .4 Trap and vent all floor drains in accordance with Plumbing Code.
- .5 Provide trap seal priming for each floor drain trap.
- .6 Floor drains in floors with surface membranes shall be installed with a membrane clamp and anchoring flange.
- .7 Floor drains, traps and drain pipes installed in slabs on grade shall be embedded in concrete and made water-tight to prevent water seepage.

3.4 WATER HAMMER ARRESTORS

- .1 Install water hammer arrestors complete with an accessible isolation valve on hot and cold water supply piping to;
 - .1 plumbing fixtures and fixture groups,
 - .2 downstream of each backflow preventor,
 - .3 Owner's equipment and appliances with flush valves, solenoid valves or other quick closing valves
 - .4 wherever necessary to prevent water hammer.

3.5 TRAP SEAL PRIMERS

- .1 Condensate drains from cooling units may not be used to prime traps.
- .2 Where floor drains are being replaced having new trap seal primers, protect existing priming lines during the floor drain replacement process. Connect existing priming lines to new trap seal primers.

3.6 WALL HYDRANTS

- .1 Locate wall hydrants where indicated.
- .2 Coordinate installation with general trades.

3.7 BACKFLOW PREVENTION

- .1 Pipe relief or drain from backflow prevention device to nearest drain.
- .2 Install a strainer upstream of each backflow preventor.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Division 22 01 01.
- .2 Plumbing systems arrangement as shown on the Contract Drawings is diagrammatic. Refer to latest Architectural Drawings for final layout of walls, partitions, and building areas. The Division 22 – Plumbing Contractor must check and verify all dimensions and conditions on the Site, and ensure that the Work can be performed as indicated. Report all discrepancies to the Consultant before proceeding with the Work.
- .3 Prepare complete plumbing systems layout drawings, arranging piping runs in proper relation to other equipment such as light fixtures and ducts to ensure clear ceiling heights indicated on the Drawings. Maintain maximum headroom in areas with no ceilings. Refer to additional design requirements contained in other sections of the Division 22 Specification.
- .4 Plumbing systems layout drawings shall take into consideration architectural, structural, mechanical and electrical layouts of the building. Piping mains and branches must be arranged to not interfere with any of the aforementioned systems and equipment.
- .5

1.2 SECTION INCLUDES

- .1 Pipe, pipe fittings, valves, and connections for piping systems.
 - .1 Storm Sewer.
 - .2 Sanitary Sewer
 - .3 Sanitary Vent
 - .4 Domestic (Potable) Water.
- .2 Disinfection of potable water distribution system
- .3 Testing and reporting results

1.3 REFERENCES

- .1 ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
- .2 ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
- .3 ASME B16.23 - Cast Copper Alloy Solder Joint Drainage Fittings - DWV.
- .4 ASME B16.26 - Copper Alloy Bronze Fittings for Flared Copper Tubes.
- .5 ASME B16.29 - Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV.
- .6 ASME B16.32 - Cast Copper Alloy Solder Joint Fittings for Solvent Drainage Systems.
- .7 ASTM A74 - Cast Iron Soil Pipe and Fittings.
- .8 ASTM B32 - Solder Metal.
- .9 ASTM B42 - Seamless Copper Pipe, Standard Sizes.
- .10 ASTM B68 - Seamless Copper Tube, Bright Annealed.
- .11 ASTM B75 - Seamless Copper Tube.

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- .12 ASTM B88 - Seamless Copper Water Tube.
 - .13 ASTM B251 - General Requirements for Wrought Seamless Copper and Copper-Alloy Tube.
 - .14 ASTM B302 - Threadless Copper Pipe, Standard Sizes.
 - .15 ASTM B306 - Copper Drainage Tube (DWV).
 - .16 ASTM C1053 - Borosilicate Glass Pipe and Fittings for Drain, Waste, and Vent (DWV) Applications.
 - .17 ASTM D2235 - Solvent Cement for Acrylonitrile - Butadiene - Styrene (ABS) Plastic Pipe and Fittings.
 - .18 ASTM D2239 - Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.
 - .19 ASTM D2241 - Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
 - .20 ASTM D2447 - Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter.
 - .21 ASTM D2466 - Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
 - .22 ASTM D2564 - Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
 - .23 ASTM D2661 - Acrylonitrile-Butadiene-Styrene (ABS) Schedule 40 Plastic Drain, Waste, and Vent Pipe and Fittings.
 - .24 ASTM D2665 - Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
 - .25 ASTM D2729 - Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
 - .26 ASTM D2751 - Acrylonitrile-Butadiene-Styrene (ABS) Sewer, Pipe, and Fittings.
 - .27 ASTM D2846 - Chlorinated Polyvinyl Chloride (CPVC) Pipe, Fittings, Solvent Cements and Adhesives for Potable Hot Water Systems.
 - .28 ASTM D2855 - Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.
 - .29 ASTM D3034 - Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
 - .30 ASTM E814 - Fire Tests of Through-Penetration Fire Stops.
 - .31 ASTM F679 - Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
 - .32 ASTM F708 - Design and Installation of Rigid Pipe Hangers.
 - .33 AWWA C110 - Ductile - Iron and Gray - Iron Fittings, 3" - 48" (76 mm - 1219 mm), for Water.
 - .34 AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - .35 AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast, for Water.
 - .36 AWWA C651 - Disinfecting Water Mains.
 - .37 AWWA C900 - Polyvinyl Chloride (PVC) Pressure Pipe (and Fabricated Fittings), 4" - 12" (100 mm - 300 mm), for Water Distribution.
 - .38 AWWA C901 - Polyethylene (PE) Pressure Pipe and Tubing, 1/2" - 3" (13 mm - 76 mm) for Water Service.
 - .39 AWWA C902 - Polybutylene (PB) Pressure Pipe and Tubing, 1/2" - 3" (13 mm - 76 mm) for Water.
 - .40 AWWA C905 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14" - 48" (350 mm - 1200mm).
 - .41 CISPI 301 - Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste and Vent Piping Applications.
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- .42 CISPI 310 - Joints with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
- .43 MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
- .44 MSS SP69 - Pipe Hangers and Supports - Selection and Application.
- .45 MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices.

1.4 SUBMITTALS FOR REVIEW

- .1 Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalogue information. Indicate valve data and ratings.

1.5 SUBMITTALS AT PROJECT CLOSEOUT

- .1 Project Record Documents: Record actual locations of valves.

1.6 QUALITY ASSURANCE

- .1 Perform Work to Province of Ontario standards. Maintain one copy on site.
- .2 Identify pipe with marking including size, ASTM material classification, ASTM specification, potable water certification, water pressure rating.

1.7 REGULATORY REQUIREMENTS

- .1 Perform Work to Province of Ontario plumbing code.
- .2 Conform to applicable code for installation of backflow prevention devices.
- .3 Provide certificate of compliance from authority having jurisdiction indicating approval of installation of backflow prevention devices.

1.8 DELIVERY, STORAGE, AND PROTECTION

- .1 Accept valves on site in shipping containers with labelling in place. Inspect for damage.
- .2 Provide temporary protective coating on cast iron and steel valves.
- .3 Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- .4 Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.9 ENVIRONMENTAL REQUIREMENTS

- .1 Do not install underground piping when bedding is wet or frozen.

2 PRODUCTS

2.1 SANITARY SEWER PIPING BURIED

- .1 Cast Iron Pipe: ASTM A74 extra heavy weight.
 - .1 Fittings: Cast iron.

- .2 Joints: Hub-and-spigot, CISPI HSN compression type with ASTM C564 neoprene gaskets or lead and oakum.
- .2 Cast Iron Pipe: CISPI 301, hubless.
 - .1 Fittings: Cast iron.
 - .2 Joints: CISPI 310, neoprene gasket and stainless steel clamp and shield assemblies.
- .3 Copper Tube: ASTM B306, DWV.
 - .1 Fittings: ASME B16.23, cast bronze, or ASME B16.29, wrought copper.
 - .2 Joints: ASTM B32, solder, Grade 50B.
- .4 PVC Pipe: ASTM D2665 or ASTM D3034.
 - .1 Fittings: PVC.
 - .2 Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement.
- .5 PVC Pipe: ASTM D2665, ASTM D3034, or ASTM F679
 - .1 Fittings: PVC.
 - .2 Joints: ASTM F477, elastomeric gaskets.

2.2 SANITARY SEWER PIPING ABOVE GRADE

- .1 Cast Iron Pipe: ASTM A74, service weight.
 - .1 Fittings: Cast iron.
 - .2 Joints: ASTM C564, neoprene gasket system
- .2 Cast Iron Pipe: CISPI 301, hubless, service weight.
 - .1 Fittings: Cast iron.
 - .2 Joints: CISPI 310, neoprene gaskets and stainless steel clamp-and-shield assemblies.
- .3 Copper Tube: ASTM B306, DWV.
 - .1 Fittings: ASME B16.23, cast bronze, or ASME B16.29, wrought copper, or ASME B16.32, solvent.
 - .2 Joints: ASTM B32, solder, Grade 50B.

2.3 WATER PIPING, BURIED WITHIN 1500 mm (5 FEET) OF BUILDING

- .1 Copper Tubing: ASTM B42, hard drawn.
 - .1 Fittings: ASME B16.18, cast copper alloy or ASME B16.22 wrought copper and bronze.
 - .2 Joints: AWS A5.8, BCuP silver braze.
- .2 Copper Tubing: ASTM B42, annealed.
 - .1 Fittings: ASME B16.26, cast bronze.
 - .2 Joints: Flared.
- .3 Ductile Iron Pipe: AWWA C151.
 - .1 Fittings: Ductile iron, standard thickness.
 - .2 Lining: cement
 - .3 Joints: AWWA C111, rubber gasket with 3/4" (19 mm) diameter rods.

2.4 WATER PIPING, ABOVE GRADE

- .1 Copper Tubing: ASTM B88M, Type L, hard drawn.
 - .1 Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought

- copper and bronze.
- .2 Joints: ASTM B32, solder, Grade 95TA.

2.5 STORM WATER PIPING, BURIED WITHIN 1500 mm (5 FEET) OF BUILDING

- .1 Cast Iron Pipe: ASTM A74 extra heavy weight.
 - .1 Fittings: Cast iron.
 - .2 Joints: ASTM C564, neoprene gasket system or lead and oakum.
- .2 Cast Iron Pipe: CISPI 301, hubless, service weight.
 - .1 Fittings: Cast iron.
 - .2 Joints: Neoprene gaskets and stainless steel clamp-and-shield assemblies.
- .3 ABS Pipe: ASTM D2680 or ASTM D2751.
 - .1 Fittings: ABS.
 - .2 Joints: ASTM D2235, solvent weld, maximum VOC content of 325 g/L.
- .4 PVC Pipe: ASTM D2665 or ASTM D3034.
 - .1 Fittings: PVC.
 - .2 Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement.
- .5 PVC Pipe: ASTM D2665, ASTM D3034, or ASTM F679.
 - .1 Fittings: PVC.
 - .2 Joints: ASTM F477, elastomeric gaskets.

2.6 STORM WATER PIPING, ABOVE GRADE

- .1 Cast Iron Pipe: ASTM A74 extra heavy weight.
 - .1 Fittings: Cast iron.
 - .2 Joints: ASTM C564, neoprene gasket system or lead and oakum.
- .2 Cast Iron Pipe: CISPI 301, hubless, service weight.
 - .1 Fittings: Cast iron.
 - .2 Joints: Neoprene gaskets and stainless-steel clamp-and-shield assemblies.

2.7 FLANGES, UNIONS, AND COUPLINGS

- .1 Pipe Size 3-1/4" (80 mm) and Under:
 - .1 Ferrous pipe: Class 150 malleable iron threaded unions.
 - .2 Copper tube and pipe: Class 150 bronze unions with soldered joints.
- .2 Pipe Size Over 1" (25 mm):
 - .1 Ferrous pipe: Class 150 malleable iron threaded or forged steel slip-on flanges; preformed neoprene gaskets.
 - .2 Copper tube and pipe: Class 150 slip-on bronze flanges; preformed neoprene gaskets.
- .3 Grooved and Shouldered Pipe End Couplings:
 - .1 Housing: Malleable iron clamps to engage and lock, designed to permit some angular deflection, contraction, and expansion; steel bolts, nuts, and washers; galvanized for galvanized pipe.
 - .2 Sealing gasket: "C" shape composition sealing gasket.

- .4 Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

2.8 VALVES - GENERAL

- .1 Conform to requirements of ANSI, ASTM, ASME, and applicable MSS standards.
- .2 Provide valves of the same manufacturer where possible.
- .3 Manufacturer's name and pressure rating clearly marked on body to MSS-SP-25.
- .4 Valid CRN (Canadian Registration Number) issued by Province of Ontario required for each valve.
- .5 Materials:
 - .1 Bronze: ASTM B62 or B61 as applicable
 - .2 Brass: ASTM B283 C3770
 - .3 Cast Iron: ASTM A126 Class B
- .6 End Connections:
 - .1 Flanged ends: ANSI B16.1 (Class 125), ANSI B16.5
 - .2 Face-to-face dimensions: ANSI B16.10
- .7 Design and Testing:
 - .1 Bronze Gate & Check valves: MSS-SP-80
 - .2 Ball Valves: MSS-SP-110
- .8 First named product as indicated in paragraphs below; other acceptable manufacturers, subject to equivalent products listed on spread sheet attached.

2.9 ISOLATION VALVES

- .1 Up To and including 2" (50mm) - Ball type
 - .1 Manufacturer: Watts, MA Stewart
 - .2 Construction: MSS SP-110, Class 150, 600 psi (4140 kPa) CWP, forged brass, two piece body, stainless steel ball and stem, full port, virgin PTFE seats and stem packing, blow-out proof stem, lever handle with balancing stops, stem extensions for insulated piping, solder ends.

2.10 CHECK VALVES

- .1 Up to and Including 3" (75 mm):
 - .1 Manufacturers: Watts, MA Stewart
 - .2 Construction: MSS SP-80, 860 kPa (125psig) 200 WOG, bronze body to ASTM B62, bronze trim, solder ends

2.11 DRAIN VALVES

- .1 Up to 150 psig - Ball type:
 - .1 Manufacturers: Watts, MA Stewart
 - .2 Construction: 150 psig (1034 kPa), 600 WOG, brass body to ASTM C37700, two piece body, full port, PTFE seats and stem packing or double "O" ring, blow-out proof stem, Chrome Plated ball, lever handle with cap and chain, (3/4") 20 mm hose connection.

2.12 CIRCUIT BALANCING VALVES

- .1 Up to 2" (50mm):
- .2 Manufacturer: SA Armstrong, MA Stewart
- .3 Furnish and install, as shown on plans and in accordance to manufacturer's installation instructions, Armstrong Circuit Balancing Valves. Valves are to be of the 'Y' pattern, equal percentage globe-style and provide three functions:
 - .1 Precise flow measurement
 - .2 Precision flow balancing
 - .3 Positive drip-tight shut-off
- .4 Valve shall provide multi-turn, 360° adjustment with micrometer type indicators located on the valve handwheel. Valves shall have a minimum of five full 360° handwheel turns. 90° 'circuit-setter' style ball valves are not acceptable. Valve handle shall have hidden memory feature, which will provide a means for locking the valve position after the system is balanced.
- .5 Valves shall be furnished with precision machined venturi built into the valve body to provide highly accurate flow measurement and flow balancing. The venturi shall have two, 1/4" threaded brass metering ports with check valves and gasketed caps located on the inlet side of the valve. Valves shall be furnished with flow smoothing fins downstream of the valve seat and integral to the forged valve body to make the flow more laminar. The valve body, stem and plug shall be brass. The handwheel shall be high-strength resin.

2.13 WATER PRESSURE REDUCING VALVES

- .1 Up to 2" (50 mm):
 - .1 Manufacturers:
 - .1 Armstrong Model GD 24.
 - .2 Watts Model Series 223.
 - .2 MSS SP-80, bronze body, stainless steel and thermoplastic internal parts, fabric reinforced diaphragm, strainer, threaded ends.
- .2 Over 2" (50 mm):
 - .1 Manufacturers:
 - .1 Armstrong Model GD 200.200H.
 - .2 Watts Model Series N223.
 - .2 MSS SP-85, cast iron body, bronze fitted, elastomeric diaphragm and seat disc, flanged.

2.14 RELIEF VALVES

- .1 Pressure Relief:
 - .1 Manufacturers:
 - .1 Watts Model Series 40.
 - .2 AGA Z21.22 certified, bronze body, teflon seat, steel stem and springs, automatic, direct pressure actuated.

2.15 STRAINERS

- .1 Up to 125 psig:
 - .1 Size 2" (50 mm) and Under:
 - .1 Manufacturers: Mueller Steam 351M
 - .2 Construction : 860 kPa (125 psig) 200 WOG Rating, Bronze body, Screwed Cap, Y Pattern, 304 stainless steel screen with 20 Mesh perforation, Threaded Ends.
 - .2 Size 2-1/2" (65 mm) and larger:
 - .1 Manufacturers: Mueller Steam 758
 - .2 Construction : 860 kPa (125 psig)/ 200 WOG Rating, Cast Iron body, Bolted Cover, Y Pattern, 304 stainless steel screen with 1/16 & 1/8 perforation, Threaded Ends.
- .2 Up to 250 psig:
 - .1 Size 2" (50 mm) and Under:
 - .1 Manufacturers: Mueller Steam 11M
 - .2 Construction : Class 250, 400 psig WOG, cast iron body, Y-pattern, screwed cap and ends, A167 304 stainless steel screen with 1/32" perforations.
 - .2 Size 2-1/2" (65 mm) and larger:
 - .1 Manufacturers: Mueller Steam 758
 - .2 Construction : 300 psig non-shock WOG, cast iron, Y-pattern, bolted cover, blow-out plug, A167 304 stainless steel screen with 1/32" perforations, flanged ends.

2.16 DISINFECTION CHEMICALS

- .1 Chemicals: AWWA B300, Hypochlorite,

3 EXECUTION

3.1 EXAMINATION

- .1 Verify that excavations are to required grade, dry, and not over-excavated.

3.2 PREPARATION

- .1 Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- .2 Remove scale and dirt, on inside and outside, before assembly.
- .3 Prepare piping connections to equipment with flanges or unions.

3.3 INSTALLATION

- .1 Install to manufacturer's instructions.
- .2 Provide non-conducting dielectric connections wherever jointing dissimilar metals.
- .3 Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.

-
- .4 Install piping to maintain headroom, conserve space, and not interfere with use of space.
 - .5 Group piping whenever practical at common elevations.
 - .6 Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
 - .7 Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
 - .8 Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with general trades.
 - .9 Establish elevations of buried piping outside the building to ensure not less than 5'6" (1.6 m) of cover.
 - .10 Install vent piping penetrating roofed areas to maintain integrity of roof assembly; coordinate with roof and waterproofing specification.
 - .11 Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer (maximum VOC content of 80 g/L) to welding.
 - .12 Provide support for utility meters to requirements of utility companies.
 - .13 Prepare exposed, unfinished pipe, fittings, supports, and accessories ready for finish painting where required. Coordinate with general trades.
 - .14 Excavate and backfill as required for work of this Section.
 - .15 Install bell and spigot pipe with bell end upstream.
 - .16 Install valves with stems upright or horizontal, not inverted.
 - .17 Pipe vents from gas pressure reducing valves to outdoors and terminate in weather proof hood.
 - .18 Sleeve pipes passing through partitions, walls and floors.
 - .19 Inserts:
 - .1 Provide inserts for placement in concrete formwork.
 - .2 Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - .3 Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4" (100 mm).
 - .4 Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
 - .5 Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
 - .20 Pipe Hangers and Supports:
 - .1 Install to OBC (Plumbing Code)
 - .2 Support horizontal piping as scheduled.
 - .3 Install hangers to provide minimum 1/2" (15 mm) space between finished covering and adjacent work.
 - .4 Place hangers within 12" (300 mm) of each horizontal elbow.
 - .5 Use hangers with 1-1/2" (40 mm) minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
 - .6 Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
 - .7 Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
-

- .8 Provide copper plated hangers and supports for copper piping.
- .9 Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
- .10 Provide hangers adjacent to motor driven equipment with vibration isolation.
- .11 Support cast iron drainage piping at every joint.

3.4 UNDERGROUND WATER MAINS 4" AND LARGER

- .1 Install pipes to bear throughout their full length. Do not support piping by the bell ends only or by blocks.
- .2 Anchoring of Mains: Provide pipe clamps and tie-rods, thrust blocks, locked mechanical or push-on mechanical joints utilizing set screw retainer glands or other approved methods or devices.
- .3 Sizing clamps, rods, bolts & washers.
 - .1 Clamps: 1/2" x 2" (12.7 x 50 mm) for pipe 6" (150 mm) and smaller
 - .2 Rods: minimum size of 5/8" (16 mm)
 - .3 Clamp bolts: minimum 5/8" (16 mm)
 - .4 Washers: minimum 5/8" x 3" (16 x 75 mm) cast iron or steel, round or square.
- .4 Sizing of anchor straps for tees: minimum 5/8" (16 mm) thick by 2-1/2" (62 mm) wide.
- .5 Sizing of plug strap for bell end pipe: minimum 3/4" (20 mm) thick by 2-1/2" (62 mm) wide.
- .6 Clean all bolted joint accessories thoroughly and coat with asphalt or other corrosion retarding material after installation.
- .7 Thrust Blocks:
 - .1 Provide at each change in direction of pipeline and at all tees, plugs, caps, and bends.
 - .2 Use a concrete mix not leaner than one part cement, two and one-half parts sand, and five parts stone. Place backing between undisturbed earth and fitting to be anchored.
 - .3 In general, place backing so that the joints will be accessible for inspection and repair.
- .8 Area of Bearing Face of Concrete Thrust Blocks

PIPE SIZE	1/4 BEND		1/8 BEND		TEES, PLUGS, CAPS AND HYDRANTS	
	SQ. FT.	SQ. M	SQ. FT.	SQ. M	SQ. FT.	SQ. M
4"	2	0.19	2	0.19	2	0.19
6"	5	0.46	3	0.28	4	0.37
8"	8	0.74	5	0.46	6	0.56
10"	13	1.21	7	0.65	9	0.84
12"	18	1.67	10	0.93	13	1.21

- .9 The above bearing face areas are based on undisturbed soil. Use the following multiplying factors for the following ground conditions:
 - .1 Soft Clay 4.0
 - .2 Sand 2.0
 - .3 Sand & Gravel 1.3
 - .4 Shale 0.4
- .10 Do hydrostatic testing prior to backfilling over joints.
- .11 Backfilling: backfill as indicated. In addition, puddle where possible to prevent settlement or lateral movement.
- .12 Install ductile iron pipe and fittings in accordance with AWWA C600, Standard for installation of Ductile Iron and Cast-Iron Watermains. Provide minimum frost cover for watermain 5'-6" (1600 mm).
- .13 Stretch copper tube installed underground until it is straight and every bend made in it thereafter shall be made with tools designed for the purpose of bending with constant radius. Provide minimum frost cover for watermain of 5'-6" (1600 mm).
- .14 Water main will be brought into building to a point 12" (310 mm) above floor, capped with a blank flange by trades doing outside services.

3.5 UNDERGROUND SEWER LINES

- .1 Provide qualified personnel to properly layout and establish all lines and grades necessary for construction. Accurately verify location and inverts of all existing services before any sewer work is started to ensure that connection of new sewers to existing can be made. Construct and maintain adequate batter boards, alignment markers and secondary bench marks as may be required for proper execution of work.
- .2 Batter boards or sight lines shall be set not more than 25 ft. (7.5 m) apart. A minimum of three (3) batter boards shall be in place at all times during laying operation.
- .3 Notify Consultant of any layout work to be carried out, Consultant shall have right to check Contractor's layout at any time, but checking layout or failure to do so on part of Consultant in no way relieves Contractor of full responsibility for construction to exact alignment and grade.
- .4 Verify all existing invert elevations before setting out drainage work.
- .5 Sewer lines, connections shall be built to exact lines and grades as shown on drawings. No deviation from these lines and grades will be permitted unless approved in writing by Consultant.
- .6 Completely surround plastic piping by at least 4" (100 mm) of non-cohesive ballast material of which at least 50% will pass a 1/4" (6.35 mm) sieve and 100% will pass a 1/2" (12.7 mm) sieve, and that is sufficiently consolidated so that the intended earth loading will not produce further compaction.

3.6 APPLICATION

- .1 Use grooved mechanical couplings and fasteners only in accessible locations.

- .2 Install unions downstream of valves and at equipment or apparatus connections.
- .3 Install brass male adapters each side of valves in copper piped system. Solder adapters to pipe.
- .4 Install gate valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- .5 Install globe valves for throttling, bypass, or manual flow control services.
- .6 Provide lug end butterfly valves adjacent to equipment when provided to isolate equipment.
- .7 Provide plug valves in natural gas systems for shut-off service.
- .8 Provide flow controls in water recirculating systems where indicated.

3.7 ERECTION TOLERANCES

- .1 Establish invert elevations, slopes for drainage to 2 percent minimum. Maintain gradients.
- .2 Slope water piping minimum 0.25 percent and arrange to drain at low points.

3.8 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

- .1 Disinfect all new and altered water distribution piping.
- .2 Verify that piping system is complete and has been flushed, cleaned, inspected, and pressure tested.
- .3 Isolate existing piping to full extent possible. Ensure that all fixtures, exiting and new that are served from piping being disinfected, are taken out of service and signs are placed at each fixture prohibiting use during the disinfection period.
- .4 Schedule and perform disinfecting activities with start-up, testing, adjusting, balancing, and demonstration procedures. Coordinate with related systems.
- .5 Ensure Ph of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).
- .6 Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/L residual.
- .7 Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15 percent of outlets.
- .8 Maintain disinfectant in system for 24 hours.
- .9 If final disinfectant residual tests less than 25 mg/L, repeat treatment.
- .10 Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.
- .11 Take samples no sooner than 24 hours after flushing, from 10 percent of outlets and from water entry, and analyze to AWWA C651.

3.9 SERVICE CONNECTIONS

- .1 Provide new sanitary sewer services. Before commencing work check invert elevations required for sewer connections, confirm inverts and ensure that these can be properly connected with slope for drainage and cover to avoid freezing.
- .2 Provide new water service complete with approved reduced pressure backflow preventer and water meter with by-pass valves pressure reducing valve.
- .3 Provide new gas service complete with gas meter and regulators. Gas service distribution piping to have initial minimum pressure of 1.75 kPa. Provide regulators on

each line serving gravity type appliances, sized to equipment.

3.10 SCHEDULES

- .1 Pipe Hanger Schedule:
 - .1 Metal Piping:
 - .1 Pipe size: 1/2" to 1-1/4" (15 to 32 mm):
 - .1 Maximum hanger spacing: 6.5' (2 m).
 - .2 Hanger rod diameter: 3/8" (9 mm).
 - .2 Pipe size: 1-1/2" to 2" (40 to 50 mm):
 - .1 Maximum hanger spacing: 10' (3 m).
 - .2 Hanger rod diameter: 3/8" (9 mm).
 - .3 Pipe size: 2-1/2" to 3" (65 to 75 mm):
 - .1 Maximum hanger spacing: 10' (3 m).
 - .2 Hanger rod diameter: 1/2" (13 mm).

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 22 01 01

1.2 SECTION INCLUDES

- .1 Stainless steel sinks, cup sinks, faucets, spouts,
- .2 Emergency showers, head-arm-flange, valves, accessories
- .3 Eyewash stations

1.3 REFERENCES

- .1 ASME A112.18.1 - Plumbing Fixture Fittings.
- .2 ASME A112.19.2 - Vitreous China Plumbing Fixtures.
- .3 ASME A112.19.4 - Porcelain Enamelled Formed Steel Plumbing Fixtures.
- .4 ASME A112.19.5 - Trim for Water-Closet Bowls, Tanks, and Urinals.
- .5 CAN/CSA-B45.0 General Requirements for Plumbing Fixtures
- .6 CAN/CSA-B45.1 Ceramic Plumbing Fixtures
- .7 CAN/CSA-B45.2 Enamelled Cast Iron Plumbing Fixtures
- .8 CAN/CSA-B45.3 Porcelain-Enamelled Steel Plumbing Fixtures
- .9 CAN/CSA-B45.4 Stainless Steel Plumbing Fixtures
- .10 CAN/CSA-B125.1 Plumbing Supply Fittings
- .11 CAN/CSA-B125.2 Plumbing Waste Fittings
- .12 CAN/CSA-B125.3 Plumbing Fittings
- .13 CAN/CSA-B125.6 Flexible Water Connectors

1.4 SUBMITTALS FOR REVIEW

- .1 Product Data:
 - .1 Provide catalogue illustrations of fixtures
 - .2 sizes
 - .3 rough-in dimensions
 - .4 service sizes (capacities)
 - .5 trim
 - .6 finishes

1.5 SUBMITTALS FOR INFORMATION

- .1 Manufacturer's Instructions: Indicate installation methods and procedures.

1.6 SUBMITTALS AT PROJECT CLOSEOUT

- .1 Maintenance Data: Include fixture trim exploded view and replacement parts lists.
- .2 Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.7 QUALITY ASSURANCE

- .1 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this Section with minimum five years documented experience.
- .2 Installer Qualifications: trades license with minimum five years documented experience.

1.8 REGULATORY REQUIREMENTS

- .1 Products Requiring Electrical Connection: Listed and classified by CSA, ULC, cUL or Special Inspection as suitable for the purpose specified and indicated.

1.9 DELIVERY, STORAGE, AND PROTECTION

- .1 Transport, handle, store, and protect products.
- .2 Accept fixtures on site in factory packaging. Inspect for damage.
- .3 Protect installed fixtures from damage by securing areas and by leaving factory packaging in place to protect fixtures and prevent use.

2 PRODUCTS

(SEE PLUMBING APPENDIX)

3 EXECUTION

3.1 EXAMINATION AND PREPARATION

- .1 Section 22 05 00: Verification of existing conditions before starting work.
- .2 Verify that walls and floor finishes are prepared and ready for installation of fixtures.
- .3 Verify that electric power is available and of the correct characteristics.

3.2 PREPARATION

- .1 Rough-in fixture piping connections to minimum sizes indicated in fixture rough-in schedule for particular fixtures.

3.3 INSTALLATION

- .1 Install each fixture with trap, easily removable for servicing and cleaning.
- .2 Provide chrome plated rigid supplies to fixtures with screwdriver stops, reducers, and escutcheons.
- .3 Install components level and plumb.
- .4 Install and secure floor mounted fixtures in place with bolts.
- .5 Seal fixtures to wall and floor surfaces with sealant having VOC content not exceeding 250 g/L. Colour to match fixture.

3.4 ADJUSTING

- .1 Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.

3.5 CLEANING

- .1 Clean plumbing fixtures and equipment.

3.6 PROTECTION OF FINISHED WORK

- .1 Do not permit use of fixtures.

END OF SECTION

GEORGIA -C341723000



Vitreous china elongated bowl, 425 mm (16 3/4 in) in height, siphon jet action, 54 mm (2 1/8 in) completely glazed trapway, left, right or top push button/lever, skirted concealed trap.

Z5957SS-AM



Solid plastic elongated seat for super-intensive use with anti-microbial protection, open front, with cover, molded bumper guard, stainless steel check hinges and fasteners. (White). **3777-**



ZH8824CRLKQ-PC - One quarter-turn, chrome plated, solid brass heavy angle stop with round wheel handle or loose key as specified, one 12[305] flexible chrome plated copper lavatory complete with one chrome plated steel flange.



Z5321

581 x 514 mm (22 7/8 x 20 1/4")

Vitreous china wall hung lavatory for barrier-free application, 581 x 514 mm (22 7/8 x 20 1/4 in), backsplash, front overflow, pre-drilled for concealed arms, drilled single hole.



Z6956XL-CWB-CV-F

Arched style hardwired electronic sensor faucet with ceramic valve, 1.9 L/min. (0.5 usgpm) spray outlet, single hole installation, polished chrome finish, infrared convergence type proximity sensor, on-demand activation with a 30 seconds run time, in-line filter, pre-mixed water supply. Includes 4 "AA" batteries as battery back-up to faucet during power outages, braided stainless steel hose supplies. Supplied with 85 in cable wire (CWB).



P6000-HW6

Hardwired power converter 120VAC/7.6 VDC, 2 amp., capable of supplying for 8 faucets or 8 flush valves or 8 faucets/ flush valves combined.



ZH8824XL-LKQ-PC/Z8952-58 (2)

One quarter-turn, chrome plated, solid brass heavy angle stop with round wheel handle or loose key as specified, one 12[305] flexible chrome plated copper lavatory complete with one chrome plated steel flange.



170-LF

127 mm x 120 mm (5 X 4") Thermostatic point of use mixing valve, 3/8" inlets, 3/8" outlet, compression connections, bronze body, Locked temperature adjustment cap (vandal resistant), Copper encapsulated thermostat assembly with, polymer thermoplastic shuttle, stainless steel springs, Buna-N O-rings, integral check valves on hot and cold inlets, compression fittings on inlets and outlet. Minimum Flow: 1.9 l/min (0.5 usgpm). Maximum Pressure: 125 PSI (8.6 BAR). Maximum Hot Water temperature: 93°C (200 °F). Certified ASSE 1070.



37DWC

32 mm "Daisy" type strainer offset drain assembly, cast brass body, 32 mm (1 1/4 in), polished chrome finish.



Z8700-8-PC-BD

32 mm (1 1/4") Cast brass adjustable P-trap, 32 mm (1 1/4 in) with deep wall flange and cleanout, chrome plate finish.



Z1231

Back to back concealed wall hung carrier, steel uprights with welded feet, cast iron adjustable headers, concealed arms, alignment truss and mounting fasteners.



Z8946-3-NT

Antimicrobial protectors, resists thermal transfers for P-trap, offset drain assembly, stop and supply.

7600-H-15

Thermostatic (T type) mixing valve for concealed piping, copper encapsulated thermostat assembly with brass shuttle, compensates for temperature and minor pressure fluctuation, rotation from cold to hot, high temperature limit stop factory preset at 43 °C (110 °F), brass body, internal brass, copper and stainless steel components, metal trim and handle, color-coded indicator, combined service stops/check stops, DN 13 mm (1/2") sweat inlet and outlet, DN 13 mm (1/2") threaded bottom outlet, 15 L/min (4 usgpm) flow. Institutional adjustable water saver shower head, chromed thermoplastic ABS body, ball joint, 5.7 L/min (1.50 usgpm), chromed brass mounting plate with optional chromed brass anchor plate.

Product's notes : Note : Pressure regulators will be required if pressure differential between hot and cold water is greater than 10%.

Norms : ASME A112. 18. 1/CSA B125.1





7600-515P

Thermostatic (T type) mixing valve for concealed piping, copper encapsulated thermostat assembly with brass shuttle, compensates for temperature and minor pressure fluctuation, rotation from cold to hot, high temperature limit stop factory preset at 43 °C (110 °F), brass body, internal brass, copper and stainless steel components, metal trim and handle, color-coded indicator, combined service stops/check stops, DN 13 mm (1/2") sweat inlet and outlet, DN 13 mm (1/2") threaded bottom outlet, 15 L/min (4 usgpm) flow. Grab bar of 610 mm (24"), fixed massage hand shower, with backflow preventer, (82") chromed hose, 5.7 L/min (1.5 usgpm).

Product's notes : Note : Pressure regulators will be required if pressure differential between hot and cold water is greater than 10%.

Norms : ASME A112. 18. 1/CSA B125.1



1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Read and conform to:
 - .1 The Contract CCDC 2-2008, Stipulated Price Contract as amended,
 - .2 Division 1 requirements and documents referred to therein.
- .2 Section 23 01 01 applies to and governs the work of all Sections of Division 23.
- .3 The technical Sections of this Division are generally divided into units of work for the purpose of ready reference. The division of the work among subcontractors is not the Consultant's responsibility and the Consultant assumes no responsibility to act as an arbiter and/or to establish subcontract limits between any Sections of the work.
- .4 The specifications are integral with the drawings which accompany them. Neither is to be used alone. Any item or subject omitted from one but implied in the other is fully and properly required.
- .5 Wherever differences occur in the tender documents, the most onerous condition governs. Base the bid on the most costly arrangement.

1.2 DEFINITIONS

- .1 The following are definitions of words found in this specification and on associated drawings under this Division:
 - .1 "Concealed" locations hidden from normal sight in furred spaces, shafts, ceiling spaces, walls, and partitions.
 - .2 "Exposed" mechanical work normally visible to building occupants.
 - .3 "Furnish" (and its derivatives) has the same meaning as the term "Supply".
 - .4 "Install" (and its derivatives) - receive, store and handle at the site, mount and support and connect all required services. Includes adjustment and calibration, testing, commissioning, inspection by authorities having jurisdiction and documentation.
 - .5 "Provide" (and its derivatives) - supply, install in place, connect the associated required services ready for operation, adjust and calibrate, test, commission, warrant, and document. Includes inspection by authorities having jurisdiction.
 - .6 "Supply" (and its derivatives) purchase and deliver to the site for installation. Includes submittals, manufacturer's field inspection and warranty.
 - .7 "Wet" locations exposed to moisture, requiring special materials and arrangement.

1.3 WORK INCLUDED

- .1 Products and methods mentioned or shown in the Contract Documents complete with incidentals necessary for a complete operating installation. Provide all tools,

- equipment and services required to do the work.
- .2 Identification of equipment, piping, ductwork, and valves and controllers.
- .3 Motors required for equipment supplied under this Division.
- .4 Variable frequency drives for motors and equipment supplied under this Division.
- .5 Internal wiring, relays, contactors, switches, transformers, motor starters, and all controls necessary for the intended operation, furnished with terminals and external controls suitable for connection to power source at a single easily accessed location for equipment items that are supplied with motors and/or electrical or electronic components under this Division.
- .6 Refer to Mechanical/Electrical Equipment Schedule for extent of wiring and electrical characteristics.
- .7 Verify the correct operation of each equipment item provided and/or altered and each system in total and obtain the Owner's approval prior to starting and/or returning to operation.

1.4 RELATED WORK

- .1 Power wiring, conduit and connections for motors under this Division will be by Division 26.
- .2 Power wiring, conduit and connections to variable frequency drives for motors under this Division will be by Division 26. Wiring and connections from VFD to motors under this Division will be by Division 26.
- .3 Flashings for mechanical equipment and services located on or passing through roofs will be provided under Division 7. Supply counter flashings, and integral flashing collars on equipment and piping under this Division.
- .4 Painting of exposed piping and ductwork other than for identification will be supplied under Division 9.

1.5 SUBMITTALS

- .1 Approval Drawings: Prepare and submit drawings necessary for approval to any authority having jurisdiction and obtain two (2) copies of approved drawings for retention by Consultant prior to commencement of work under this Division.
- .2 Shop Drawings: Prepare and submit two (2) hard copies and one (1) electronic copy of shop drawings of major equipment items (including those items specifically indicated under Part 1: General of each Section), to the Consultant for review. The Consultant will return one copy, marked with comments and his review stamp as he deems appropriate. Prepare the necessary number of copies of the returned set and distribute to the Owner, the Prime Consultant, the General Contractor, the site, and to subcontractors and suppliers.
 - .1 Clearly indicate manufacturer's and supplier's names, catalogue model numbers, details of construction, accurate dimensions, capacities and performance. Prior to submission check and certify as correct, shop drawings and data sheets. Do not order equipment until a copy of the shop drawings, reviewed by Consultant, has been returned to Contractor.
 - .2 Clearly indicate the weight, location, method of support and anchor point forces and locations for each piece of equipment on shop drawings.
 - .3 The Consultant will not review shop drawings that fail to bear the

-
- Contractor's stamp of approval or certification.
- .4 Read the following in conjunction with the wording on the shop drawing review stamp applied to each and every drawing submitted:
"This review by the Consultant is for the sole purpose of ascertaining conformance with general design concept. This review shall not mean that the Consultant approves the detail design inherent in the shop drawings, responsibility for which shall remain with the Contractor submitting same, and such review shall not relieve the Contractor of his responsibility for errors or omissions in the shop drawings or of his responsibility for meeting all requirements of the Contract Documents. The Contractor is responsible for dimensions to be confirmed and correlated at the job site, for information that pertains solely to fabrication processes or to techniques of construction and installation and for coordination of the work of all sub trades."
- .3 Composite Wiring Diagrams: Prepare and submit three (3) copies of complete composite wiring diagrams of each specific mechanical system. Indicate all electrical equipment and wiring, both internal and external, for review and coordination of trades.
- .4 Contractor's Material and Test Certificates: Prepare and submit certificates for each system installed. Where certificates are prescribed by regulations, codes or standards ensure they conform to the requirements of those documents. Include a copy of each certificate in the Operation and Maintenance manual. Certificates shall include the following:
- .1 description of the system (description and type),
 - .2 description of the tests conducted and results observed, including re-testing, where necessary,
 - .3 description of any corrective measures undertaken,
 - .4 description of materials used (pipe and fittings),
 - .5 list of witnesses for each test conducted,
 - .6 date system left ready for service,
 - .7 signature of installing Contractor.
- .5 Directories & Schematics
- .1 Submit five (5) copies of a neat typewritten directory indicating the valve number, related service, and location of each valve under this Division.
 - .2 Submit five (5) copies of system control schematics for each mechanical system indicating relative locations of equipment and control devices.
 - .3 Enclose one (1) copy of each directory/schematic under glass in a neat polished 18" x 24" (460 mm x 610 mm) metal frame, complete with mounting clips.
- .6 Maintenance Data and Operating Instructions
- .1 Submit three (3) copies of Operation and Maintenance Manual individually bound in hard backed three-ring binders.
 - .2 Ensure the binder spines have typewritten lettering as follows:
OPERATION & MAINTENANCE MANUAL
for
TCDSB
"Insert date of submission"
Division 23 00 00
-

-
- .3 Provide a list of names, addresses and telephone numbers of equipment suppliers, installing contractors, general contractors, architect and Consultant. Include special telephone numbers for service departments on normal and emergency call basis.
 - .4 Provide descriptive literature (shop drawings) of each manufactured item. Include a bill of material with purchase order numbers and vendor's identification of equipment orders for each item.
 - .5 Include copies of start-up reports and checklists and all certificates issued with respect to this contract.
 - .6 Ensure operating instructions include the following:
 - .1 General description of each mechanical system.
 - .2 Step by step procedure to follow in putting each piece of equipment into service.
 - .3 Schematic control diagrams for each separate mechanical system, control thermometers, freezestats, firestats, pressure gauges, automatic valves, and refrigeration accessories. Mark correct operating settings for each control device on these diagrams.
 - .4 Diagram of the electrical control system indicating the wiring of all related electrical components such as PE and EP switches, firestats, freezestats, fuses, interlocks, electrical switches and relays.
 - .5 Drawings of each control panel including temperature control and electrical panels, completely identifying all components on the panels and their function.
 - .7 Ensure maintenance instructions include the following:
 - .1 Manufacturer's maintenance instructions for each item of mechanical equipment installed under this Division. Instructions shall include installation instructions, parts numbers and lists, name of supplier and maintenance and lubrication instructions.
 - .2 Summary list of each item of mechanical equipment requiring lubrication, indicating the name of the equipment item, location of all points of lubrication, type of lubricant recommended, and frequency of lubrication.
 - .3 Equipment directory indicating name, model, serial number and nameplate data of each item of equipment supplied, and system with which it is associated.
 - .4 Balancing and testing reports.
 - .5 Copy of valve directory.
 - .7 As-Built Records: Prepare and submit complete as-built records prior to Substantial Performance of the Contract. Refer to Division 1 for requirements.

1.6 QUALITY ASSURANCE

- .1 Conform to minimum requirements or better of provincial and local codes, where existing, and to requirements of local inspection authorities for execution of work under this Division.
- .2 Ensure materials supplied under this Division conform to minimum requirements

- and recommendations or better of applicable standards of the following:
- .3 Use latest editions and amendments in effect on date of Bid call subject to requirements of OBC.
 - .4 Arrange and pay for permits and inspections by authorities having jurisdiction, required in the undertaking of this Division. Make modifications required by authorities.
 - .5 All tradesmen employed on the project shall hold valid trade certificates/licenses and shall make a copy available for review by the Consultant and/or Owner when requested.
 - .6 All welding and brazing shall be executed by certified welders in accordance with registered procedures.
 - .7 All refrigeration work shall be executed only by mechanics with valid ODP cards.

1.7 PRODUCT DELIVERY, HANDLING AND STORAGE

- .1 Immediately after letting of contract, review material and equipment requirements for this work, determine supply and delivery dates for all items, and notify Consultant of any potential delays in completion of this project in order that remedial action may be taken.
- .2 Store neatly out of the way and protected from damage and theft, materials and equipment supplied under this Division that are received at the site by this Division.

1.8 JOB CONDITIONS

- .1 Visit site and examine existing conditions which may affect work of this Division.
- .2 Examine all Contract Documents to ensure that work of this Division may be satisfactorily completed.
- .3 Notify Consultant upon discovery of conditions which adversely affect work of this Division. No allowance will be made after letting of contract for any expenses incurred through failure to do so.
- .4 Submission of a bid confirms that the Contract Documents and site conditions are accepted without qualifications, unless exceptions are specifically noted in the Bid.

1.9 WARRANTY

- .1 Refer to General Conditions. Arrange with each manufacturer/supplier to extend warranties as necessary to coincide with warranty period or those periods specified.
- .2 Make submissions necessary to register product warranties to the benefit of the Owner.
- .3 Submit to Consultant, prior to Substantial Performance of the Contract, manufacturer's written warranties covering periods longer than one year or offering greater benefits than required in specifications and in the Owner's name.

1.10 INTERRUPTIONS

- .1 Arrange execution of work to maintain present building operations, and to

- minimize the effect of work under this Division on existing operations.
- .2 Prior to interrupting any existing service notify the Owner and Consultant, in writing, at least 7 days in advance, and obtain written authorization. Do not interrupt any existing service without Consultant's specific authorization. Refer to Division 1 for requirements.
- .3 Arrange time and duration of interruption through the Owner's Physical Plant Department. Include in Bid Price for all overtime or premium time hours necessary to minimize duration of service interruption.
- .4 Test and verify the proper operation of existing equipment and systems that are shut down due to work of this project, prior to returning to service.
- .5 Assume responsibility for consequential costs on failure to obtain permission to shut-down and/or start-up any item of equipment, system or service.

1.11 PHASING AND SCHEDULING

- .1 The contractor shall phase the work as required to support commissioning, start-up & construction services.
- .2 All phasing shall be in correspondence & agreement with the general contractor.
- .3 The contractor shall comprehend construction activities in conjunction with the general contractor & perform phasing as such to support construction activities.
- .4 Coordinate work of all Sections of Division 23 with other trades and assist in the development of the Phasing Strategy.
- .5 Refer to O.B.C. Division C, Part 1, Subsection 1.3.3 Occupancy of Unfinished Building
- .6 Where occupancy of a part of the work is required prior to completion of the entire project, ensure that equipment, systems and services that serve the areas to be occupied are completed, tested and fully operational 2-weeks prior to scheduled turn over and ensure that reports, certificates and documentation are submitted at that time.

2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- .1 Ensure materials and equipment provided under this Division are new and free from defects and bear labels of approval as required by codes referred to in this Division and/or by inspection authorities.
- .2 Ensure apparatus and equipment provided under this Division bears manufacturer's nameplate indicating name of manufacturer, model number or type, size, capacity, CRN, and other pertinent information. Ensure nameplates are easily read and clearly visible, with openings provided where equipment is insulated.
- .3 Ensure manufacturers and suppliers of equipment or materials under this Division determine if their products are composed of any hazardous materials. If they are, the products are suitably labeled and supplied with Material Safety Data sheets. Obtain the Owner's approval in writing to bring hazardous materials onto the site prior to doing so.
- .4 When utilizing any products that are hazardous, keep Material Safety Data

sheets on file at the job site and present them to anyone requesting this information. When transferring hazardous materials from original container into other containers, provide Workplace Labels on such containers.

2.2 ACCEPTABLE PRODUCTS

- .1 First item named or specified by catalogue number meets specifications regarding performance, quality of material and workmanship, and is acceptable to the Consultant.
- .2 Items, other than first named, meeting specifications regarding quality of materials and workmanship are acceptable to the Consultant, only, if they also meet performance and/or capacities specified and can be accommodated within the space allotted.
- .3 General approval indicated by inclusion of other manufacturers named is subject to final review of shop drawings, performance data and test reports.

2.3 EQUIVALENTS AND ALTERNATIVES

- .1 Suppliers wishing approval for additional equipment items or alternatives as equivalent to those specified **must submit complete description, technical and performance data to the Toronto Catholic District School Board's (TCDSB) Procurement Services Department Representative at least twelve (12) working days prior to Bid closing date.** Such equivalent equipment, if accepted, to conform to specifications with regard to all details, accessories, modifications, features and performance. Deviations from specifications must be stated in writing at time of submission for approval.
- .2 Bid Prices shall include only products specified or approved equivalents.

2.4 SUBSTITUTIONS DURING PROGRESS OF WORK

- .1 Refer to Section 01 25 00.

2.5 CONSULTANT'S REVIEW

- .1 The consultants will review and evaluate unsolicited alternatives and substitutions proposed by the Contractor. Such review and evaluation work will be undertaken by the Consultant on an additional fee basis. The Contractor shall reimburse the Owner for all costs associated with such reviews and evaluations.
- .2 The Contractor shall also reimburse the Owner for any and all costs incurred in updating Contract Documents to reflect such changes.

3 EXECUTION

3.1 RELATIONSHIP WITH OTHER TRADES

- .1 Cooperate with other trades whose work affects or is affected by work of this Division to ensure satisfactory installation and to avoid delays.
- .2 Provide materials to be built-in, such as sleeves, anchors, and inserts, together with templates and/or measurements, promptly when required by other trades.
- .3 Provide structural supports for equipment to be mounted on or in walls,

supported above floors and/or suspended from the structure.

3.2 INSTALLATION REQUIREMENTS

- .1 The Consultant's drawings and instructions govern the location of all items. Prepare fully coordinated installation drawings prior to installation.
- .2 Install equipment neatly to the satisfaction of the Consultant. Unless noted otherwise install products and services to follow building planes. Ensure installation permits free use of space and maximum headroom.
- .3 Confirm the exact location of outlets, fixtures and connections. Confirm location of outlets for equipment supplied under other Divisions.
- .4 Install equipment and apparatus to allow free access for maintenance, adjustment and eventual replacement.
- .5 Provide suitable shielding and physical protection for devices.
- .6 Install products and services in accordance with the manufacturer's requirements and/or recommendations.
- .7 Provide bases, supports, hangers and fasteners. Secure products and services so as not to impose undue stresses on the structure and systems.
- .8 Do not use power activated tools without written permission of the Consultant. Use them in accordance with the Owner's health and safety policies.
- .9 Ensure that the load onto structures does not exceed the maximum loading per square metre indicated on the structural drawings or as directed by the Consultant.

3.3 CONTRACT DRAWINGS

- .1 The drawings of this Division are performance drawings and indicate general arrangement of the work. They are diagrammatic except where specific details are given.
- .2 Obtain accurate dimensions from the architectural and structural drawings, or by measurement. Location and elevation of services are approximate. Verify them before construction is undertaken.
- .3 Make changes where required to accommodate structural conditions, (beams, columns, etc.). Obtain Consultant's approval before proceeding.
- .4 Adjust the location of materials and/or equipment as directed without adjustment to contract price, provided that the changes are requested before installation and do not affect material quantity. **Note that outlets and/or equipment may be relocated up to 10 feet (3 m) in any direction without a change to the contract price.**
- .5 Note that the layout and orientation of the ceiling outlets on the architectural reflected ceiling drawings may differ from that shown on the mechanical drawings. Make the installation in accordance with the latest architectural ceiling drawings. Provide the equipment as specified and/or shown on the documents of this Division.
- .6 The drawings of this Division are intended for tender pricing. The quantities and quality to be included in the bid price shall be based on the layout and specifications as shown on the mechanical documents. If there is a difference in quantity between the architectural and drawings of this Division, base the

- contract price on the greater quantity.
- .7 Prepare installation (construction) drawing to reflect the latest architectural ceiling layout.

3.4 CONSTRUCTION DRAWINGS

- .1 Prepare fully dimensioned drawings showing devices, fixtures, equipment, outlets, sleeves and openings through structure. Indicate locations and weights on load points.
- .2 Prepare fully dimensioned construction drawings of products and services suitably interfaced with work of the sub-trades, in mechanical rooms, service and ceiling spaces, and other critical locations. Coordinate the work with other divisions. Base drawings on reviewed shop drawings and latest architectural drawings. Indicate details pertaining to the following: access, clearances, cleanouts, sleeves, electrical connections, drain locations and elevation of pipes, ducts, conduits.
- .3 Prepare drawings of pits, curbs, sills, equipment bases, anchors, inertia slabs, etc.
- .4 Submit construction drawings to other Divisions. Provide one (1) transparency and four (4) print copies of construction drawings to the Consultant for record purposes.
- .5 Submit construction drawings prior to commencement of work.

3.5 RECORD DRAWINGS

- .1 Maintain project "as-built" record drawings. Obtain white prints from the Consultant for this purpose and pay printing costs. Identify each set as "Project Record Copy".
- .2 Record deviations from contract documents caused by site conditions or by changes ordered by the Consultant. Record deviations in red ink clearly and accurately, using industry standard drafting procedures consistent with quality and standards of Consultants documents.
- .3 Record deviations as work progresses throughout the execution of this contract. Maintain record drawings on site in clean, dry, legible condition, making them available for periodic review by the Consultant.
- .4 Record location of concealed services, particularly underground services. Before commencing any backfilling, obtain accurate measurements and information concerning correct location and depth of services.

3.6 USE OF EQUIPMENT

- .1 For the duration of this contract, do not use any piece of equipment provided under this contract for the purposes of heating, ventilation or air conditioning without the specific authorization of the Owner and Consultant. Ensure the building is "broom clean" and painting is finished before asking permission for testing to commence.
- .2 Where specific written authorization is given for the use of equipment while work is still in progress, seal off ductwork, grilles, diffusers, and registers or other openings to the air distribution systems or air handling equipment that is not in

use. Provide filters over openings in ductwork, over grilles, diffusers and registers and in or at any air handling equipment that is in use. Ensure that the edges are sealed so that the filters are not bypassed. Change the filters frequently, to the satisfaction of the Consultant, until the building is turned over the Owner.

3.7 SPECIAL TOOLS AND SPARE PARTS

- .1 Within 30 days of award of contract, prepare a complete itemized list of spare parts and submit to Consultant for review. List will be used as a checklist and should include provision for sign off by the Owner on receipt.
- .2 On completion of the project furnish spare parts to the Owner as follows:
 - .1 One set of new filters for each filter bank installed (per equipment).
- .3 Identify spare parts containers as to contents and replacement parts number.

3.8 EXTRAS AND CREDITS

- .1 Accompany all price submissions requested by Consultant for extra work, or work to be deleted, with a complete cost breakdown as follows:
 - .1 Materials, quantities and unit costs including any applicable contractors trade discount clearly identified.
 - .2 Labour hours and unit costs.
 - .3 Total materials and labour costs.
 - .4 Overhead and profit mark-ups in accordance with the General Conditions of the Contract.

3.9 INSTRUCTION

- .1 Instruct and familiarize Owner's operating personnel with the various mechanical systems. Arrange instruction for each system separately.
- .2 Provide instruction for each system on two separate occasions, coordinated with the Owner's staff operating schedule, in order that interested personnel may arrange to attend.
- .3 Ensure each instruction period includes, but is not limited to the following:
 - .1 a classroom seminar with operating manuals, product and system drawings and such other audio/visual aids as may be appropriate,
 - .2 instruction during the classroom seminar by the manufacturer's representative regarding the proper operating and maintenance procedures for each item of equipment,
 - .3 demonstration of the proper operating procedures for each item of equipment,
 - .4 explanation of the purpose and function of all safety devices provided,
 - .5 demonstration of all measures required for safe and proper access for operation and maintenance.
- .4 Provide a period of follow-up instruction (on two occasions) approximately one month after completing Owner's instruction to clarify and reinforce earlier instructions.
- .5 Submit a letter from the Owner's management staff indicating the instruction has been given satisfactorily to the Consultant prior to substantial completion of the

project.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 23 01 01.

1.2 COMMON WORK RESULTS

- .1 Section 23 05 00 applies to and governs all work of Division 23.

1.3 REFERENCE STANDARDS

- .1 Provide all work in accordance with requirements of Regulatory Agencies and conform to:
 - .1 Local and district by-laws, regulations and published engineering standards.
 - .2 the Ontario Building Code as amended,
 - .3 the Ontario Gas Utilization Code as amended
 - .4 Regulations for Construction Projects under The Occupational Health and Safety Act.
 - .5 Fire Code made under the Fire Marshal's Act.
- .2 Conform to following CSA Standards:
 - .1 CAN/CSA-B149-15: Natural Gas & Propane Installation Code.
 - .2 CSA B242 Groove and Shoulder Type: Mechanical Pipe Couplings.
 - .3 CSA W48 series Electrodes.
 - .4 CSA B51, Boiler, Pressure Vessel and Pressure Piping Code.
 - .5 CAN/CSA-W117.2, Safety in Welding, Cutting and Allied Processes
- .3 Conform to following National Research Council Canada publications:
 - .1 National Building Code of Canada and Supplements to National Building Code of Canada
 - .2 National Fire Code of Canada.
 - .3 Canadian Plumbing Code.
- .4 Conform to following American Society for Testing and Materials (ASTM) Standards:
 - .1 ASTM E1 - Specification for ASTM Thermometers.
 - .2 ASTM E77 - Inspection and Verification of Thermometers.
- .5 Conform to NEMA MG 1 - Motors and Generators.
- .6 Provide work where indicated in conformance with guide Specification of the Victaulic System for Building Services, G-100.
- .7 The above documents or portions thereof are referenced within the work of Division 23 and shall be considered part of the requirements of this document as though fully repeated herein.

1.4 QUALIFICATIONS

- .1 Motor manufacturer: Company specializing in manufacture of electric motors for HVAC use, and their accessories, with minimum three years documented product development, testing, and manufacturing experience.
- .2 Firestop Sealant Manufacturer: Company specializing in manufacture of sealants

with minimum three years documented product development, testing, and manufacturing experience.

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

1.5 SUBMITTALS

- .1 Submit shop drawings in accordance with refer to section 23 01 01.

1.6 DELIVERY, STORAGE, AND HANDLING

- .1 Transport, handle, store, and protect products. refer to Division 1 requirements as well.
- .2 Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

2 PRODUCTS

2.1 PIPING SPECIALTIES

- .1 Cast brass, pressure, copper to copper unions shall be used with seamless copper tubing smaller than 3" (75 mm).
- .2 Cast brass flanges shall be used with seamless copper tubing, type L for tubing 3" (75 mm) and larger.
- .3 Dart type, 125 lb. (860 kPa) black malleable iron unions shall be used with all steel pipe for piping 2-1/2" (65 mm) and smaller.
- .4 Slip-on, 150 lb. (1000 kPa) carbon steel flanges with 1/16" (4 mm) raised face shall be used with all steel pipe for piping larger than 2-1/2" (65 mm).
- .5 Gaskets for joining flanged steel pipe shall be 1/16" (4 mm) Cranite ring type gaskets.
- .6 Piping specialties including backflow preventers, strainers, valves etc. shall be line size unless indicated otherwise on drawings.

2.2 ADHESIVES, SEALANTS, PAINTS AND COATINGS

- .1 Adhesives, Sealants, Paints and Coatings: Use only low VOC emitting materials meeting following criteria;
 - .1 Paint for Mechanical Identification: maximum VOC emission of 250g/L
 - .2 Touch-Up Paint: maximum VOC emission of 250g/L
 - .3 Zinc-Rich Primer: maximum VOC emission of 250g/L
 - .4 Adhesives for Mechanical Identification: maximum VOC emission of 70g/L
 - .5 Sealants for service penetrations: maximum VOC emission of 650g/L clear and 350 g/L pigmented
 - .6 Sealants for Firestopping: max. VOC emission of 650g/L clear and 350 g/L pigmented
 - .7 Acrylic Sealant for supports and anchors: maximum VOC emission of 250g/L

- .8 Insulation Vapour Barrier Lap Adhesive: maximum VOC emission of 80g/L
- .9 Insulation Joint Sealer: maximum VOC emission of 250g/L
- .10 Insulation Vapour Barrier Mastic: maximum VOC emission of 400g/L
- .11 Flame Retardant Adhesive: maximum VOC emission of 650g/L clear and 350 g/L pigmented

2.3 WELDING ELECTRODES

- .1 Electrodes: in accordance with CSA W48 Series.

2.4 NAMEPLATES

- .1 Provide laminated plastic plates with black face and white centre of minimum size 3-1/2" x 1-1/2" x 3/32" (90 x 40 x 2 mm) nominal thickness, engraved with 1/4" (6 mm) high lettering. Use 1" (25 mm) lettering for major equipment.
- .2 Fasten nameplates securely in conspicuous place. Where nameplates cannot be mounted on cool surface, provide standoffs.
- .3 Identify equipment type and number and service of areas or zone of building served.
- .4 For each item of equipment which may be started automatically or remotely, add a red lamacoid plate, 2-1/2" x 9" (65 x 230 mm), reading: "WARNING. THIS EQUIPMENT IS AUTOMATICALLY CONTROLLED AND MAY START AT ANY TIME."

2.5 TAGS

- .1 Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background colour. Tag size minimum 1-1/2" (40 mm) diameter.
- .2 Chart: Typewritten letter size list in anodized aluminum frame.

2.6 ACCESS DOORS

- .1 Standard Universal Flush
 - .1 Material: Up to 16" x 16" (400x400) 16 Gauge mounting frame, over 16" x 16" (400x400) 14 gauge door, 16 gauge mounting frame.
 - .2 Hinge: Continuous, concealed.
 - .3 Latch: Stainless steel screwdriver operated cam latch
 - .4 Finish: Steel: 5-stage iron phosphate preparation with prime coat of white, Alkyd Baking Enamel or stainless steel type 304, No. 4 satin polish.
 - .5 Manufacturers:
 - .1 Acudoor UF-500
 - .2 CEB
 - .3 MIFAB
 - .4 Cendrex Contour
- .2 Recessed Access Door
 - .1 Material: Steel or stainless steel, 22 gauge door, 22 gauge mounting frame. Door -recessed 5/8"
 - .2 Hinge: Continuous, concealed.

- .3 Latch: Stainless steel screwdriver operated cam latch
- .4 Finish: Satin coat steel
- .5 Manufacturers:
 - .1 Acudoor UF-5015
 - .2 CEB
 - .3 MIFAB
 - .4 Cendrex Contour
- .3 Fire Rated
 - .1 Access doors in fire separations or fire rated assemblies: ULC labelled. Refer to Architectural drawings for ratings of fire separations and assemblies. Minimum 12 gauge.
 - .2 Hinge: Continuous, concealed.
 - .3 Latch: Stainless steel screwdriver operated cam latch
 - .4 Finish: Steel: 5-stage iron phosphate preparation with prime coat of white, Alkyd Baking Enamel or stainless steel type 304, No. 4 satin polish.
 - .5 Manufacturers:
 - .1 Acudoor
 - .2 CEB
 - .3 MIFAB
 - .4 Cendrex Contour

2.7 PRESSURE GAUGES

- .1 Manufacturer: Trerice Model 600C.
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Weiss
 - .2 Winter
 - .3 Morrisson
 - .4 Taylor
- .3 Gauge: 4-1/2" (115mm) diameter black cast aluminum, phosphor bronze bourdon tube, rotary brass movement, brass socket, with front recalibration adjustment, black scale on white background, mid-scale accuracy: 1%, scale: psi and kPa.
- .4 Gauge Cock: Tee or lever handle, brass for maximum 150 psi (1034 kPa).
- .5 Needle Valve: Brass, 1/4" (6 mm) NPT for minimum 150 psi (1034 kPa).
- .6 Pulsation Damper: Pressure snubber, brass with 1/4" (6 mm) connections.
- .7 Syphon: Steel, Schedule 40, 1/4" (6 mm) angle or straight pattern.

2.8 STEM TYPE THERMOMETERS

- .1 Manufacturer: Trerice Model BX91403-1/2.
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Weiss Model 9VS3-1/2.
 - .2 Winter
 - .3 Morrison
 - .4 Taylor
- .3 Thermometer: 9" (230mm) scale, red appearing thermal fluid with black figures on white scale, calibrated in both degrees F and degrees C, accuracy to ASTM

- E77 of 2%, clear glass lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device, 3/4" (20mm) NPT brass stem.
- .4 All thermometers to include a separable well.
- .5 Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.
- .6 Flange: 3" (75 mm) outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

2.9 DIAL THERMOMETERS

- .1 Manufacturer: Terice
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Weiss.
 - .2 Winter.
 - .3 Morrisson.
 - .4 Taylor
- .3 Thermometer: ASTM E1, stainless steel case, vapour or liquid actuated with brass or copper bulb, copper or bronze braided capillary, white with black markings and black pointer glass lens.
 - .1 Size: 2-3/8" (60 mm) diameter dial.
 - .2 Lens: Clear glass.
 - .3 Length of Capillary: Minimum 60" (1500 mm).
 - .4 Accuracy: 2 percent.
 - .5 Calibration: Both degrees F and degrees C.
- .4 Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.
- .5 Flange: 3" (75 mm) outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

2.10 TEST PLUGS

- .1 Manufacturer: Pete's Plug.
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Watts TP.
- .3 Test Plug: 1/4" or 1/2" (6 mm or 15 mm) brass fitting and cap for receiving 1/8" (3 mm) outside diameter pressure or temperature probe with neoprene core for temperatures up to 93°C (200°F).
- .4 Test Kit: Carrying case, internally padded and fitted containing one diameter pressure gauges, one gauge adapters with 1/8" (3 mm) probes, two 1" (25 mm) dial thermometers.

2.11 STATIC PRESSURE GAUGES

- .1 Manufacturer: Terice
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Weiss.
 - .2 Winter.
 - .3 Taylor.

- .3 3-1/2" (90 mm) diameter dial in metal case, diaphragm actuated, black figures on white background, front recalibration adjustment, 2 percent of full scale accuracy.
- .4 Inclined manometer, red liquid on white background with black figures, front recalibration adjustment, 3 percent of full scale accuracy.
- .5 Accessories: Static pressure tips with compression fittings for bulkhead mounting, 1/4" (6 mm) diameter tubing.

2.12 ADHESIVES, SEALANTS, PAINTS & COATINGS

- .1 Adhesives, Sealants, Paints and Coatings: Use only low VOC emitting materials meeting following criteria;
 - .1 Sealants for Service Penetrations: maximum VOC emission of 650g/L clear and 350 g/L pigmented
 - .2 Sealants for Firestopping: max. VOC emission of 650g/L clear and 350 g/L pigmented

2.13 FIRESTOPPING COMPOUNDS

- .1 Manufacturer: 3M products indicated.
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Dow Corning
 - .2 John Manville
 - .3 Hilti Firestop Systems
- .3 Fire Rated Sealants: intumescent material, synthetic elasomers, capable of expanding up to 8 to 10 times when exposed to temperatures of 250°F (121°C) or higher. ULC listed and labelled.

2.14 SLEEVES

- .1 Materials: minimum schedule 20 galvanized steel or cast iron.

2.15 FLASHINGS AND COUNTERFLASHINGS

- .1 Thaler or equivalent mechanical/electrical flashings as recommended for specific purpose.
- .2 Stainless steel flashing sleeve, integral deck flange and EPDM seal.

3 EXECUTION

3.1 INSPECTION

- .1 Inspect installed work of other trades and verify that such work is complete to point where work under this Division may properly commence.
- .2 Verify that work of this Division may be executed in accordance with pertinent codes and regulations, specifications, drawings, and referenced standards.
- .3 Review drawings and verify dimensions at the site. Report discrepancies immediately to Consultant before proceeding with any construction work or shop drawings.

3.2 PREPARATION

- .1 Existing services and equipment shall be relocated or removed to suit new construction and renovation work.
- .2 Services that are no longer required shall be removed or cut back and capped to the satisfaction of Consultant.
- .3 Obtain written authorization from Consultant for renovation work that is not specifically indicated.
- .4 Where modifications or connections to existing systems require shutdown of the system the Contractor shall submit a request for system shutdown describing the system or part to be shutdown, the duration of the shutdown, the work planned and steps to be taken to reinstate the system to full operation. The request shall be submitted in the format stipulated by the Owner.
- .5 All work required to prepare systems for shutdown and/or re-instatement, such as draining, chemical treatments, and re-filling shall be included in this Bid Price.

3.3 PIPING INSTALLATION - ABOVE GROUND

- .1 Cooperate with other trades whose work affects or is affected by work of this Section, to ensure satisfactory installation and to avoid delays. Provide all materials to be built-in such as sleeves, anchors, etc., together with accurate dimensions or templates, promptly.
- .2 Layout all work accurately, installing piping parallel to lines of building.
- .3 Install piping, wherever possible, in partitions and above ceiling. Do not install piping in outside walls unless so shown on drawings. Wrap uninsulated piping in masonry walls with building paper.
- .4 Install concealed piping close to building structure to minimize furring dimensions.
- .5 Provide adequate space around piping to facilitate application of insulation.
- .6 Use dielectric couplings where piping of dissimilar metals connect.
- .7 Where piping passes through concrete floors, or walls, sleeves shall be sized to permit the pipe to expand freely without binding or crushing pipe insulation.
- .8 Where branch pipes are welded into main without the use of "T" connections, torch cut openings must be cut true, bevelled and filed smooth. Branch pipes must not be allowed to project inside of main pipe. Openings must not be cut large enough to permit entry of welding metal and slag within the pipe.
- .9 Arrange all take-offs from mains to allow for expansion and contraction of pipes. Hot water branches serving downfeed risers must be taken from lower sides or bottom of mains and grade down slightly to risers. Branches which serve units above the mains shall be taken from the top or sides of mains.
- .10 Install pressure independent automatic control valves and wells supplied under other Sections.

3.4 PIPING JOINTS

- .1 Make joints in piping installed under this Division using persons familiar with the particular materials being used and in accordance with CSA B51 and CSA B52, manufacturer's instructions, and as specified herein.

-
- .2 Use silver solder or Silfos for joining copper tubing 4" (100 mm) and larger in size.
 - .3 Carefully ream joints in threaded pipe and paint with approved graphite type joint sealer on male connections only. Make connections with proper wrench to suit pipe size. Where leaks occur, the joint shall be disassembled and corrected if possible, or replaced. Over-tightening, caulking or peening will not be acceptable.
 - .4 When using Victaulic Grooved Piping Method:
 - .1 Make joints in grooved piping with couplings and gaskets in accordance with Victaulic Company of Canada Ltd, General Catalogue G-100, latest edition. Cut or roll grooves using tools specifically designed for that purpose.
 - .2 Use Zero-flex or rigidlok couplings in locations where rigidity is required, in particular in mechanical rooms on coils, headers and pumps.
 - .3 Vic-Boltless couplings may be used.
 - .5 Install unions or welding flanges at connections to valves, etc. to facilitate removal.

3.5 FLUSHING AND CLEANING

- .1 Thoroughly flush all piping installed by this Division.
- .2 Remove, clean and replace all strainers in systems after flushing.
- .3 Thoroughly clean and lubricate HVAC equipment and leave all items in perfect order ready for operation.

3.6 PIPING SYSTEMS TESTING AND INSPECTION

- .1 Prior to tests, isolate all equipment or other parts which are not designed to withstand test pressures.
- .2 Test all piping at the completion of roughing-in, before connecting to existing systems, and prior to concealment, insulation or covering of piping.
- .3 Make tests, that are required by any authority having jurisdiction, in the presence of the authority's authorized inspector and shall be certified by him.
- .4 Conduct tests in the presence of:
 - .1 Authorized inspector(s) for authorities having jurisdiction.
 - .2 The Commissioning Agent
 - .3 The Owner's Representative
 - .4 The Consultant
- .5 Notification must be given at least 48 hours in advance of tests being conducted, to all persons required to be present.
- .6 Repair all leaks exposed during testing and retest. If defects in pipe or fittings are discovered in the system, they shall be removed and replaced.
- .7 Certify tests not required by authorities having jurisdiction.

3.7 EQUIPMENT TESTING AND INSPECTION

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

-
- requiring adjustment or replacement.
 - .2 Pay all fuel consumption charges for equipment under testing and during commissioning.
 - .3 Conduct tests before application of external insulation and before concealment of piping or ductwork.
 - .4 Arrange and pay for inspections by authorities as required by code and complete any changes or alterations required by such inspections.
 - .5 Conduct tests in the presence of:
 - .1 Authorized inspector(s) for authorities having jurisdiction.
 - .2 The Commissioning Agent.
 - .3 The Consultant.
 - .4 The Owner's Representative.
 - .6 Notification must be given at least 48 hours in advance of tests being conducted, to all persons required to be present.

3.8 TESTING AND BALANCING

- .1 Allow sufficient time for testing and verification prior to substantial completion. Notify Testing and Balancing Agency on completion of adjusting and balancing of systems.
- .2 Adjust systems and components (drives, sheaves, belts, etc.) as required by Testing and Balancing Agency.
- .3 Maintain systems in full operation during testing and verification.
- .4 Make adjustments to control systems as required to facilitate verification. Maintain all safety controls in operation.
- .5 Check and correct alignment of V-belts, drive shaft coupling drives, etc. as required by Testing and Balancing Agency.
- .6 Provide pitot tube test fittings at all main branches of sheet metal work and at intake and discharge locations of air handling systems as required by Testing and Balancing Agency.

3.9 ELECTRICAL COMPONENTS AND WIRING

- .1 Conform to requirements of Division 26 for all wiring included in Division 23. Includes pre-wired equipment provided by Sections under Division 23.
- .2 Ensure that all pre-wired electrical equipment is CSA approved. Arrange and pay for special approval where this is not possible.
- .3 Coordinate all wiring requirements with other Divisions. Line voltage wiring from power distribution panels to starters and from starters to motors will be provided under Division 26. All field wiring for equipment shall be included under Division 23, unless specifically called for under Division 25.

3.10 PROTECTION

- .1 Protect finished and unfinished work by tarpaulins, or other covering, from damage due to execution of work under this Division.
- .2 Repair to satisfaction of Consultant, damage to building resulting from failure to provide such protection.
- .3 All existing air intake and exhaust openings that may be affected by dust and/or

debris from the construction work shall be fitted with appropriate filter media to protect against entry of dust and/or debris into the building and its air distribution systems. Filters shall be closely monitored and replaced when necessary. The Contractor shall replace existing filters that become contaminated with dust and/or debris from construction work with new filters.

- .4 In the event that dust and debris from construction work does penetrate the building and/or its air distribution systems, the Contractor shall be responsible for cleaning the affected areas and/or systems.
- .5 Temporary filters shall be removed on completion of the construction works.

3.11 SEALANTS & CAULKING

- .1 Fill voids around pipes:
 - .1 Seal between sleeve and pipe in foundation walls and below grade floors with penetration seals (link-seal)). Install as per manufacturer's installation instructions.
 - .2 Where sleeves pass through non-fire rated walls or floors, caulk space between pipe and sleeve with fiberglass. Seal space at each end with waterproof, fire retardant, non-hardening mastic.
 - .3 Ensure no contact between copper tube or pipe and ferrous sleeve.
 - .4 Fill future-use sleeves with easily removable filler.
 - .5 Coat exposed exterior surfaces or ferrous sleeves with heavy application of zinc rich paint (VOC content not to exceed 250 g/L).
- .2 Temporarily plug all openings during construction.

3.12 FIRESTOPPING

- .1 All openings in fire separations and fire rated assemblies for service penetrations shall be protected with ULC listed service penetration firestop systems (SP).
- .2 The service penetration firestop system shall have F and FT ratings equal to or greater than ratings specified by the Architect for the fire separation (F) and firewall (FT) joint firestop systems (JF).
- .3 All components employed in the service penetration firestop system shall conform to the ULC listing.
- .4 Contractor shall prepare and submit a schedule of service penetration firestop systems to be employed indicating the ULC listing designation, services involved, location of opening through fire separation and the components of the fire separation assembly.
- .5 Refer to architectural drawings for ratings of fire separations and assemblies.

3.13 SLEEVES AND CURBS

- .1 Provide pipe sleeves at points where pipes pass through masonry or concrete.
- .2 Provide sleeves of minimum schedule 20 galvanized steel or cast iron.
- .3 Use cast iron or steel pipe sleeves with annular fin continuously welded at midpoint:
 - .1 through foundation walls, with penetration seals.
 - .2 through floors of mechanical rooms and equipment rooms.
- .4 Provide 1/4" (6 mm) clearance all around, between sleeve and pipes or between

-
- sleeve and insulation.
 - .5 Where piping passes below footings, provide minimum clearance of 2" (50 mm) between sleeve and pipe. Backfill up to underside of footing with concrete of same strength as footing with concrete of same strength as footing.
 - .6 Terminate sleeves flush with surface of concrete and masonry and 2" (50 mm) above floors. Not applicable to concrete floors on grade.
 - .7 Provide watertight concrete curb 4" (100 mm) high around mechanical services (pipes, ducts, conduits) which rise through mechanical (service) room floors. Provide minimum 4" (100 mm) clearance between openings for services within curbs.
 - .8 For pipes passing through roofs, use cast iron sleeves with caulking recess and flashing clamp device. Anchor sleeves in roof construction, caulk between sleeve recess and pipe, fasten roof flashing to clamp device, make water-tight durable joint. Co-ordinate with roofing Section.

3.14 FLASHINGS

- .1 Provide all flashing at each point where piping passes through the roof.
- .2 Coordinate this work with the roofing Trades to ensure a satisfactory installation and to avoid delays.

3.15 ESCUTCHEONS AND PLATES

- .1 Provide on pipes passing through finished walls, partitions, floors and ceilings.
- .2 Use chrome or nickel-plated brass, solid type with set screws for ceiling or wall mounting.
- .3 Inside diameter shall fit around finished pipe. Outside diameter shall cover opening or sleeve.
- .4 Where sleeve extends above finished floor, escutcheon or plates shall clear sleeve extension.
- .5 Secure to pipe or finished surface, but not insulation.

3.16 SUPPORT AND ATTACHMENT

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

3.17 PAINTING

- .1 Repair minor damage to finish of equipment with standard factory applied baked enamel finish under the appropriate Sections of this division. Replace entirely, items suffering major damage to finish if too extensive to be repaired in the opinion of the Consultant.
- .2 Apply at least one coat of corrosion resistant primer paint to supports, and equipment fabricated from ferrous metals.

3.18 DISSIMILAR METALS

- .1 Separate dissimilar metals in order to prevent galvanic corrosion.
- .2 Provide gaskets or shims of approved materials to avoid electrolytic action.
- .3 Use dielectric unions and/or flanges where piping of dissimilar metals are connected.

3.19 EQUIPMENT BASES AND CURBS

- .1 Provide all necessary inserts, anchor bolts and other fasteners required, for floor mounted tanks, heaters, pumps, air handlers, boilers, etc Anchor equipment to pads using 8" (200 mm) cast-in-place anchor bolts.

3.20 SERVICE CONNECTIONS

- .1 Include in Bid Price all amounts required by utilities for service connections and /or modifications to service connection. Ensure amounts include fees, assessments, charges, etc., required in relation to service connection.

3.21 FIELD QUALITY CONTROL

- .1 Temporary and Trial Usage
 - .1 Do not construe such usage as evidence of acceptance of work by Owner.
 - .2 Repair damage to work tested, resulting from such trial usage, by this Contractor at no cost to Owner.
- .2 Systems Verification:
 - .1 Verify the correct installation and proper operation of equipment and systems installed. Adjust and balance each system as necessary to achieve optimum operation of each system.
 - .2 Co-operate with the TAB agency as follows:
 - .1 provide assistance when and as requested,
 - .2 co-ordinate completion of work systematically to permit orderly verification and adherence to schedules,
 - .3 provide additional necessary flow balancing devices as directed by agency,
 - .4 notify TAB Agency of tests being conducted.

3.22 ADJUST AND CLEAN

- .1 Clean equipment and fixtures, lubricate mechanical equipment installed under this Division and leave items in perfect order ready for operation.
- .2 Test and adjust control devices, instrumentation, relief valves, dampers, etc., installed in this Division after cleaning of systems and leave in perfect order ready for operation.
- .3 Remove from the premises upon completion of work of this division, debris, surplus, and waste materials resulting from operations.

3.23 MECHANICAL IDENTIFICATION INSTALLATION

- .1 Degrease and clean surfaces to receive adhesive for identification materials.
- .2 Prepare surfaces for stencil painting.
- .3 Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer (VOC content not to exceed 680 g/L).
- .4 Install tags with corrosion resistant chain.
- .5 Comply with standard detail drawing plate, "Detail of Piping Identification".
- .6 Apply stencil markings on all covered piping.
- .7 Install plastic tape pipe markers complete around bare pipe to manufacturer's instructions.
- .8 Identify control panels and major control components outside panels with plastic nameplates.
- .9 Identify valves in main and branch piping with tags. Consecutively number valves in each system.
- .10 Identify piping, concealed or exposed, with stencilled painting and plastic tape pipe markers. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 6 m on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.
- .11 For each item of equipment which may be started automatically or remotely, add a red lamacoid plate, 2-3/8" x 9" (60 x 230 mm), reading: **"WARNING. THIS EQUIPMENT IS AUTOMATICALLY CONTROLLED. IT MAY START AT ANY TIME."**
- .12 Provide colour coded self-adhesive dots to locate valves or dampers above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

3.24 MECHANICAL IDENTIFICATION SCHEDULES

- .1 Consult the Owner and identify piping, ductwork and equipment as directed;
 - .1 conforming to the Owner's existing identification practices, or
 - .2 conforming to the following Pipe and Valve Identification Table:

SERVICE	COLOURS		LEGEND
	BACKGROUND	LETTERS	
City water	Green	Black	CITY WATER
Hot water heating supply	Yellow	Black	HEATING SUPPLY
Hot water heating return	Yellow	Black	HEATING RETURN
Glycol Heating Supply	Yellow	Black	GLYCOL SUPPLY
Glycol Heating Return	Yellow	Black	GLYCOL RETURN
Chilled Water Supply	Yellow	Black	CHILLED WATER SUPPLY
Chilled Water Return	Yellow	Black	CHILLED WATER RETURN
Fresh Air Ductwork	Green	Black	FRESH AIR

Exhaust Air Ductwork	Green	Black	EXHAUST AIR
Supply Air Ductwork	Yellow	Black	RETURN AIR
Return Air Ductwork	Yellow	Black	SUPPLY AIR
Make-up water	Yellow	Black	MAKE-UP WTR
Humidifier Feed Water	Yellow	Black	HUM. FEED
Gas regulator vents	to Code		

3.25 MANUFACTURER'S NAMEPLATES

- .1 Provide metal nameplates on each piece of equipment, mechanically fastened with raised or recessed letters.
- .2 Include registration plates, Underwriters' Laboratories and CSA approval, as required by respective agency and as specified. Indicate size, equipment model, manufacturer's name, serial number, voltage, cycle, phase and power of motors, all factory supplied.
- .3 Locate nameplates so that they are easily read. Do not insulate or paint over plates.

3.26 INSTALLATION OF GAUGES AND THERMOMETERS

- .1 Install to manufacturer's instructions.
- .2 Install positive displacement meters with isolating valves on inlet and outlet to AWWA M6. Provide full line size valved bypass with globe valve for liquid service meters.
- .3 Provide one pressure gauge per pump, installing taps before strainers and on suction and discharge of pump. Pipe to gauge.
- .4 Install pressure gauges with pulsation dampers. Provide gauge cock to isolate each gauge. Provide syphon on gauges in steam systems. Extend nipples and syphons to allow clearance from insulation.
- .5 Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-3/8" (60 mm) for installation of thermometer sockets. Ensure sockets allow clearance from insulation.
- .6 Install gauges and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.
- .7 Adjust gauges and thermometers to final angle, clean windows and lenses, and calibrate to zero.
- .8 Locate test plugs adjacent thermometers and thermometer sockets.

3.27 INSTALLATION OF ACCESS DOORS

- .1 Supply access doors for access to equipment requiring service, lubrication or adjustment and all concealed valves, cleanouts, trap primers, control and volume dampers, and other such equipment.
- .2 Turn over access doors to the appropriate general trade for installation under other Sections.

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- .3 Refer to architectural drawings for ratings of fire separations and assemblies. install fire rated access doors in fire rated partitions, walls, and ceilings.
 - .4 Access doors in ceilings shall be minimum 24" x 24" (600mm x 600mm), unless otherwise approved by the Consultant.
 - .5 Provide concealed access doors in GWB ceilings and coordinate in-fill with general trades.

END OF SECTION

1 05GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 23 01 01.

1.2 SECTION INCLUDES

- .1 Pipe and equipment hangers and supports.
- .2 Equipment bases and supports.

1.3 REFERENCES

- .1 ASME B31.5 - Refrigeration Piping and Heat Transfer Components.
- .2 ASTM F708 - Design and Installation of Rigid Pipe Hangers.
- .3 MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
- .4 MSS SP69 - Pipe Hangers and Supports - Selection and Application.
- .5 MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices.
- .6 UL 203 - Pipe Hanger Equipment for Fire protection Service.

1.4 SUBMITTALS

- .1 Section 23 01 01: Procedures for submittals.
- .2 Shop Drawings: Indicate system layout with location and detail of trapeze hangers.
- .3 Product Data: Provide manufacturers catalogue data including load capacity.
- .4 Design Data: Indicate load carrying capacity of trapeze, multiple pipes, and riser support hangers.
- .5 Manufacturer's Installation Instructions: Indicate special procedures and assembly of components.

1.5 REGULATORY REQUIREMENTS

- .1 Conform to CSA B-51 for support of piping.

2 PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

- .1 Manufacturers:
 - .1 Anvil
 - .2 Myat
 - .3 Hunt
- .2 Condenser Piping:
 - .1 Conform to CSA B-51 and ASME B31.9.
 - .2 Hangers for Pipe Sizes 1/2" to 1-1/2" (13 to 38 mm): Carbon steel, adjustable swivel, split ring.
 - .3 Hangers for Cold Pipe Sizes 2" (50 mm) and Over: Carbon steel, adjustable, clevis.

-
- .4 Hangers for Hot Pipe Sizes 2" to 4" (50 to 100 mm): Carbon steel, adjustable, clevis.
 - .5 Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
 - .3 Hydronic Piping:
 - .1 Conform to CSA B-51 and ASME B31.9.
 - .2 Hangers for Pipe Sizes 1/2" to 1-1/2" (13 to 38 mm): Carbon steel, adjustable swivel, split ring.
 - .3 Hangers for Cold Pipe Sizes 2" (50 mm) and Over: Carbon steel, adjustable, clevis.
 - .4 Hangers for Hot Pipe Sizes 2" to 4" (50 to 100 mm): Carbon steel, adjustable, clevis.
 - .5 Hangers for Hot Pipe Sizes 6" (150 mm) and Over: Adjustable steel yoke, cast iron roll, double hanger.
 - .6 Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
 - .7 Multiple or Trapeze Hangers for Hot Pipe Sizes 6" (150 mm) and Over: Steel channels with welded spacers and hanger rods, cast iron roll.
 - .8 Wall Support for Pipe Sizes to 3" (76 mm): Cast iron hook.
 - .9 Wall Support for Pipe Sizes 4" (100 mm) and Over: Welded steel bracket and wrought steel clamp.
 - .10 Wall Support for Hot Pipe Sizes 6" (150 mm) and Over: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.
 - .11 Vertical Support: Steel riser clamp.
 - .12 Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 - .13 Floor Support for Hot Pipe Sizes to 4" (100 mm): Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 - .14 Floor Support for Hot Pipe Sizes 6" (150 mm) and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
 - .15 Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

2.2 ACCESSORIES

- .1 Hanger Rods: galvanized, carbon steel continuous threaded.
- .2 Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.3 EQUIPMENT ROOF CURBS

- .1 Fabrication: Welded 0.05" (1.2 mm) galvanized steel shell and base, mitred 3" (75 mm) cant, variable step to match roof insulation, factory installed wood nailer.

2.4 ROOFTOP PIPE/DUCT SUPPORTS

- .1 Acceptable manufacturers;
 - .1 Portable Pipe Hangers, Inc.
 - .2 Unistrut
- .2 Pre-engineered pipe/duct support system including;
 - .1 Bases: weather resistant and UV radiation resistant with seismic attachments
 - .2 Framing: 1-5/8" (41.3mm) strut or 1-7/8" (47.6mm) strut, fabricated of steel to ASTM A570, Grade 33., roll formed of 12-gauge (2.7mm thick) steel into 3-sided or tubular shape.
 - .3 Pipe Supports and Hangers: Conform to MSS SP-58 and MSS SP-69, fabricated of carbon steel. Single roller supports for piping subject to expansion and contraction.
 - .4 Finishes:
 - .1 Plastics as moulded with UV radiation protection.
 - .2 Metal surfaces hot dip galvanized free of roughness, whiskers, unsightly spangles, icicles, runs, barbs, sags, droplets and other surface blemishes. Galvanizing shall conform to ASTM A123 for tubing and to ASTM A153 for hardware and accessories.
 - .5 Shop Drawings: Manufacturer to provide detailed shop drawings to indicate layout and supporting capacities of system components with installation and assembly instructions for each application. Shop drawings shall bear the signature and seal of a professional engineer licenced in Ontario.

3 EXECUTION

3.1 INSTALLATION

- .1 Install to manufacturer's instructions and best trade practises.

3.2 INSERTS

- .1 Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- .2 Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
- .3 Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.

3.3 PIPE HANGERS AND SUPPORTS

- .1 Support horizontal piping as scheduled.
- .2 Install hangers to provide minimum 1/2" (13 mm) space between finished covering and adjacent work.
- .3 Place hangers within 12" (300 mm) of each horizontal elbow.
- .4 Use hangers with 1-1/2" (38 mm) minimum vertical adjustment.
- .5 Support horizontal cast iron pipe adjacent to each hub, with 5 feet (1.5 m) maximum spacing between hangers.
- .6 Design hangers for pipe movement without disengagement of supported pipe.
- .7 Prime coat exposed steel hangers and supports. Hangers and supports located in suspended ceiling spaces are not considered exposed.

3.4 EQUIPMENT BASES AND SUPPORTS

- .1 Provide templates, anchor bolts, and accessories for mounting and anchoring equipment.
- .2 Construct supports of steel members. Steel pipe and fittings. Brace and fasten with flanges bolted to structure.
- .3 Provide rigid anchors for pipes after vibration isolation components are installed.

3.5 ROOFTOP PIPE/DUCT SUPPORT

- .1 Coordinate installation of supports and bases with roofing work. Ensure that roofing surfaces are smooth and flat and are ready to receive work.
- .2 Use care in installation of support systems not to damage roofing, flashing, equipment or related materials.
- .3 Install and secure support systems in strict accordance with manufacturer's written instruction.
- .4 Consult manufacturers of roofing system to determine if walk pads are required. Provide and fully adhere walk pads to roof system where required.
- .5 Bases and support framing shall be located as indicated on shop drawings provided by support system manufacturer and as specified herein. The support of all piping shall be complete and adequate, whether or not all required devices are shown.
- .6 The use of wood or wire for supporting piping will not be permitted.
- .7 Deflection of pipes shall not exceed 1/240th of the span.
- .8 Accurately locate and align bases. Where applicable, replace gravel around bases. Set framing posts into bases and assemble framing structure as indicated.
- .9 Use galvanized fasteners for galvanized framing, and use stainless steel fasteners for stainless steel framing.

3.6 FLASHING

- .1 Provide flexible flashing and metal counterflashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.
- .2 Flash vent and soil pipes projecting 3" (75 mm) minimum above finished roof surface with lead worked 1" (25 mm) minimum into hub, 8" (200 mm) minimum clear on sides with 24" x 24" (600 x 600 mm) sheet size. For pipes through outside walls, turn flanges back into wall and caulk, metal counterflash, and seal.
- .3 Flash floor drains in floors with topping over finished areas with lead, 10" (250 mm) clear on sides with minimum 36" x 36" (910 x 910 mm) sheet size. Fasten flashing to drain clamp device.
- .4 Seal roof, floor, shower and mop sink drains watertight to adjacent materials.
- .5 Provide acoustical lead flashing around ducts and pipes penetrating equipment rooms, installed to manufacturer's instructions for sound control.
- .6 Provide curbs for mechanical roof installations 14" (350 mm) minimum high above roofing surface. Flash and counterflash with sheet metal; seal watertight. Attach counterflashing mechanical equipment and lap base flashing on roof

curbs. Flatten and solder joints.

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

3.7 SLEEVES

- .1 Set sleeves in position in formwork. Provide reinforcing around sleeves.
 .2 Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.
 .3 Extend sleeves through floors 1" (25 mm) above finished floor level. Caulk sleeves.
 .4 Where piping or ductwork penetrates floor, ceiling, or wall, close off space between pipe or duct and adjacent work with stuffing insulation and caulk. air tight. Provide close fitting metal collar or escutcheon covers at both sides of penetration.
 .5 Install chrome plated steel escutcheons at finished surfaces.

3.8 SCHEDULES

- .1 Imperial Measure (IP)

Pipe Size (in)	Rod Diameter (in)	Support Spacing (Ft)	
		Steel Pipe	Copper Tube
1/2	3/8	7	6
3/4	3/8	7	6
1	3/8	7	6
1-1/4	3/8	7	6
1-1/2	3/8	9	8
2	3/8	10	9
2-1/2	3/8	12	10
3	3/8	12	10
4	5/8	14	12
6	7/8	17	

- .2 Metric Measure (SI)

Pipe Size (mm)	Rod Diameter (mm)	Support Spacing (m)	
		Steel Pipe	Copper Tube

13	10	2.1	1.8
20	10	2.1	1.8
25	10	2.1	1.8
32	10	2.1	1.8
38	10	2.7	2.4
50	10	3	2.7
65	10	3.6	3
75	10	3.6	3
100	16	4.2	3.6
150	22	17	

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 23 01 01.

1.2 SECTION INCLUDES

- .1 Testing, adjustment, and balancing of air systems
- .2 Testing, adjustment, and balancing of piping systems
- .3 Testing, adjustment, and balancing of equipment
- .4 Measurement of final operating condition of HVAC systems

1.3 REFERENCES

- .1 Ontario Building Code.
- .2 Ontario Fire Code.
- .3 AABC - National Standards for Total System Balance.
- .4 ACG - AABC Commissioning Guideline.
- .5 ADC - Test Code for Grilles, Registers, and Diffusers.
- .6 ASHRAE 111 - Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-conditioning, and Refrigeration Systems.
- .7 ASHRAE Guideline 0 The Commissioning Process,
- .8 ASHRAE Guideline 1 The HVAC Commissioning Process,
- .9 ASHRAE Guideline 1.1 HVAC&R Technical Requirements for the Commissioning Process,
- .10 NEBB - Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.
- .11 SMACNA - HVAC Systems Testing, Adjusting, and Balancing.
- .12 SMACNA HVAC Systems Commissioning Manual,

1.4 SUBMITTALS

- .1 Submit name of adjusting and balancing agency for approval within 30 days after award of Contract.
- .2 Field Reports: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
- .3 Prior to commencing work, submit report forms or outlines indicating adjusting, balancing, and equipment data required.
- .4 Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Consultant and for inclusion in operating and maintenance manuals.
- .5 Provide reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side.
- .6 Include detailed procedures, agenda, sample report forms and copy of AABC National Project Performance Guaranty prior to commencing system balance.
- .7 Test Reports: Indicate data on AABC National Standards for Total System

Balance forms. Submit data based on Project designation IP imperial/SI Metric Units.

- .8 All reports shall be prepared in electronic (computer) format using MS Word software and all tabulations shall be prepared in electronic (computer) format using MS Excel spreadsheet software. Submittals shall include three (3) copies each of hard copy printout and two (2) copies with text in ".pdf" and tabulations in ".xls" or ".xlsx" formats on CD, DVD, or USB flash drive.

1.5 PROJECT RECORD DOCUMENTS

- .1 Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets and indicating thermostat locations.
.2 Record actual locations of flow measuring stations.

1.6 QUALITY ASSURANCE

- .1 Perform total system balance to AABC National Standards for Field Measurement and Instrumentation, Total System Balance.
.2 Maintain one copy of each document on site.

1.7 INDEPENDENT AGENCY

- .1 All work of Mechanical Testing, Adjusting and Balancing shall be undertaken by a single agency, employed under Division 23. Other agencies may be proposed as an Alternate only, in accordance with Section 23 01 01, paragraph.
.2 The work of the agency consists of the furnishing of all labour, materials, equipment and accessories necessary in the testing, verification and documentation of the operational performance of all equipment and systems installed under the Sections of Division 23: Mechanical.

1.8 QUALIFICATIONS

- .1 Agency: Company specializing in the testing, adjusting, and balancing of systems under this Section with minimum five years documented experience certified by AABC or prequalified as listed below.
.2 Work shall be performed under the supervision of an AABC certified Test and Balance Engineer, an NEBB Certified Testing, Adjusting and Balancing Supervisor or a registered Professional Engineer experienced in the performance of this work and licenced at the place where the Project is located.

PRE-BALANCING CONFERENCE

- .1 Convene one week prior to commencing work of this Section.

1.9 CO-OPERATION

- .1 Co-operate with installing Contractor(s) in advising them of specific scheduling requirements for systems verification.
.2 Provide advice to installing Contractors regarding the location and installation of devices required to permit system balancing and measurements, prior to start of

the installation work.

- .3 TAB Contactor responsible for 22 05 93 and TAB Contractor responsible for 23 05 93 are required to work in conjunction with each other to achieve a fully balanced and functional HVAC system. Where two separate contractors are used, the General Contractor is responsible for coordinating this work.

2 PRODUCTS

2.1 REFERENCE STANDARDS

- .1 All equipment required for the verification of equipment and systems shall be furnished by the agency employed to conduct the Mechanical Systems Verification.
- .2 Testing and measuring equipment used in the verification of the mechanical systems shall be calibrated to give true readings within the accuracy specifications of the equipment used. A certificate of calibration from an independent testing laboratory may be required by the Consultant if there is any reason to suspect that the equipment used is giving erroneous readings. In such an event the verification agency shall reconduct its verifications.
- .3 All equipment used by the agency in its verification of mechanical systems remains the property/responsibility of the agency and is not included in the supply to the project.

3 EXECUTION

3.1 EXAMINATION

- .1 Verify that systems are complete and operable before commencing work. Ensure the following conditions:
 - .1 Systems are started and operating in a safe and normal condition.
 - .2 Temperature control systems are installed complete and operable.
 - .3 Proper thermal overload protection is in place for electrical equipment.
 - .4 Final filters are clean and in place. If required, install temporary media in addition to final filters.
 - .5 Duct systems are clean of debris.
 - .6 Fans are rotating correctly.
 - .7 Fire dampers are in place and open.
 - .8 Air coil fins are cleaned and combed.
 - .9 Access doors are closed and duct end caps are in place.
 - .10 Air outlets are installed and connected.
 - .11 Duct system leakage is minimized.
 - .12 Hydronic systems are flushed, filled, and vented.
 - .13 Pumps are rotating correctly.
 - .14 Proper strainer baskets are clean and in place.
 - .15 Service and balance valves are open.
- .2 Submit field reports. Report defects and deficiencies noted during performance of services which prevent system balance.

- .3 Beginning of work represents acceptance of existing conditions in the areas served.

3.2 PREPARATION

- .1 Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Consultant to facilitate spot checks during testing.
- .2 Provide additional balancing devices as required.

3.3 INSTALLATION TOLERANCES

- .1 Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 5 percent of design for return and exhaust systems.
- .2 Air Outlets and Inlets: Adjust total to within plus 5 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 5 percent of design.
- .3 Hydronic Systems: Adjust to within plus or minus 10 percent of design.

3.4 ADJUSTING

- .1 Ensure recorded data represents actual measured or observed conditions.
- .2 Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- .3 After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- .4 Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
- .5 At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

3.5 AIR SYSTEM PROCEDURE

- .1 Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.
- .2 Make air quantity measurements in ducts by Pitot tube traverse of entire cross-sectional area of duct.
- .3 Measure air quantities at air inlets and outlets.
- .4 Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.
- .5 Use branch volume control dampers and splitters to regulate air quantities. Devices at air outlets may be used only to the extent that adjustments do not create objectionable air motion or sound levels.
- .6 Provide system schematic with required and actual air quantities recorded at each outlet or inlet.
- .7 Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan.
- .8 Adjust outside air, return air, and exhaust dampers for design conditions.

- .9 Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

3.6 WATER SYSTEM PROCEDURE

- .1 Adjust water systems to provide required or design quantities.
- .2 Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.
- .3 Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
- .4 Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.

3.7 SCHEDULES

- .1 Equipment requiring testing, adjusting and balancing:
 - .1 Energy Recovery Unit
 - .2 Roof Top Unit
 - .3 Fans
 - .4 Fan Coil Units
 - .5 Air Terminal Units
 - .6 Air Inlets and Outlets
 - .7 Plumbing Pumps
 - .8 HVAC Pumps
 - .9 Condenser Units
 - .10 Radiant Heating Coil
 - .11 Radiant In-Floor Heating Panel
 - .12 Heating Boiler
- .2 Report Forms
 - .1 Title Page:
 - .1 Name of Testing, Adjusting, and Balancing Agency
 - .2 Address of Testing, Adjusting, and Balancing Agency
 - .3 Telephone number of Testing, Adjusting, and Balancing Agency
 - .4 Project name
 - .5 Project location
 - .6 Project Architect
 - .7 Project Engineer
 - .8 Project Contractor
 - .9 Project altitude
 - .10 Report date
 - .2 Summary Comments:
 - .1 Design versus final performance
 - .2 Notable characteristics of system
 - .3 Description of systems operation sequence

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- .4 Summary of outdoor and exhaust flows to indicate amount of building pressurization
 - .5 Nomenclature used throughout report
 - .6 Test conditions
 - .3 Instrument List:
 - .1 Instrument
 - .2 Manufacturer
 - .3 Model number
 - .4 Serial number
 - .5 Range
 - .6 Calibration date
 - .4 Electric Motors:
 - .1 Manufacturer
 - .2 Model/Frame
 - .3 HP/BHP
 - .4 Phase, voltage, amperage; nameplate, actual, no load
 - .5 RPM
 - .6 Service factor
 - .7 Starter size, rating, heater elements
 - .8 Sheave Make/Size/Bore
 - .5 V-Belt Drive:
 - .1 Identification/location
 - .2 Required driven RPM
 - .3 Driven sheave, diameter and RPM
 - .4 Belt, size and quantity
 - .5 Motor sheave diameter and RPM
 - .6 Centre to centre distance, maximum, minimum, and actual
 - .6 Pump Data:
 - .1 Identification/number
 - .2 Manufacturer
 - .3 Size/model
 - .4 Impeller
 - .5 Service
 - .6 Design flow rate, pressure drop, BHP
 - .7 Actual flow rate, pressure drop, BHP
 - .8 Discharge pressure
 - .9 Suction pressure
 - .10 Total operating head pressure
 - .11 Shut off, discharge and suction pressures
 - .12 Shut off, total head pressure
 - .7 Air Cooled Condenser:
 - .1 Identification/number
 - .2 Location
 - .3 Manufacturer
 - .4 Model number
 - .5 Serial number
 - .6 Entering DB air temperature, design and actual
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- .7 Leaving DB air temperature, design and actual
 - .8 Number of compressors
 - .8 Air Moving Equipment
 - .1 Location
 - .2 Manufacturer
 - .3 Model number
 - .4 Serial number
 - .5 Arrangement/Class/Discharge
 - .6 Air flow, specified and actual
 - .7 Return air flow, specified and actual
 - .8 Outside air flow, specified and actual
 - .9 Total static pressure (total external), specified and actual
 - .10 Inlet pressure
 - .11 Discharge pressure
 - .12 Sheave Make/Size/Bore
 - .13 Number of Belts/Make/Size
 - .14 Fan RPM
 - .9 Return Air/Outside Air Data:
 - .1 Identification/location
 - .2 Design air flow
 - .3 Actual air flow
 - .4 Design return air flow
 - .5 Actual return air flow
 - .6 Design outside air flow
 - .7 Actual outside air flow
 - .8 Return air temperature
 - .9 Outside air temperature
 - .10 Required mixed air temperature
 - .11 Actual mixed air temperature
 - .12 Design outside/return air ratio
 - .13 Actual outside/return air ratio
 - .10 Exhaust Fan Data:
 - .1 Location
 - .2 Manufacturer
 - .3 Model number
 - .4 Serial number
 - .5 Air flow, specified and actual
 - .6 Total static pressure (total external), specified and actual
 - .7 Inlet pressure
 - .8 Discharge pressure
 - .9 Sheave Make/Size/Bore
 - .10 Number of Belts/Make/Size
 - .11 Fan RPM
 - .11 Duct Traverse:
 - .1 System zone/branch
 - .2 Duct size
 - .3 Area

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- .4 Design velocity
 - .5 Design air flow
 - .6 Test velocity
 - .7 Test air flow
 - .8 Duct static pressure
 - .9 Air temperature
 - .10 Air correction factor
 - .12 Duct Leak Test:
 - .1 Description of ductwork under test
 - .2 Duct design operating pressure
 - .3 Duct design test static pressure
 - .4 Duct capacity, air flow
 - .5 Maximum allowable leakage duct capacity times leak factor
 - .6 Test apparatus
 - .1 Blower
 - .2 Orifice, tube size
 - .3 Orifice size
 - .4 Calibrated
 - .7 Test static pressure
 - .8 Test orifice differential pressure
 - .9 Leakage
 - .13 Fan Coil Unit Data:
 - .1 Manufacturer
 - .2 Type, constant, variable, single, dual duct
 - .3 Identification/number
 - .4 Location
 - .5 Model number
 - .6 Size
 - .7 Minimum static pressure
 - .8 Minimum design air flow
 - .9 Maximum design air flow
 - .10 Maximum actual air flow
 - .11 Inlet static pressure
 - .14 Air Distribution Test Sheet:
 - .1 Air terminal number
 - .2 Room number/location
 - .3 Terminal type
 - .4 Terminal size
 - .5 Area factor
 - .6 Design velocity
 - .7 Design air flow
 - .8 Test (final) velocity
 - .9 Test (final) air flow
 - .10 Percent of design air flow
 - .15 Sound Level Report:
 - .1 Location
 - .2 Octave bands - equipment off
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- .3 Octave bands - equipment on
- .16 Vibration Test:
 - .1 Location of points:
 - .1 Fan bearing, drive end
 - .2 Fan bearing, opposite end
 - .3 Motor bearing, centre (if applicable)
 - .4 Motor bearing, drive end
 - .5 Motor bearing, opposite end
 - .6 Casing (bottom or top)
 - .7 Casing (side)
 - .8 Duct after flexible connection (discharge)
 - .9 Duct after flexible connection (suction)
 - .2 Test readings:
 - .1 Horizontal, velocity and displacement
 - .2 Vertical, velocity and displacement
 - .3 Axial, velocity and displacement
 - .3 Normally acceptable readings, velocity and acceleration
 - .4 Unusual conditions at time of test
 - .5 Vibration source (if non-complying)

3.8 VERIFICATION CHECKLIST

- .1 Prepare a series of checklists to record the verification of each item of equipment and each system. Submit a draft of each checklist to the Consultant and the Owner for review and approval. Discuss comments offered the Consultant and Owner and include improvements as directed.
- .2 Checklists shall include the following as a minimum;
 - .1 date(s) of observations and/or tests,
 - .2 a record of the nameplate data for each equipment item and each associated motor,
 - .3 a list of observations appropriate to the equipment item or system with space adjacent to indicate whether the item was satisfactory or unsatisfactory,
 - .4 appropriate space for recording comments and/or instructions given during observations.

3.9 EQUIPMENT VERIFICATION

- .1 Test the operation of all equipment installed under Division 23 according to instructions in appropriate articles of this Division. Advise installing contractor of any required adjustments or replacements to ensure that equipment is operating as intended. Retest equipment after adjustment or replacement.
- .2 Ensure that the Contractor has given proper advance notification to all persons required to be present as tests are conducted.
- .3 Instrumentation: verify installation of air filter gauges, pumps, thermometers, thermometer wells, pitot traverse stations, and flow-measuring devices ensuring that:

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- .1 Location of points for readings is appropriate to measure what it is intended to measure.
 - .2 The scale range is appropriate to place the normal reading near mid-range of the scale.
 - .3 Proper positioning of instrumentation to allow reading from a convenient location, and for easy access.
 - .4 Filters Inspection: visually inspect each filter installation. Verify adjustment of latching devices, installation of end spacers in filter boxes, and proper latching and sealing of access doors. Verify the installation of new (clean) filter media after Contractor's start-up procedures.
 - .5 Pre-start-up Inspection:
 - .1 Verify proper equipment mounting and setting.
 - .2 Verify that control, interlock, and power wiring are complete.
 - .3 Verify proper alignment of motors and drives.
 - .4 Verify proper piping connections and accessories.
 - .5 Verify that lubrication is complete.
 - .6 First Run Observation:
 - .1 Verify direction of rotation.
 - .2 Verify setting of safety controls.
 - .3 Monitor heat build-up in bearings.
 - .4 Check motor loads against nameplate ratings.
 - .7 Equipment Checkout:
 - .1 Verify the proper overload heater sizes.
 - .2 Verify function of safety and operating controls.
 - .3 Verify proper operation of equipment.
 - .4 Report on inspection, observation, and checkout procedures.
 - .8 Stuffing Boxes and Packing Glands: verify adjustment of boxes on pump shafts and packing glands on valve stems.
 - .9 Motor Rotation: visually inspect and verify the direction of motor rotation. It is possible for motor rotation to have been checked by the electrician when power connections were made on temporary electric power, then when final connections were made to the permanent transformer bank, crossed phasing may reverse the rotation of all three-phase motors on the system.
 - .10 Overload Heaters: verify supply voltage to each equipment. If the applied voltage is different from the motor nameplate, determine whether the applied voltage is within the range allowed under the motor guarantee. If not, take the necessary action to have the Contractor change the motor or the applied voltage. When the voltage is off the nameplate value, but within the allowable range, compute the equivalent amperage at nameplate voltage and compare to the overload heater amperage rating range. Then, consider whether the ambient temperature of the starter is above, below, or the same as the ambient temperature are not the same. Advise the Contractor to use overload heaters of higher range for "hot area" starters or ones of lower range for "cold area" starters to compensate the heater trip point for heat gains or losses with the environment.
 - .11 Alignment of Drives: verify the alignment of drives, belt and direct coupled, and the adjustment of belt tension.
 - .12 Control Diagrams and Sequences: provide for coordination with work under the
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automatic control systems to have the control diagrams and sequences of operation corrected to "as installed", reflecting changes brought about in response to contract modifications and to the more pragmatic changes in diagrams and sequences to make the installed system control the building systems as intended by the designer.

- .13 Safety and Operating Control Setpoints: systematically verify the safety and operating controls of equipment, including an operational check of associated control sequences.
- .14 Fin Straightening: inspect finned surface heat transfer coils for damages fins and advise Contractor of repairs required.
- .15 Verify that manufacturer's start-up procedures have been performed and that equipment is installed in accordance with the manufacturer's written installation recommendations.
- .16 Where work is noted to be done in stages a complete air balance and verification report will be required at the end of each stage.

3.10 PIPING SYSTEMS VERIFICATION

- .1 Review the drawings, specifications, and installed work to ensure that systems may be properly balanced in accordance with drawings. Advise the installing Contractor of any additional requirements for effective balancing.
- .2 Complete air balance must have been accomplished before water balance is verified.
- .3 Open all valves to full position, including coil stop valves, close bypass valves, and return line balancing cocks.
- .4 Verify that all strainers are clean.
- .5 Examine water in system to determine if it has been treated and is clean.
- .6 Check and record type and concentration of glycol in systems which require freeze protection.
- .7 Check pump rotation.
- .8 Check diaphragm expansion tanks to ensure that fill pressure is adequate (re. static head of systems plus 5 psig or 12 psig minimum (35 kPa or 83 kPa minimum)).
- .9 Check open expansion tanks to make sure they are not air bound and that the system is full of water.
- .10 Check all air vents at high points of water systems to make sure they are installed properly and are operating freely. Verify that all air is removed from circulating system.
- .11 To balance hot water coils, set systems to call for full heating.
- .12 Verify operation of automatic bypass valve.
- .13 Verify operating temperature of heat exchangers, to design requirements.
- .14 Check and record the following items at each heating element:
 - .1 Inlet water and air temperatures. Note rise or drop in temperature train source.
 - .2 Leaving water and air temperatures.
 - .3 Pressure drop and flow through each coil.
 - .4 Pump operating suction and discharge pressure and final t.d.h. and flow delivered.

- .5 Pressure drop across bypass valve.
- .6 All mechanical specifications of pumps.
- .7 Rated and actual running amperage of pump motor.
- .15 Witness all piping tests.

3.11 AIR SYSTEM VERIFICATION

- .1 Review drawings, specifications and installed work to ensure that systems may be properly balanced in accordance with drawings. Advise installing Contractor of any additional requirements for effective balancing.
- .2 In air handling systems which include supply fans with variable speed drives, airflows shall be verified to design with all filters clean and with all filters loaded to filter manufacturer's recommended final (change-out) resistance. Motor and drive capacity to accommodate full range of filter loadings shall be verified.
- .3 In air handling systems which include supply fans without variable speed drives, air filters shall be verified to design airflows with air filters loaded so that the air pressure drop through each filter is equal to the average of the manufacturers listed initial resistance and recommended final (change-out) resistance.
- .4 Test and record blower rpm for each fan and air handling unit.
- .5 Test and record motor full load amperes.
- .6 Make Pitot tube traverse of main supply and obtain operating air quantities at fans.
- .7 Test and record system static pressures, suction and discharge.
- .8 Test and record system operating recirculated air quantities.
- .9 Test and record system operating outside air quantities.
- .10 Test and record entering drybulb air temperatures (hydronic coils).
- .11 Test and record entering wet bulb air temperatures (hydronic coils).
- .12 Test and record leaving dry bulb air temperatures (hydronic coils).
- .13 Measure airflow in all main and zone branch supply and return air ducts.
- .14 Test and record airflow at each diffuser, grille, and register.
- .15 Tabulate and certify test results on suitable forms and submit Consultant for approval and record. Identify each diffuser, grille, and register as to location and area. Identify and list size, type, and manufacturer of diffusers, grilles, registers, and all testing equipment. Use manufacturer's rating on all equipment to make required calculations.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 23 01 01

1.2 SECTION INCLUDES

- .1 Duct work insulation
- .2 Acoustic Duct Lining

1.3 REFERENCES

- .1 Section 23 01 01: Requirements for references and standards.
- .2 ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
- .3 ASTM C518 - Steady-State Thermal Transmission Properties by Means of the Heat Flow Metre Apparatus.
- .4 ASTM C553 - Standard Specification for Mineral Fibre Blanket Thermal Insulation for Commercial and Industrial Applications.
- .5 ASTM C612 - Standard Specification for Mineral Fibre Block and Board Thermal Insulation.
- .6 ASTM C921 - Properties of Jacketing Materials for Thermal Insulation.
- .7 ASTM C1071 - Fibrous Glass Duct Lining Insulation (Thermal Sound Absorbing Material).
- .8 ASTM C 1338 - Fungi Resistance of Insulation Materials and Facings Standard.
- .9 ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- .10 ASTM E96 - Water Vapour Transmission of Materials.
- .11 ASTM E 119 (UL 263) - Standard Test Methods for Fire Tests of Building Construction and Materials.
- .12 ASTM E 136 - Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750C.
- .13 ASTM E162 - Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source.
- .14 ASTM E 814 - Fire Tests of Through-Penetration Fire Stops Standard.
- .15 ASTM E 2336 - Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems.
- .16 ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
- .17 NAIMA National Insulation Standards.
- .18 NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.
- .19 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- .20 UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.
- .21 CAN/CGSB-51.9 Mineral Fiber Thermal Insulation for Piping and Round Ducting.

- .22 CAN/CGSB-51.10 Mineral Fiber Board Thermal Insulation
- .23 CAN/CGSB-51.11 Mineral Fiber Thermal Insulation Blanket.
- .24 CAN/CGSB-5140 Mineral Insulation, Flexible, Elastomeric, Unicellular, Sheet & Pipe Coverup.
- .25 CAN/CGSB-51-GP-52 Ma Vapor Barrier, Jacket and Facing Material for Pipe, Duct & Equipment Thermal Insulation.

1.4 SUBMITTALS FOR REVIEW

- .1 Section 23 01 01: Procedures for submittals.
- .2 Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- .3 Product Certificates: Submit certificates signed by firestop system manufacturer certifying that materials furnished comply with requirements.

1.5 SUBMITTALS FOR INFORMATION

- .1 Section 23 01 01: Procedures for submittals.
- .2 Manufacturer's Instructions: Indicate installation procedures which ensure acceptable workmanship and installation standards will be achieved.

1.6 QUALITY ASSURANCE

- .1 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- .2 Applicator Qualifications: Company specializing in performing the work of this section with minimum 6 years documented experience.

1.7 REGULATORY REQUIREMENTS

- .1 Materials: Flame spread/smoke developed rating of 25/50 to the requirements of the Ontario Building Code.

1.8 DELIVERY, STORAGE, AND PROTECTION

- .1 Section 23 01 01: Transport, handle, store, and protect products.
- .2 Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.
- .3 Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.9 ENVIRONMENTAL REQUIREMENTS

- .1 Section 23 01 01: Environmental conditions affecting products on site.
- .2 Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- .3 Maintain temperature during and after installation for minimum period of 24 hours.

2 PRODUCTS

2.1 GLASS FIBRE, FLEXIBLE (CONCEALED DUCTWORK LOCATIONS)

- .1 Manufacturer: Johns Manville
- .2 Other acceptable manufacturers offering equivalent products:
 - .1 Manson
 - .2 Knauf Fiber Glass
- .3 Microlite FSK Formaldehyde-free Fiber glass duct wrap insulation
- .4 Insulation: ASTM C553 Type II, ASTM C1290, CGSB 51-GP-11M; flexible, noncombustible blanket
 - .1 'ksi' value : 0.042 at 24 °C (0.29 @ 75 °F).
 - .2 Density: 0.75lb/ft³, 1.01lb/ft³
 - .3 .2 Maximum service temperature: 121 °C (250 °F)
 - .4 .3 Maximum moisture absorption: ASTM C1104 <5% by weight
 - .5 Corrosivity with steel: ASTM C665 Does not accelerate
 - .6 Fungi Resistance: ASTM C1338 Does not breed or promote
 - .7 Maximum flame spread index: 25
 - .8 Maximum smoke development index: 50
- .5 Vapour Barrier Jacket:
 - .1 FSK Aluminum foil; reinforced with fiber glass scrim laminated to UL-rated kraft
 - .2 Moisture vapour transmission: ASTM E96; 0.02 perm
 - .3 Secure with pressure sensitive tape
- .6 Vapour Barrier Tape:
 - .1 Kraft paper reinforced with glass fibre yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive
- .7 Outdoor Vapour Barrier Mastic:
 - .1 Vinyl emulsion type acrylic or mastic, compatible with insulation, black colour.
- .8 Tie Wire: Annealed steel, 1/16" (1.5 mm)

2.2 GLASS FIBRE, FLEXIBLE (EXPOSED DUCTWORK LOCATIONS)

- .1 Manufacturer: Johns Manville
- .2 Other acceptable manufacturers offering equivalent products:
 - .1 Manson
 - .2 Knauf Fiber Glass
- .3 Microlite White PSK Formaldehyde-free Fiber glass duct wrap insulation
- .4 Insulation: ASTM C553 Type II, ASTM C1290, CGSB 51-GP-11M; flexible, noncombustible blanket.
 - .1 'ksi' value : 0.042 at 24 °C (0.29 @ 75 °F).
 - .2 Density: 0.75lb/ft³, 1.01lb/ft³
 - .3 .2 Maximum service temperature: 121 °C (250 °F).
 - .4 .3 Maximum moisture absorption: ASTM C1104 <5% by weight.
 - .5 Corrosivity with steel: ASTM C665 Does not accelerate.

- .6 Fungi Resistance: ASTM C1338 Does not breed or promote.
- .7 Maximum flame spread index: 25
- .8 Maximum smoke development index: 50
- .5 Vapour Barrier Jacket:
 - .1 White PSK metalized polypropylene; reinforced with fiber glass scrim laminated to UL-rated kraft.
 - .2 Moisture vapour transmission: ASTM E96; 0.02 perm.
 - .3 Secure with pressure sensitive tape.
- .6 Vapour Barrier Tape:
 - .1 Kraft paper reinforced with glass fibre yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.
- .7 Outdoor Vapour Barrier Mastic:
 - .1 Vinyl emulsion type acrylic or mastic, compatible with insulation, black colour.
- .8 Tie Wire: Annealed steel, 1/16" (1.5 mm).

2.3 GLASS FIBRE, RIGID (CONCEALED AND EXPOSED DUCTWORK LOCATIONS)

- .1 Manufacturer: CertainTeed Saint-Gobain Cooperation, ASJ Finish
- .2 Other acceptable manufacturers offering equivalent products:
 - .1 Manson
 - .2 Knauf Fiber Glass
 - .3 Johns Manville
- .3 Insulation: ASTM C612; ASTM C553, CertaPro Board, rigid, noncombustible blanket.
- .4 Fire Hazard Classification: ASTM E84, UL 723
 - .1 CAN/ULC S102-M88
 - .2 Max flame spread index: 25
 - .3 Max smoke spread index: 50
- .5 Water vapour permeance: ASTM E96, dessicant method/max 0.02 perms (ASJ facing). Class I vapor retarder.
- .6 Thermal performance: ASTM C117 or ASTM C518
- .7 Acoustical performance: ASTM C423
- .8 Operating limits: ASTM C411, Max 250F (121 C)
- .9 Water vapour absorption: ASTM C1104 <5% by weight
- .10 Corrosiveness: ASTM C665 Pass
- .11 Fungi resistance: ASTM C1338 Pass
- .12 Odor emission: ASTM C1304 Pass
- .13 Vapour Barrier Jacket:
 - .1 White kraft scrim foil (ASJ) facing adhered to the fiber glass board. .
 - .2 Moisture vapour transmission: ASTM E96; 0.02 perm.
 - .3 Secure with pressure sensitive tape

2.4 ACOUSTIC DUCT LINING

- .1 Refer to Section 23 31 00.

2.5 FIRE BARRIER DUCT WRAP

- .1 Refer to Section 23 31 00.

2.6 ACCESSORIES

- .1 Adhesives and finishes shall be as recommended by the insulation manufacturer and shall comply with Section 23 01 01.2.2. Accessories such as adhesives, mastics and cements shall have the same properties as listed above and shall not detract from any of the system ratings specified.
- .2 Vapor retarder lap adhesive shall be water based, fire retardant
- .3 Tapes shall be of cloth reinforced aluminum, soft adhesive with minimum 2" (50 mm) width.
- .4 Tie wire shall be of 1/16" (1.5 mm) \varnothing stainless steel.
- .5 Fasteners shall be of 1/8" (4 mm) \varnothing pins, with 35 mm square clips. Clip length to suit insulation thickness.
- .6 Bands shall be 1/2" (12 mm) wide 1/4" (6mm) thick galvanized steel.
- .7 Facing shall be of 1" (25 mm) galvanized steel hexagonal wire mesh attached on both faces of insulation.

3 EXECUTION

3.1 EXAMINATION

- .1 Verify that ductwork has been tested before applying insulation materials.
- .2 Verify that surfaces are clean, foreign material removed, and dry.

3.2 DUCT INSULATION

- .1 Insulate new ductwork as follows:

Service	Insulation Type	Thickness
ERU-01 air supply - rectangular	Rigid	1"
ERU-01 air supply - round	Flexible	1"
ERU-02 Supply Air Duct - rectangular	Rigid	1"
ERU-02 Supply Air Duct - round	Flexible	1"
AC-01 Supply Air Duct - rectangular	Rigid	1"
AC-01 Supply Air Duct - round	Flexible	1"
Exhaust within 6' of exhaust fan connection - rectangular	Rigid	3"
Exhaust within 6' of exhaust fan connection - round	Flexible	3"

Service	Insulation Type	Thickness
ERU-01 air supply - rectangular	Rigid	25mm
ERU-01 air supply - round	Flexible	25mm
ERU-02 Supply Air Duct - rectangular	Rigid	25mm
ERU-02 Supply Air Duct - round	Flexible	25mm
AC-01 Supply Air Duct - rectangular	Rigid	25mm
AC-01 Supply Air Duct - round	Flexible	25mm
Exhaust within 6' of exhaust fan connection - rectangular	Rigid	75mm
Exhaust within 6' of exhaust fan connection - round	Flexible	75mm

3.3 INSTALLATION

- .1 Install duct insulations to TIAC National Installation Standards.
- .2 Apply insulation materials, accessories, jackets and finishes in accordance with manufacturer' written instructions and as specified.
- .3 Insulated ductwork conveying air below ambient temperature:
 - .1 Provide insulation with vapour barrier jackets.
 - .2 Finish with tape and vapour barrier jacket.
 - .3 Continue insulation through walls, sleeves, hangers, and other duct penetrations.
 - .4 Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
- .4 Insulated ductwork conveying air above ambient temperature:
 - .1 Provide with all service jacket.
 - .2 Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.
- .5 Ductwork Exposed in Mechanical Equipment Rooms or Finished Spaces: Finish with canvas jacket sized for finish painting.
- .6 Exterior Applications: Provide insulation with vapour barrier jacket. Cover with outdoor jacket finished as specified.
- .7 Duct and Plenum Liner Application:
 - .1 Adhere insulation with adhesive for 90 percent coverage.
 - .2 Secure insulation with mechanical liner fasteners. Refer to SMACNA Standards for spacing.
 - .3 Seal and smooth joints. Seal and coat transverse joints.
 - .4 Seal liner surface penetrations with adhesive.
 - .5 Duct dimensions indicated are net inside dimensions required for air flow. Increase duct size to allow for insulation thickness.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 23 01 01.

1.2 SECTION INCLUDES

- .1 Equipment insulation
- .2 Covering

1.3 REFERENCES

- .1 ASTM A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
- .2 ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
- .3 ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
- .4 ASTM C195 - Mineral Fibre Thermal Insulating Cement.
- .5 ASTM C240 - Testing Cellular Glass Insulation Block.
- .6 ASTM C449/C449M - Mineral Fibre Hydraulic-Setting Thermal Insulating and Finishing Cement.
- .7 ASTM C518 - Steady-State Thermal Transmission Properties by Means of the Heat Flow Metre Apparatus.
- .8 ASTM C533 - Calcium Silicate Block and Pipe Thermal Insulation.
- .9 ASTM C534 - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
- .10 ASTM C552 - Cellular Glass Thermal Insulation.
- .11 ASTM C553 - Mineral Fibre Blanket Thermal Insulation for Commercial and Industrial Applications.
- .12 ASTM C592 - Mineral Fibre Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type).
- .13 ASTM C612 - Mineral Fibre Block and Board Thermal Insulation.
- .14 ASTM C921 - Properties of Jacketing Materials for Thermal Insulation.
- .15 ASTM D1056 - Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber.
- .16 ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- .17 ASTM E96 - Water Vapour Transmission of Materials.
- .18 NAIMA National Insulation Standards.
- .19 NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.
- .20 UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.
- .21 CAN/CG5B-51.11 Mineral Fiber Thermal Insulation Blanket.
- .22 CAN/CG5B-51-GP-52 Ma Vapor Barrier, Jacket & Facing Material For Pipe Duct & Equipment Thermal Insulation.
- .23 CAN/CG5B-51-GP-53 M Jacketing, Polyvinyl Chloride Sheet for Insulating Pipes,

Vessels of Round Ducts.

1.4 SUBMITTALS

- .1 Refer to Section 23 01 01.
- .2 Product Data: Provide product description, thermal characteristics, list of materials and thickness for equipment scheduled.
- .3 Manufacturer's Instructions: Indicate installation procedures which ensure acceptable workmanship and installation standards will be achieved.
- .4 Samples: Submit two samples of any representative size illustrating each insulation type.

1.5 QUALITY ASSURANCE

- .1 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- .2 Applicator Qualifications: Company specializing in performing the work of this section with minimum 5 years documented experience.

1.6 REGULATORY REQUIREMENTS

- .1 Materials: Flame spread/smoke developed rating of 25/50 to the requirements of the Ontario Building Code.

1.7 DELIVERY, STORAGE, AND PROTECTION

- .1 Transport, handle, store, and protect products.
- .2 Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.
- .3 Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.8 ENVIRONMENTAL REQUIREMENTS

- .1 Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- .2 Maintain temperature during and after installation for minimum period of 24 hours.

2 PRODUCTS

2.1 GLASS FIBRE, FLEXIBLE

- .1 Manufacturer: Owens Corning Fiberglas
- .2 Other acceptable manufacturers offering equivalent products:
 - .1 Knauf Fiber Glass
 - .2 Johns Manville
- .3 Insulation: ASTM C553; flexible, noncombustible.
 - .1 'ksi' Value: ASTM C177 or ASTM C518, 0.035 at 75.2 °F (24 °C).
 - .2 Maximum Service Temperature: 250 °F (121 °C).

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- .3 Maximum Moisture Absorption: 0.2 percent by volume.
 - .4 Density: 2.4 lb/ft³ (38 kg/cu m).
 - .4 Vapour Barrier Jacket:
 - .1 ASTM C921,.
 - .2 Moisture vapour transmission: ASTM E96; 0.02 perm.
 - .3 Secure with self-sealing longitudinal laps and butt strips.
 - .4 Secure with outward clinch expanding staples and vapour barrier mastic.
 - .5 Tie Wire: 3/64" (1.22 mm) stainless steel with twisted ends on maximum 12" (300 mm) centres.
 - .6 Vapour Barrier Lap Adhesive: Compatible with insulation, maximum VOC content of 80 g/L
 - .7 Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool, maximum VOC content of 80 g/L.
 - .8 Taps shall be of aluminum, self adhesive with minimum 2" (50 mm) width.

2.2 GLASS FIBRE, RIGID

- .1 Manufacturer: Owens Corning Fiberglas
- .2 Other acceptable manufacturers offering equivalent products:
 - .1 Knauf Fiber Glass
 - .2 Johns Manville
- .3 Insulation: ASTM C612 or ASTM C592; rigid, noncombustible.
 - .1 'ksi' Value: ASTM C177 or ASTM C518, 0.035 at 75.2 °F (24 °C).
 - .2 Maximum Service Temperature: 450 °F (232 °C).
 - .3 Maximum Moisture Absorption: 0.1 percent by volume.
 - .4 Density: 16 kg/cu m.
- .4 Vapour Barrier Jacket:
 - .1 Kraft paper reinforced with glass fibre yarn and bonded to aluminized film.
 - .2 Moisture vapour transmission: ASTM E96; 0.02 perm.
 - .3 Secure with self-sealing longitudinal laps and butt strips.
 - .4 Secure with outward clinch expanding staples and vapour barrier mastic.
- .5 Facing: 1" (25 mm) galvanized steel hexagonal wire mesh stitched on one face of insulation.
- .6 Vapour Barrier Lap Adhesive: Compatible with insulation, maximum VOC content of 80 g/L.
- .7 Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool, maximum VOC content of 80 g/L.

2.3 JACKETS

- .1 Canvas Jacket: UL listed.
 - .1 Fabric: ASTM C921, 220 g/sq m, plain weave cotton treated with dilute fire retardant lagging adhesive.
 - .2 Lagging Adhesive:
 - .1 Compatible with insulation.
- .2 PVC Jacket (Indoor):
 - .1 Jacket: ASTM C921, One piece sheet material.
 - .1 Minimum Service Temperature: -31 °F (-35 °C).
 - .2 Maximum Service Temperature: 150 °F (66 °C).

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- .3 Moisture Vapour Transmission: ASTM E96; 0.03 perm inches.
 - .4 Maximum Flame Spread: ASTM E84; 25 or less.
 - .5 Maximum Smoke Developed: ASTM E84; 50 or less.
 - .6 Thickness: 20 mil (0.4 mm) minimum.
 - .2 Colour: standard off-white
 - .3 Covering Adhesive Mastic
 - .1 Compatible with insulation, low VOC.
 - .4 Manufacturer;
 - .1 Ceel-Co 300 series
 - .2 Speedline *Smoke Safe*

2.4 ACCESSORIES

- .1 Adhesives and finishes shall be as recommended by the insulation manufacturer and shall comply with Section 15100.2.2. Accessories such as adhesives, mastics and cements shall have the same properties as listed above and shall not detract from any of the system ratings specified.
- .2 Vapor retarder lap adhesive shall be water based, fire retardant
- .3 Tapes shall be of cloth reinforced aluminum, soft adhesive with minimum 2" (50 mm) width.
- .4 Tie wire shall be of 1/16" (1.5 mm) \varnothing stainless steel.
- .5 Fasteners shall be of 1/8" (4 mm) \varnothing pins, with 35 mm square clips. Clip length to suit insulation thickness.
- .6 Bands shall be 1/2" (12 mm) wide 1/4" (6mm) thick galvanized steel.
- .7 Facing shall be of 1" (25 mm) galvanized steel hexagonal wire mesh attached on both faces of insulation.

3 EXECUTION

3.1 EXAMINATION

- .1 Verify that equipment has been tested before applying insulation materials.
- .2 Verify that surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION

- .1 Install equipment insulations to TIAC National Installation Standards.
- .2 Apply insulation materials, accessories, jackets and finishes in accordance with manufacturer' written instructions and as specified.
- .3 Do not insulate factory insulated equipment.
- .4 Exposed Equipment: Locate insulation and cover seams in least visible locations.
- .5 Apply insulation close to equipment by grooving, scoring, and bevelling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
- .6 Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapour barrier cement.
- .7 Insulated equipment containing fluids below ambient temperature: Insulate entire system.
- .8 Fibre glass insulated equipment containing fluids below ambient temperature:

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- Provide vapour barrier jackets, factory-applied or field-applied. Finish with glass cloth and vapour barrier adhesive.
 - .9 For hot equipment containing fluids 140°F (60°C) or less, do not insulate flanges and unions, but bevel and seal ends of insulation.
 - .10 For hot equipment containing fluids over 140°F (60°C), insulate flanges and unions with removable sections and jackets.
 - .11 Fibre glass insulated equipment containing fluids above ambient temperature: Provide standard jackets, with or without vapour barrier, factory-applied or field-applied. Finish with glass cloth and adhesive.
 - .12 Inserts and Shields:
 - .1 Application: Equipment 1-1/2 " (40 mm) diameter or larger.
 - .2 Shields: Galvanized steel between hangers and inserts.
 - .3 Insert location: Between support shield and equipment and under the finish jacket.
 - .4 Insert configuration: Minimum 6" (150 mm) long, of same thickness and contour as adjoining insulation; may be factory fabricated.
 - .5 Insert material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
 - .13 Finish insulation at supports, protrusions, and interruptions.
 - .14 Equipment in Mechanical Equipment Rooms or Finished Spaces: Finish with PVC jacket.
 - .15 Exterior Applications: Provide vapour barrier jacket or finish with glass mesh reinforced vapour barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal equipment.
 - .16 Cover glass fibre insulation with metal mesh and finish with heavy coat of insulating cement.
 - .17 Nameplates and ASME Stamps: Bevel and seal insulation around; do not insulate over.
 - .18 Provide removable / reusable insulation covers for equipment, devices and fittings requiring access for maintenance, repair, or cleaning.

3.3 EQUIPMENT INSULATION

- .1 Insulate new or altered equipment as follows:

Mineral Fiber Blanket - Hot Surfaces 68°F - 750°F	
Item	Thickness
Heating Pump including Fittings & Accessories	2"
Expansion Tanks, Air Separators	2"
Any Other Equipment Operating at High Temp.	2"

Mineral Fiber Blanket - Hot Surfaces 20°C - 400°C	
Item	Thickness
Heating Pump including Fittings & Accessories	50 mm

Expansion Tanks, Air Separators	50 mm
Any Other Equipment Operating at High Temp.	50 mm

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 23 01 01 and 01 91 00.

1.2 COMMISSIONING AGENT

- .1 The commissioning agent (CA) has been contracted directly by the Owner for this project. The CA has overall responsibility for planning and coordinating the commissioning process. Commissioning involves all parties to the design and construction process, including the Contractor and his sub-contractors and suppliers.

1.3 DESCRIPTION OF WORK

- .1 The purpose of the commissioning process is to provide the owner/operator of the facility with assurance that the plumbing systems have been installed according to the contract documents, and operate within the performance guidelines set out in the design intent documents and these specifications. The CA will provide the Owner with an unbiased, objective view of the system's installation, operation, and performance. The commissioning process does not take away or reduce the responsibility of the installing contractors to provide a finished product, installed and fully functional in accordance with the contract documents.
- .2 Commissioning is intended to enhance the quality of system start up and aid in the orderly completion and transfer of systems for beneficial use of owner. The CA will be the leader of the commissioning team, planning and coordinating all commissioning activities in conjunction with the design professionals, construction manager, subcontractors, manufacturers, and equipment suppliers.
- .3 The General Contractor and Division 21, 22, 23, 25, 26, 27 and 28 sub-contractors are responsible for cooperating, and coordinating their work, with the CA. They shall also be responsible for carrying out all the physical activities required for installation of components and systems and operating them during the commissioning process as required in this Section.

1.4 RELATED DOCUMENTS

- .1 Drawings and General Requirements of the contract, including General and Supplementary General Conditions, General Requirements, and applicable Sections of Divisions 21, 22, 23, 25, 26, 27 and 28 apply to work of this Section.
- .2 Refer to specification section Appendix C.

1.5 REFERENCES

- .1 Ontario Building Code (OBC).
- .2 Ontario Fire Code (OFC).
- .3 ASHRAE Guideline 0 The Commissioning Process,

1.6 SYSTEMS TO BE COMMISSIONED

- .1 The following HVAC work shall be commissioned as part of the Work of this contract:
- .2 Air handling (AC-01) Unit
- .3 Energy Recovery (ERU-01) Unit
- .4 Energy Recovery (ERU-02) Unit
- .5 Heating Boiler
- .6 Fan Coil Systems
- .7 Ductwork Systems
- .8 Hydronic systems
- .9 Controls, Point-to-Point
- .10 Duct pressure testing

2 PRODUCTS

2.1 COMMISSIONING AUTHORITY

- .1 The commissioning authority shall consist of representatives of the following:
 - .1 Owner and the Owner's Operating and Maintenance Staff
 - .2 Architect
 - .3 Mechanical Design Engineer
 - .4 Electrical Design Engineer
 - .5 Commissioning Consultant (CC)
 - .6 General Contractor
 - .7 Fire Protection Subcontractor
 - .8 Mechanical Subcontractor
 - .9 Controls Subcontractor
 - .10 Electrical Subcontractor
 - .11 Testing, Adjusting and Balancing Agency
 - .12 Related Subcontractors and Suppliers.

2.2 SYSTEMS START-UP/VERIFICATION CHECKLISTS

- .1 The Appendix specification section contains the system start-up and verification checklists as listed below:
- .2 Air handling (AC-01) Unit
- .3 Energy Recovery (ERU-01) Unit
- .4 Energy Recovery (ERU-02) Unit
- .5 Heating Boiler
- .6 Fan Coil Systems
- .7 Ductwork Systems
- .8 Hydronic systems
- .9 Controls, Point-to-Point
- .10 Duct pressure testing

2.3 FUNCTIONAL PERFORMANCE TEST CHECKLISTS

- .1 This Appendix specification section contains functional performance test

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- checklists as listed below:
- .2 Air handling (AC-01) Unit
 - .3 Energy Recovery (ERU-01) Unit
 - .4 Energy Recovery (ERU-02) Unit
 - .5 Heating Boiler
 - .6 Fan Coil Systems
 - .7 Ductwork Systems
 - .8 Hydronic systems
 - .9 Controls, Point-to-Point
 - .10 Duct pressure testing

3 EXECUTION

3.1 COMMISSIONING CONSULTANT'S RESPONSIBILITIES

- .1 The Commissioning Consultant shall:
 - .1 plan, organize and implement the commissioning process as specified herein;
 - .2 prepare the commissioning plan, ensure its distribution for review and comment;
 - .3 revise the commissioning plan as required during construction;
 - .4 chair commissioning meetings, and prepare and distribute minutes to all commissioning team members, whether or not they attended the meeting;
 - .5 in conjunction with the General Contractor, coordinate commissioning activities among all contractors, sub-trades and suppliers;
 - .6 monitor system verification checks, and ensure the results are documented as the checks are done;
 - .7 monitor controls point-to-point checks done by the controls contractor, and ensure the results documented as the checks are done;
 - .8 observe all start-ups and initial system operations tests and checks;
 - .9 direct the contractors to operate equipment and systems as required to ensure that all required functional performance tests are carried out for verification purposes;
 - .10 witness all functional performance tests and document the results;
 - .11 prepare and submit a commissioning report which documents all checks and tests done throughout the commissioning process, and the results obtained from each; and
 - .12 ensure all required O&M manuals, instructions and demonstrations are provided to the owner's designated operating staff.

3.2 MECHANICAL ENGINEER'S RESPONSIBILITIES

- .1 The Mechanical Engineer will review the commissioning plan, and will participate, as appropriate, in on-site commissioning meetings.
- .2 During the acceptance phase of the commissioning process, the Mechanical Engineer may be on site to review commissioning documentation, to witness

functional performance tests, and to analyze the installation and its performance.

3.3 OWNER'S RESPONSIBILITIES

- .1 The Owner will ensure the availability of operating staff for all scheduled instructions and demonstration sessions. This staff will possess sufficient skills and knowledge to operate and maintain the installation following attendance at these sessions. The owner will also ensure the appropriate involvement of the Electrical Engineer, Architect, and any other consultants as required, in the commissioning process.

3.4 GENERAL CONTRACTOR'S RESPONSIBILITIES

- .1 The General Contractor has responsibility to ensure the overall completion of the work. In this regard, he shall;
 - .1 participate as required in the HVAC Systems Commissioning process,
 - .2 ensure the HVAC contractor performs all assigned commissioning responsibilities as specified in 3.5,
 - .3 ensure the testing, adjusting and balancing agency performs all assigned commissioning responsibilities as specified in 3.6,
 - .4 ensure the Division 25 sub-contractor performs all assigned commissioning responsibilities as specified in 3.7,
 - .5 ensure the Division 26 sub-contractor performs all assigned commissioning responsibilities as specified in 3.8,
 - .6 ensure the cooperation and participation in the commissioning process of all other sub-contractors as applicable.
- .2 The General Contractor shall assign a representative to the commissioning team, and submit the person's name to the commissioning agency, within one (1) month of the award of the contract. The representative shall have the authority to make decision on behalf of the general contractor as they relate to the organization and scheduling of HVAC commissioning. The representative shall facilitate communications among all contractors and suppliers and other commissioning team members and shall foster the necessary cooperative action. One specific responsibility shall be to attend commissioning meetings and ensure action items arising from them are attended to as required to allow the commissioning process to proceed on schedule.
- .3 In the event that any scheduled equipment or system start-ups or functional performance tests are terminated because the CC or the mechanical engineer discover deficient or incomplete work, or due to the non-attendance of required contractor or supplier personnel, the contractor or sub-contractor responsible for the termination shall also be responsible for paying reasonable costs of time and travel expenses of any or all of the following representatives who were physically present for the purpose of witnessing the start-up or the FPT: the CC, the mechanical engineer, the electrical engineer, and the owner. The owner may provide a statement to the General Contractor identifying the specific activity that was terminated, the scheduled date, and a list of those in attendance, along with their reasonable time and travel expense costs.

3.5 HVAC SUBCONTRACTOR'S RESPONSIBILITIES

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- .1 The HVAC sub-contractor, and all the sub-contractors and suppliers within Division 23, shall cooperate with the commissioning consultant (CA), and other commissioning team members, to facilitate the successful completion of the commissioning process.
 - .2 The contractor shall assign a representative to the commissioning team, and submit the person's name to the commissioning agency, within one (1) month of the award of the contract. The representative shall have the authority to make decisions on behalf of the mechanical contractor as they relate to the organization and scheduling of HVAC commissioning. The representative shall ensure communications between Division 23 contractors and supplies and all other commissioning team members and shall foster the necessary cooperative action. One specific responsibility shall be to attend commissioning meetings and ensure action items arising from them are attended to as required to allow the commissioning process to proceed on schedule.
 - .3 The HVAC sub-contractor, and all mechanical sub-contractors and supplies, shall cooperate with the Commissioning Agency in carrying out the HVAC commissioning process. In this context, the HVAC sub-contractor shall:
 - .1 include in their quotes the cost of participating in the commissioning process as specified herein.
 - .2 Ensure the Division 25 sub-contractor performs HVAC commissioning responsibilities as listed in 3.7.
 - .3 Provide instruction and demonstrations for the Owner's designated operating staff, in conjunction with the commissioning agency and mechanical engineer, and with the participation of qualified technicians from major equipment suppliers and the controls contractor.
 - .4 Include requirements for submittal data. O&M data, and training information in each purchase order or sub-contract written.
 - .5 Ensure cooperation and participation of specialty sub-contractors such as sheet metal, piping, refrigeration, and water treatment as applicable.
 - .6 Ensure participation of major equipment manufacturing in appropriate start-up, testing and training activities.
 - .7 Attend commissioning meetings scheduled by the CA.
 - .8 Notify the CA a minimum of two weeks in advance of scheduled equipment and system start-ups, so that the CA may witness system verifications, and equipment and system start-ups.
 - .9 Provide sufficient personnel to assist the CA as required during system verification and functional performance testing.
 - .10 Prior to set-up, inspect, check and confirm the correct and complete installation of all equipment and systems for which system verification checklists are included in the commissioning plan. Document the results of all inspections and checks on the checklists and sign them. If deficient or incomplete work is discovered, ensure corrective action is taken and re-check until the results are satisfactory and the system is ready for safe start-up.
 - .11 Notify the CA a minimum of two weeks in advance, of the time for start of the TAB work. Attend the initial TAB meeting for review of the TAB procedures.
 - .12 Provide equipment and systems start-up resources as specified and

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- required. If during an attempted equipment or system start-up, deficient or incomplete work is discovered that would preclude safe operation, the start-up shall be aborted until corrective action has been taken. Ensure such action is taken and verified before re-scheduling a new start-up. Those responsible for deficient or incomplete work will be responsible for costs in accordance with 3.4 in this Section.
- .13 Carry-out performance checks to ensure that all equipment and systems fully functional and ready for the CA to witness formal functional performance tests (FPTs).
- .14 Operate equipment and systems for FPTs in accordance with the commissioning plan and as directed by the commissioning agency. If improper functionality, incomplete work, or other deficiencies affecting system performance are discovered, the FPTs will be stopped by the CC. Those responsible for deficient or incomplete work will be responsible for costs in accordance with 3.4 in this Section. Ensure that all corrections necessary for full and complete system operation as specified are completed; then with the ATC contractor and other applicable sub-contractors, carry-out functional performance checks to confirm correct operation before applying to the CA to re-schedule the FPTs for the system in question.
- .15 Prepare preliminary schedule for mechanical system orientation and inspections. O&M Manual submission, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up TAB, and task completion for use by the CA. Update schedule as appropriate throughout the construction period.
- .16 Attend initial O&M staff training session.
- .17 Conduct mechanical system orientation and inspection at the equipment placement completion stage.
- .18 Update drawings to as-built condition and review with the CA.
- .19 Gather O&M data on all equipment and assemble in binders as required by the commissioning specification. Submit to CA prior to the completion of construction.
- .20 Participate in, and schedule vendors and contractors to participate in the O&M staff training sessions as set-up by the CA.
- .21 Provide written notification to the general contractor (or construction manager) and CA that the following work has been completed in accordance with the contract documents and the equipment, systems and sub-systems are operating as required.
- .1 HVAC equipment including all fans, air handling units, dehumidification units, ductwork, dampers, terminals, and all Division 23 equipment.
 - .2 Refrigeration equipment, pumping systems and heat rejection equipment.
 - .3 Fire-stopping in the fire-rated construction, including fire and smoke damper installation, caulking, gasketing and sealing of smoke barriers.
 - .4 Seismic restraints installed to specification; a certification from the seismic restraint engineer meets this requirement.

- .5 Dedicated smoke control systems including stairway pressurization and atrium systems.
- .6 Non-dedicated systems using the air-handling units for smoke control.
- .7 Fire detection and smoke detection devices furnished under other divisions of this specification as they affect the operation of the smoke control systems.
- .8 That the building control system is functioning to control HVAC equipment and smoke control systems as specified.
- .22 Provide a complete set of as-built drawings and O&M manuals to the CA.

3.6 TAB AGENCY'S RESPONSIBILITIES

- .1 With respect to HVAC commissioning, the TAB agency shall:
 - .1 Include costs for HVAC commissioning requirements in the quoted price.
 - .2 Attend commissioning meetings scheduled by the CA prior to , and during, on-site TAB work being done.
 - .3 Submit proposed TAB procedures to the CA and mechanical engineer for review and acceptance.
 - .4 Attend the TAB planning meeting scheduled by the CA. Be prepared to discuss the procedures that shall be followed in testing, adjusting and balancing the HVAC system.
 - .5 At the completion of the TAB work, submit the final TAB report to the mechanical contractor, submittal will be to the mechanical contractor, with general contractor, CA, and mechanical engineer notified
 - .6 Participate in verification of the TAB report by the CA for verification or diagnostic purposes. This will consist of repeating a sample (normally 10% to 20%) of the measurements contained in the TAB report as directed by the CA.
 - .7 Participate in O&M personnel training sessions as scheduled by the CA.

3.7 CONTROLS SUBCONTRACTOR'S RESPONSIBILITIES

- .1 With respect to HVAC commissioning, the controls contractor shall:
 - .1 Include cost for commissioning requirements in the quoted price.
 - .2 Review design for controllability with respect to equipment selected for the project;
 - .1 Review and confirm in writing that a proper hardware specification exists to permit functional performance testing as required by specification and sequence of operation.
 - .2 Review and confirm in writing that proper safeties and interlocks are included in design.
 - .3 Ensure the proper sizing of control valves and actuators, based on design pressure drops. Ensure that control valve authority will result in capacity control as specified. Include valve sizing and authority information in submittal to mechanical engineer.
 - .4 Ensure the proper sizing of control dampers. Ensure damper authority to control air flows as specified. Review and confirm in

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- writing proper damper positioning for mixing to prevent stratification. Ensure correct actuator vs. damper movement for smooth operation. Include damper sizing, control authority and actuator selection data in submittal to mechanical engineer.
 - .5 Ensure the proper selection of sensor ranges and include data with submittal to mechanical engineer.
 - .6 Clarify all questions concerning sequences of operation with the mechanical engineer.
 - .3 Attend commissioning meetings scheduled by the CC.
 - .4 Provide the following submittals to the CC for review:
 - .1 Hardware and software submittals.
 - .2 Control panel construction shop drawings.
 - .3 Diagrams showing all control points, sensor locations, point names, actuators, controllers and where necessary, points of access, all superimposed on diagrams of the physical equipment.
 - .4 Narrative description of all control sequences for each piece of equipment controlled.
 - .5 Logic diagrams showing the logic flow of all control sequences.
 - .6 A list of all control points, including analog inputs, analog outputs, digital inputs and digital outputs. Include the values of all parameters for each system point. Provide a separate list for each stand-alone control unit.
 - .7 A complete control language program listing including all software routines employed in operating the control system. Also, provide a program write-up, organized in the same manner as the control software. This narrative shall describe the logic flow of the software and the functions of each routine and sub-routine. It should also explain individual math or logic operations that are not clear from reading the software listing.
 - .8 Hardware operation and maintenance manuals.
 - .9 Application software and project applications code manuals.
 - .5 Inspect, check, and confirm the proper installation and performance of controls/BAS hardware and software provided by others.
 - .6 Integrate installation and programming scheduling with construction and commissioning schedules.
 - .7 Inspect, check and confirm the correct installation and operation of input and output field points and devices through documented and signed off point-to-point checkouts.
 - .8 Provide thorough training to operating personnel on hardware operations and programming, and the application program for the system, in accordance with the O&M staff training program in the commissioning plan.
 - .9 In conjunction with the mechanical contractor, demonstrate system performance to the CC including all modes of system operation (e.g. occupied, unoccupied, emergency) during the functional performance tests (FTP). If improper functionality, incomplete work, or other deficiencies affecting system performance are discovered, the FTPs will be stopped by the CC. Those responsible for deficient or incomplete
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- work will be responsible for costs in accordance with 3.2 in this Section.
 - .10 Provide control system technician to assist during system verification and functional performance testing.
 - .11 Provide support and coordination with TAB contractor on all interfaces between controls and TAB scopes of work. Provide, at no additional cost to the TAB and commissioning agencies, all devices, such as portable operator's terminals and all software for the TAB agency to use in completing TAB procedures.

3.8 ELECTRICAL SUBCONTRACTOR'S RESPONSIBILITIES

- .1 With respect to HVAC commissioning, the electrical contractor shall:
 - .1 Include cost for HVAC commissioning requirements in the quoted price.
 - .2 Review design with respect to providing power to the HVAC equipment:
 - .1 Verify that proper hardware specifications exist for functional performance and sequence of operation required by specification.
 - .2 Verify that proper safeties and interlocks are included in the design of electrical connections for HVAC equipment.
 - .3 Attend commissioning meetings scheduled by the CC.
 - .4 Schedule work so that required electrical installations are completed, and systems verification checks and functional performance tests can be carried out on schedule.
 - .5 Inspect, check and confirm in writing the proper installation and performance of all electrical services provided.
 - .6 Provide electrical system technicians to assist during system verification and functional performance testing as required by the CC.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 23 01 01.

1.2 SECTION INCLUDES

- .1 Pipe and pipe fittings for:
 - .1 Heating water piping system.
 - .2 Glycol/water piping system.
 - .3 Equipment drains and overflows.
- .2 Valves:
 - .1 Gate valves.
 - .2 Globe or angle valves.
 - .3 Ball valves.
 - .4 Butterfly valves.
 - .5 Check valves.
 - .6 Circuit balancing valves
 - .7 Drain valves.

1.3 REFERENCES

- .1 ASME - Welding and Brazing Qualifications.
- .2 ASME B16.3 - Malleable Iron Threaded Fittings Class 50 and 300.
- .3 ASME B16.5 Pipe Pumps & Fittings.
- .4 ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
- .5 ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
- .6 ASME B31.5 - Refrigeration Piping and Heat Transfer Components.
- .7 ASME B31.1 - Code for Power Piping.
- .8 ASTM A53/A53M - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
- .9 A183 Carbon Steel Track Bolts and Nuts.
- .10 ASTM A234/A234M - Piping Fittings of Wrought-Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
- .11 ASTM B32 - Solder Metal.
- .12 ASTM B88 - Seamless Copper Water Tube.
- .13 ASTM D1785 - Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
- .14 ASTM D2235 - Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings.
- .15 ASTM D2241 - Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR-Series).
- .16 ASTM D2310 - Machine-Made Fibreglass' (Glass Fibre-Reinforced Thermosetting Resin) Pipe.
- .17 ASTM D2466 - Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
- .18 ASTM D2467 - Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
- .19 ASTM D2680 - Acrylonitrile-Butadiene-Styrene (ABS) and Poly(Vinyl Chloride) (PVC) Composite Sewer Piping.
- .20 ASTM D2683 - Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
- .21 ASTM D2751 - Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings.
- .22 ASTM D2855 - Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.

- .23 ASTM D3309 - Polybutylene (PB) Plastic Hot-and Cold-Water Distribution Systems.
- .24 ASTM F477 - Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
- .25 ASTM F708 - Design and Installation of Rigid Pipe Hangers.
- .26 ASTM F876 - Crosslinked Polyethylene (PEX) Tubing.
- .27 ASTM F877 - Crosslinked Polyethylene (PEX) Plastic Hot - and Cold - Water Distribution Systems.
- .28 AWS A5.8 - Filler Metals for Brazing and Braze Welding.
- .29 AWS D1.1 - Structural Welding Code - Steel.
- .30 AWWA C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
- .31 AWWA C110 - Ductile - Iron and Grey -Iron Fittings 3 inch - 48 inch (76 mm - 1219 mm), for Water and Other Liquids.
- .32 AWWA C111 - Rubber-Gasket Joints for Ductile Iron and Pressure Pipe and Fittings.
- .33 AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast, for Water.
- .34 MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacture.
- .35 MSS SP69 - Pipe Hangers and Supports - Selection and Application.
- .36 MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices.

1.4 SUBMITTALS

- .1 Product Data: Include data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalogue information. Indicate valve data and ratings.
- .2 Welders Certificate: Include welders certification of compliance with ASME SEC 9.
- .3 Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
- .4 Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.5 QUALIFICATIONS

- .1 Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- .2 Installer: Company specializing in performing the work of this section with minimum 3 years documented experience.
- .3 Welders: Certify to ASME SEC 9.

1.6 REGULATORY REQUIREMENTS

- .1 Conform to ASME B31.1 code for installation of piping system.
- .2 Welding Materials and Procedures: Conform to ASME SEC 9 and applicable provincial labour regulations.
- .3 Provide certificate of compliance from authority having jurisdiction indicating approval of welders.

1.7 DELIVERY, STORAGE, AND HANDLING

- .1 Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- .2 Provide temporary protective coating on cast iron and steel valves.
- .3 Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- .4 Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.8 ENVIRONMENTAL REQUIREMENTS

- .1 Do not install underground piping when bedding is wet or frozen.

2 PRODUCTS

2.1 VALVES - GENERAL

- .1 Conform to requirements of ANSI, ASTM, ASME, and applicable MSS standards.
- .2 Provide valves of the same manufacturer where possible.
- .3 Manufacturer's name and pressure rating clearly marked on body to MSS-SP-25.
- .4 Valid CRN (Canadian Registration Number) required for each valve.
- .5 Materials:
 - .1 Bronze: ASTM B62 or B61 as applicable
 - .2 Brass: ASTM B283 C3770
 - .3 Cast Iron: ASTM A126 Class B
- .6 End Connections:
 - .1 Threaded ends: ANSI B1.20.1
 - .2 Flanged ends: ANSI B16.1 (Class 125), ANSI B16.5
 - .3 Face-to-face dimensions: ANSI B16.10
- .7 Design and Testing:
 - .1 Bronze Gate & Check valves: MSS-SP-80
 - .2 Ball Valves: MSS-SP-110
 - .3 Cast Iron Gate Valves: MSS-SP-70
 - .4 Cast Iron Globe Valves: MSS-SP-85
 - .5 Cast Iron Check: MSS-SP-71
 - .6 Butterfly Valves: MSS-SP-67
- .8 First named product as indicated in paragraphs below; other acceptable manufacturers, subject to equivalent products include:
 - .1 Kitz
 - .2 Crane
 - .3 Jenkins

2.2 HYDRONIC SYSTEMS TO 150 PSIG, ABOVE GROUND

- .1 Nominal Operating Pressure 125 psig
- .2 Design Pressure 150 psig
- .3 Test Pressure 225 psig
- .4 Design Temperature 350°F
- .5 Corrosion Allowance 0.0625 in.
- .6 Steel Pipe ASTM A53 Gr.B ERW or ASTM A106 Gr.B SMLS, sch 40,
- .7 Joints, 2" and smaller screwed
- .8 Screwed Fittings 150 Lb. malleable iron
- .9 Unions CI.150, ASTM A-47 malleable iron, ASTM A-153 galvanized, ANSI B2.1 threads.
- .10 Joints, 2-1/2" and larger welded, with flanges at connections to equipment
- .11 Butt weld fittings ASTM A234 Gr. WFB
- .12 Flanges ASTM A105, Class 150, raised face, weld neck or slip on
- .13 Bolts ASTM A307 C.S. bolts, sq. head; ASTM A563 nuts, hex head
- .14 Gaskets 1/16" (1.6 mm) thick preformed non-asbestos graphite

	fibre.	
.15	Copper Tubing, 2" and Smaller	ASTM B88, Type L, hard drawn.
.16	Joints:	Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin
	and	silver, with melting range 220°C to 280°C.
.17	Fittings:	ASME B16.18, cast brass, or ASME B16.22, solder
	wrought	copper
.18	Dielectric Unions	Union with galvanized or plated steel threaded end,
	copper	solder end, water impervious isolation barrier.
.19	Valves, 2" and smaller	ASTM A105
	Gate Valves (Isolating)	300 psig non-shock WOG, ASTM B62 bronze body,
		solid wedge disc, rising stem, bronze trim, threaded
		ends, Kitz #25
	Globe Valves (Throttling)	300 psig non-shock WOG, ASTM B62 bronze body,
		composition (Teflon) disc, rising stem, bronze trim,
		threaded ends, Kitz #09
	Check Valves (Backflow)	300 psig non-shock WOG, ASTM B62 bronze body, Y-
		pattern horizontal, swing type disc, threaded ends, Kitz
		#29
	Ball Valves (Drain)	600 psig non-shock WOG, forged brass, 2-piece,
	chrome ball and	stem, full port, blow-out proof PTFE seats & stem, lever
	handle,	threaded ends, Kitz #68AC.
.20	Valves, 2-1/2" and larger	ASTM A216 WCB
	Gate Valves (Isolating)	200 psig non-shock WOG, ASTM A126 Class B cast iron
		body, bolted bonnet, bronze mounted, solid wedge disc,
		OS&Y, non-asbestos packing, flanged ends, Kitz #72.
	Globe Valves (Throttling)	200 psig non-shock WOG, ASTM A126 Class B cast iron
		body, bolted bonnet, bronze mounted, bevelled wedge
		disc, OS&Y, non-asbestos packing, flanged ends, Kitz
		#76.
	Check (Backflow)	200 psig non-shock WOG, ASTM 126 Class B cast iron
		body, bolted cover, bronze mounted, swing type disc,
		flanged ends, Kitz #78
.21	Provide stem extensions for insulated piping.	
.22	Provide gear operator and chain on valves installed above 10-ft AFF.	
.23	Strainers, 2" and smaller	Class 250, 400 psig WOG, cast iron body, Y-pattern,
	screwed cap	
		and ends, A167 304 stainless steel screen with 1/32"
		perforations. Mueller Steam 11M.
.24	Strainers, 2-1/2" and larger	Class 250 psig non-shock WOG, cast iron, Y-pattern,
	bolted	flange cover, blow-out plug, A167 304 stainless
	steel screen	with 1/32" perforations, flanged ends, Mueller
	Steam 752 .	

2.3 EQUIPMENT DRAINS AND OVERFLOWS

- .1 Copper Tubing: ASTM B88, Type M and DWV, hard drawn.
 - .1 Fittings: ASME B16.18, cast brass, or ASME B16.22 solder wrought copper.
 - .2 Joints: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 4428°F to 536°F (220°C to 280°C).

2.4 CIRCUIT BALANCING VALVES

- .1 Circuit Balancing Valves; 2" (50 mm) and smaller)
 - .1 Screwed connection, globe style design, nonferrous, pressure die-cast, nonporous Ametal Copper Alloy. Each valve shall be such that when installed in any direction, it will not affect flow measurement.
 - .2 Valves shall provide the following functions:
 - .1 Precise flow measurement.
 - .2 Precision flow balancing.
 - .3 Positive shut off with no drip seat and teflon disc.
 - .4 Drain connection with protective cap.
 - .3 Valves shall have four 360° adjustment turns of handwheel for maximum vernier-type setting with "Hidden Memory" feature to program the valve with precision tamper-proof balancing setting.
 - .4 Valves shall be shipped in a 4.5 R factor polyurethane container that shall be used as insulation after valve is installed.
 - .5 Provide valves suitable for maximum working pressure of 250 psi (1720 kPa) and maximum operating temperature of 250°F (121°C).
 - .6 Acceptable Products: S.A. Armstrong CRV I indicated or Tour & Anderson STAD or Newman Hattersley.
- .2 Circuit Balancing Valves 2 1/2" (65 mm) and larger
 - .1 Flanged, line size connection, globe style design, nonferrous, pressure die-cast, nonporous Ametal Copper Alloy.
 - .2 Valves, shall provide the following functions:
 - .1 Precise flow measurement.
 - .2 Precision flow balancing.
 - .3 Positive shut off with no drip seat and teflon disc.
 - .3 Valves shall have twelve 360° adjustment turns of handwheel for maximum vernier-type setting with "Hidden Memory" feature to program the valve with precision tamper-proof balancing setting.
 - .4 Valves shall be suitable for maximum working pressure of 250 psi (1720 kPa) and maximum operating temperature of 250°F (120°C).
 - .5 Acceptable Products: S.A. Armstrong CBV II indicated or Tour & Anderson STAF or Newman Hattersley.

3 EXECUTION

3.1 PREPARATION

- .1 Ream pipe and tube ends, remove burrs and bevel plain end ferrous pipe.
- .2 Remove scale and dirt on inside and outside before assembly.
- .3 Prepare piping connections to equipment with flanges or unions.
- .4 Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.
- .5 After completion, fill, clean, and treat systems.

3.2 APPLICATIONS

- .1 Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
- .2 Where permitted, install grooved mechanical couplings and fasteners in accessible locations.

- .3 Install unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.
- .4 Provide non-conducting dielectric connections whenever jointing dissimilar metals in open systems.
- .5 Provide pipe hangers and supports to CSA B51 unless indicated otherwise.
- .6 Use gate valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- .7 Use globe valves for throttling, bypass, manual flow control services, for balancing & in bypass around control valves.
- .8 Use spring loaded check valves on discharge of condenser water pumps.
- .9 Use wafer check valves where required to suit space and or weight limitations
- .10 Use 3/4 inch (20 mm) gate or ball valves with cap and chain for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. Pipe to nearest floor drain.
- .11 Use lug end butterfly valves to isolate equipment.
- .12 Butterfly valves may be used isolation and throttling duty for large pipe sizes 2-1/2" (65 mm) and above.
- .13 Gasket material shall be Grade 'E' EPDM compound conforming of ASTM D2-2000 and suitable for an operating temperature range of -34°C to 110°C.
- .14 Small runouts, size 3/4" (20 mm) and less for extension of domestic make-up piping may be constructed using hand drawn copper tube type 'K' or "L" and comply to ASTM B88.

3.3 INSTALLATION

- .1 Install to manufacturer's instructions.
- .2 Install heating water, glycol, chilled water, condenser water piping to CSA B51.
- .3 Route piping in orderly manner, parallel to building structure, and maintain gradient.
- .4 Install piping to conserve building space, and not interfere with use of space.
- .5 Group piping whenever practical at common elevations.
- .6 Sleeve pipe passing through partitions, walls and floors.
- .7 Slope piping and arrange to drain at low points.
- .8 Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- .9 Inserts:
 - .1 Provide inserts for placement in concrete formwork.
 - .2 Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - .3 Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4" (100 mm).
 - .4 Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
 - .5 Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- .10 Pipe Hangers and Supports:
 - .1 Install to CSA B51.
 - .2 Support horizontal piping as scheduled.
 - .3 Install hangers to provide minimum 1/2" (13 mm) space between finished covering and adjacent work.
 - .4 Place hangers within 12" (300 mm) of each horizontal elbow.
 - .5 Use hangers with 1-1/2" (38 mm) minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
 - .6 Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.

- .7 Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- .8 Provide copper plated hangers and supports for copper piping.
- .9 Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
- .11 Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
- .12 Provide access where valves and fittings are not exposed.
- .13 Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.
- .14 Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer (VOC content not to exceed 250 g/L) to welds.
- .15 Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting.
- .16 Install valves with stems upright or horizontal, not inverted.
- .17 Air vents shall be selected to suit the system operating pressures and shall be automatic and complete with isolating valves.
- .18 All strainers 1-1/2" (38mm) & larger shall be fitted with chain valves.
- .19 Unless specified otherwise, drain piping shall be sloped down in the direction of flow not less than 1" in 40 feet.
- .20 Eccentric reducers shall be provided to keep the bottom of sloped piping aligned in order to minimize risk of water hammer and to facilitate drainage.
- .21 Valves shall be installed with stems upright or angled 45 deg. above horizontal unless instructed otherwise.
- .22 Pipe all discharge from temperature & pressure safety relief valves to a point of safe discharge directly into a floor drain, hub drain or safe outdoor location.

3.4 EQUIPMENT CONNECTIONS

- .1 Install unions or flanges at connections to all equipment and specialty components.
- .2 Arrange piping connections to allow ease of access and removal of equipment.
- .3 Align and independently support piping adjacent to equipment connections in order to prevent piping stresses from being transferred to equipment.
- .4 Piping reducers shall be used where equipment connections differ from pipe sizes indicated. The use of bushings will not be permitted.
- .5 Install removable sections of pipe 12" (300 mm) spool pieces on the suction side of pumps and where needed for ease of maintenance.

3.5 VALVES, COCKS AND FAUCETS

- .1 Use valves of line size unless noted otherwise.
- .2 Provide isolating valves in each branch from the main line and where indicated.
- .3 Provide isolating valves at all equipment connections.
- .4 Provide globe valves or ball valves complete with memory stop at the discharge of each pump and where valves are used for regulating or throttling purposes.
- .5 Provide 1/2" (13 mm) brass hose bibbs at all low points of each system, where the system cannot be drained through the main floor or return piping.
- .6 Where new valves are installed to replace existing valves and it is impractical to shut-down and drain the entire system, valves shall be replaced using pipe freezing techniques.

3.6 HYDRONIC SPECIALTIES

- .1 Air Vents
 - .1 Provide 1" (25 mm) diameter air vent chamber at each riser feeding terminal units. Install chambers as high as possible within unit, and provide manual air vent connected to air chamber by flexible tubing.
 - .2 Provide a float type automatic air vent at any high points of hot water supply and return piping not vented through a convector etc. and at high point of piping for each hot water coil. The discharge of air vent shall terminate over a floor drain in mechanical rooms or over a sink in service rooms. A shut-off valve shall be provided on each automatic air vent and an access door and frame shall be provided for air vents located above ceilings.
- .2 Automatic Feed Valves: provide automatic feed valve on the cold water make-up line to each new hot water heating system.
- .3 Circuit Balancing Valve (CBV): provide a CBV in each branch serving a heating and/or cooling terminal unit and where indicated on drawings. Installation shall be in accordance with manufacturer's installation instructions. Ensure that manufacturer's recommended clearances are maintained to minimize turbulence and to promote accuracy.
- .4 Supply and install threaded couplings or half coupling for flow switches that are supplied under Section 25
- .5 Install flow switches as supplied under Section 25

3.7 CONTROLS DEVICES

- .1 Install pipe wells for various remote sensors such as temperature, pressure and flow sensors. Supply of sensors and controls wiring will be under Section 25.
- .2 Install control valves for fluid flow control. Supply of valves, valve actuators and controls wiring will be under Section 25.

3.8 TESTING AND INSPECTION

- .1 Test liquid heat transfer piping hydrostatically at not less than 150% of operating pressure or not less than 125 psi (860 kPa) whichever is the greater. Test period shall be not less than six (6) hours duration during which time each joint shall be inspected, given a sharp tap with a hammer and checked for leaks.
- .2 Arrange and pay for inspection by authorities having jurisdiction.

3.9 ADJUSTING AND BALANCING

- .1 Instruments used for this work shall be accurately calibrated and maintained in good working order, and shall include:
 - .1 one set of pressure gauges and fittings.
 - .2 dry bulb thermometer.
 - .3 wet bulb thermometer.
 - .4 thermocouple unit and thermocouple.
 - .5 set of balancing cock adjustment wrenches.
 - .6 portable field flow meter.
- .2 Prepare the liquid heat transfer systems as follows:
 - .1 Install any additional devices required for effective balancing as advised by the Systems Verification Agency.
 - .2 Open all valves, and return line balancing cocks.
 - .3 Remove and clean all strainers.

- .4 Check pump rotation.
- .5 Check expansion tanks to make sure they are not air bound and that the system is full of water.
- .6 Check all air vents at high points of water systems to make sure they are installed properly and are operating freely. Make certain all air is removed from circulating system.
- .7 Set all temperature controls so that all coils are calling for full cooling. This should close all automatic bypass valves at coil and chillers. To balance hot water coils, set systems to call for full heating.
- .8 Check operation of automatic bypass valve.
- .9 Check and set operating temperature of heat exchangers to design requirements.
- .3 Balance the liquid heat transfer systems as follows:
 - .1 Complete air balance must have been accomplished before water balance is begun.
 - .2 Set chilled water, hot water and glycol pumps to proper gpm delivery.
 - .3 Adjust flow of hot water through heat exchangers.
 - .4 Check leaving water temperatures and return water temperatures, and pressure drop through heat exchangers. Reset to correct design temperatures.
 - .5 Check water temperature at inlet side of cooling and heating coils. Note rise or drop of temperatures from source.
 - .6 Balance each chilled water and hot water coil.
 - .7 Upon completion of flow readings and coil adjustments, mark all settings and record all data.
 - .8 After making adjustments to coils, recheck settings at pumps, and heat exchangers. Readjust if required.
 - .9 Install pressure gauges on each coil, then read pressure drop through coil at set flow rate on call for full cooling and full heating. Set pressure drop across bypass valve to match coil full flow pressure drop. This prevents unbalanced flow conditions when coils are on full bypass.
 - .10 Check and record the following items at each cooling and heating element:
 - .1 Inlet water and air temperature.
 - .2 Leaving water and air temperature.
 - .3 Pressure drop of each coil.
 - .4 Pump operating suction and discharge pressures and final t.d.h.
 - .5 Pressure drop across bypass valve.
 - .6 All mechanical specifications of pumps.
 - .7 Rated and actual running amperage of pump motor.
- .4 After completion of adjusting and balancing and submittal of records notify the Systems Verification Agency and the Consultant and assist in verifications. If systems fail verification, readjust and balance systems to the satisfaction of the Consultant.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 23 01 01.

1.2 REFERENCES

- .1 ASHRAE HANDBOOK, HVAC SYSTEMS & EQUIPMENT, Duct Construction Recommendations
- .2 Sheet Metal And Air Conditioning Contractors' National Association (SMACNA)
- .1 HVAC Duct Construction Standards - Metal and Flexible
- .2 HVAC Duct Systems Design
- .3 Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems
- .4 Accepted Industry Practice for Industrial Duct Design
- .5 HVAC Systems - Testing, Adjusting and Balancing
- .6 Round Industrial Duct Construction Standards
- .7 Rectangular Industrial Duct Construction Standards
- .8 HVAC Air Duct Leakage Test Manual.
- .9 Guide for Steel Stack Construction
- .3 National Fire Protection Association (NFPA)
- .1 80 Standard for Fire Doors and Windows
- .2 90A Standard for Installation of AC and Ventilation Systems
- .3 90B Standard for Installation of Warm Air Heating and AC Systems
- .4 96 Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
- .5 255 Building Materials, Test of Burning Characteristics (same as ASTM E84)
- .4 American Society for Testing and Materials (ASTM)
- .1 A90/A90M - Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
- .2 A167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
- .3 A480/A480M - General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
- .4 A653/A653M - Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- .5 A1011/A1011M - Standard Specification for Steel, Sheet, and Strip Hot-Rolled, Carbon, Structural, High-Strength, Low-Alloy with Improved Formability.
- .6 B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
- .7 A240 - Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels
- .8 A480 - Standard Specification for General Requirements for Flat Rolled Stainless Heat-Resisting Steel Plate, Sheet and Strip

- .9 A653 - Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated by the Hot Dip Process
- .10 E84 - Standard Test Method for Surface Burning Characteristics of Building Materials
- .11 E477 - Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Material and Prefabricated Silencers
- .12 E814 - Standard Test Method for Fire Tests of Through Penetration Fire Stops
- .5 American Welding Society (AWS)
 - .1 B2.2 Brazing Procedures and Performance Qualifications
 - .2 D9.1 Sheet Metal Welding Code
- .6 Underwriter's Laboratories (UL)
 - .1 181 Factory Made Air Ducts and Air Connectors
 - .2 555 Standard for Safety Fire Dampers
 - .3 555S Leakage Rated Dampers for Use in Smoke Control Systems
 - .4 723 Test for Surface Burning Characteristics of Burning Materials (ASTM E84)

1.3 PERFORMANCE REQUIREMENTS

- .1 No variation of duct configuration or sizes permitted except by written permission.
- .2 Size round ducts installed in place of rectangular ducts to ASHRAE table of equivalent rectangular and round ducts.
- .3 Sizes indicated on drawings are clear inside dimensions and do not include for duct linings.

1.4 SUBMITTALS

- .1 Division 23 01 01: Procedures for submittals.
- .2 Product Data: Provide data for duct materials.
- .3 Shop Drawings:
 - .1 Plenums and plenum related items showing physical dimensions, joints, sealants, door construction and hardware.
 - .2 Factory fabricated ducts, fittings and joining systems.
 - .3 Firewall duct penetrations; fire and smoke dampers; louvers and access doors.
 - .4 Duct fitting particulars such as gauges, sizes, welds, reinforcements and configuration for 4" wg. (1000 kPa) pressure class and higher systems.
- .4 Submit changes or alterations in ductwork layout, with supporting calculations showing that the modified design will not increase total pressure, before work commences. Submittals for proposed changes shall be stamped for acceptance prior to commencement of work.
- .5 Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA HVAC Air Duct Leakage Test Manual.
- .6 Material Safety Data Sheets (MSDS) for sealants, adhesives and coatings.

1.5 PROJECT RECORD DOCUMENTS

- .1 Division 1: Submittals for project closeout.
- .2 Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

1.6 QUALITY ASSURANCE

- .1 Perform Work to SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- .2 Perform Duct Leakage Testing to SMACNA "HVAC Air Duct Leakage Testing Manual"
- .3 Maintain one copy of document on site.
- .4 Asbestos Free: Insulating and sealing materials must be certified to be free of asbestos.
- .5 Brazing: Certify brazing procedures, brazers, and operators in accordance with AWS B2.2 Brazing Procedures and Performance Qualifications
- .6 Welding: Certify welding procedures, welding equipment and welders in accordance with AWS D9.1 Sheet Metal Welding Code.

1.7 REGULATORY REQUIREMENTS

- .1 Ontario Building Code (OBC)
- .2 Ontario Fire Code (OFC)
- .3 Construct ductwork to NFPA 90A standards.

1.8 ENVIRONMENTAL REQUIREMENTS

- .1 Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
- .2 Maintain temperatures during and after installation of duct sealants.

2 PRODUCTS

2.1 MATERIALS

- .1 Table of Materials:

APPLICATIONS	MATERIALS
Rigid HVAC ducts, casings and fittings	ASTM A653 galvanized steel sheet, lock form quality, G90 zinc coating (0.90 oz/ft ²) to ASTM A90. Sheets free of pits, blisters, slivers, and ungalvanized spots.
Rigid HVAC ducts, casings and fittings installed underground (below slabs on grade). Rigid HVAC ducts, casings and fittings installed in swimming pools (natatorium).	PVC coated, galvanized steel sheets, lock form quality to ASTM A653, G90 zinc coating (0.90 oz/ft ² both sides) and factory applied 4-mil PVC coating. Ductwork shall be UL-181, Class 1 listed.

Aluminum Ducts, dryer vents	ASTM B209; aluminum sheet, alloy 3003-H14. Aluminum Connectors and Bar Stock: Alloy 6061- T6 or of equivalent strength.
Kitchen exhaust hoods, canopies and exposed ductwork in finished areas. Fume exhaust hoods, canopies and ductwork.	Type 316L steel sheet per ASTM A480 and ASTM A240 with a finished surfaced No. 4 for exposed locations, and No. 2B for concealed locations. Longitudinal seams welded, transverse joints and connections to equipment or accessories welded or flanged. Welds on exposed ducts shall be ground smooth and polished to a bright finish.
Concealed wet exhaust from dishwashers, cart washers, vents and other utility applications.	Type 304 steel sheet per ASTM A480 and ASTM A240 with a 2B finish. Ducts shall have longitudinally welded seams and welded or flanged transverse joints and connections to equipment or accessories.
Breeching and chimneys	Black steel to ASTM A621 Specification for Steel Sheet and Strip Carbon Hot Rolled Drawing Quality. All seams and joints continuously welded.

- .2 Hanger Rod: continuously threaded, ASTM A36 galvanized steel in general, stainless steel for stainless steel ducts.
- .3 Sealant: Non-hardening, water resistant, fire resistive, low VOC (VOC content not to exceed 250 g/L), compatible with mating materials; liquid used alone or with tape, or heavy mastic.
- .4 Supports: Angle iron, channels, rods and related supporting materials shall be galvanized or red oxide coated.
- .5 Fasteners: Use galvanized rivets, screws and bolts throughout, except on stainless steel ductwork, use SS fasteners.
- .6 Reinforcements: Provide galvanized steel or stainless steel reinforcement shapes and plates to match ductwork.
- .7 Tie Rods: Use galvanized steel, 1/4 inch minimum diameter fasteners for ductwork 36 inch or less in length; use 3/8 inch minimum diameter for lengths longer than 36 in.

2.2 DUCT CONSTRUCTION

Duct Construction Schedule:

Duct Application	Duct Pressure	Pressure Class (in.wg.)	Seal Class	Leakage Class
Rectangular HVAC Supply from AHU to terminal unit or reheat coil	Positive	4	A	6

Round HVAC Supply from AHU to terminal unit or reheat coil	Positive	4	A	3
Rectangular HVAC Supply from terminal unit or reheat coil to HEPA filter in OR air outlet	Positive	4	A	6
Round HVAC Supply from terminal unit or reheat coil to HEPA filter in OR air outlet	Positive	4	A	3
Rectangular HVAC Supply from terminal unit or reheat coil to air outlet	Positive	2	A	6
Round HVAC Supply from terminal unit or reheat coil to air outlet	Positive	2	A	3
Rectangular HVAC Single zone supply from AC Unit to air outlet	Positive	2	A	6
Round HVAC Single zone supply from AC Unit to air outlet	Positive	2	A	3
Rectangular HVAC Return from air outlet to AHU	Negative	2	A	6
Round HVAC Return from air outlet to AHU	Negative	2	A	3
Rectangular Sanitary exhaust ductwork	Negative	2	A	6
Round Sanitary exhaust ductwork	Negative	2	A	3
Rectangular General HVAC exhaust ductwork	Negative	2	A	6
Round General HVAC exhaust ductwork	Negative	2	A	3
Exhaust fan discharge ductwork	Positive	2	A	0
Kitchen exhaust duct	Negative	4	A	0
Notes: 1. Pressure class shall be the lower of exhaust fan shut-off pressure or value shown				

2.3 DUCT SEALING

.1 Duct Sealing Requirements:

SEAL CLASS	SEALING REQUIREMENTS
A	All tranverse joints, longitudinal seams and duct wall penetrations
B	All tranverse joints and longitudinal seams a
C	All tranverse joints

2.4 DUCT LEAKAGE

.1 Leakage Class is defined as $CL = F / (P)^{0.65}$

where: CL = Leakage Class
 F = Leakage Factor (cfm/100-ft² of duct surface)
 P = Static pressure in the duct (in.wg.)

.2 Table

LEAKAGE FACTOR (F) CFM/100 –sq.ft. of DUCT SURFACE					
LEAK CLASS	PRESSURE CLASS (in.wg.) (+ve or –ve)				
C_L	1	2	4	6	10
48	48	75	118	154	214
24	24	38	59	77	107
12	12	19	30	38	54
6	6	9	15	19	27
3	3	5	7	10	13
0	0	0	0	0	0

2.5 DUCTWORK FABRICATION

- .1 All Ductwork shall be constructed to withstand 1-1/2 times fan pressure at shut-off and 2" (500 Pa) minimum.
- .2 Fabricate and support to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated in accordance with recommendations of ASHRAE and SMACNA.
- .3 Joints and reinforcements:
 - .1 to SMACNA and ASHRAE
 - .2 may be made with the Ductmate System or Nexus System. System components shall be made of standard catalogue manufacture as supplied by Ductmate Industries, Inc. or Nexus Inc.
- .4 Construct Tees, bends, and elbows with radius of not less than 1-1/2 times width of duct on centreline. Where not possible and where rectangular elbows are used, provide air foil turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fibre insulation.
- .5 Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- .6 Fabricate continuously welded round and oval duct fittings two gauges heavier than duct gauges indicated in SMACNA Standard. Joints: minimum 100 mm cemented slip joint, brazed or electric welded. Prime coat welded joints.
- .7 Provide standard 45-degree lateral wye takeoffs. Alternative 90-degree conical tee connections may be used only where specifically indicated.
- .8 Stainless steel ductwork for utility use, shall be fabricated from type 304 stainless steel, 2B finish, one gauge lighter than if the duct were to be fabricated from

- galvanized steel.
- .9 High Transmission Loss (HTL) Ductwork: galvanized ductwork of same gauge as outer casing of adjacent duct silencer, minimum 16 gauge.
- .10 Zero (0) leakage ductwork shall have all seams and joints continuously welded to SMACNA standards and recommendations.

2.6 HIGH PRESSURE, HIGH VELOCITY DUCTWORK

- .1 Round ducts constructed or galvanized steel sheets for static pressures up to 10" wg. (2500 Pa) positive.
- .2 Duct construction shall comply with SMACNA High Velocity Duct Construction Standards.
- .3 Schedule of Galvanized Steel Sheet Gauges – IP:

Diameter		Minimum Steel Gauge		
From	To	Spiral Lock	Longitudinal	Fittings
--->	8"	26	24	22
9"	22"	24	22	20
23"	36"	22	20	20
37"	50"	20	20	18
51"	60"	--	18	18
61"	84"	--	16	16

- .4 Schedule of Joints and Reinforcements – IP:

Diameter		Girth Joints	Girth Reinforcing
From	To		Min. Reinforcing Angle at Max. Longitudinal Spacing
--->	8"	2" Slip Joint	None required
9"	22"	4" Slip Joint	None required
23"	36"	4" Slip Joint/ Draw Band	None required
37"	50"	Flanged/Draw Band	1-1/4" x 1-1/4" x 1/8" at 72"
51"	60"	Flanged/Draw Band	1-1/4" x 1-1/4" x 1/8" at 72"
61"	84"	Flanged/Draw Band	1-1/2" x 1-1/2" x 1/8" at 48"

- .5 Elbows smooth or stamped elbows preferred. Gored elbows acceptable with 2 gores for elbows up through 36°, 3 gores for elbows from 37° to 72° and 5 gores for elbows from 73° to 90°

2.7 ROUND SPIRAL LOCK SEAM DUCTWORK

- .1 Spiral ducts and elbows shall not be used for watertight exhaust systems.
- .2 Ducts and fittings shall be manufactured from minimum G90 galvanized steel meeting ASTM A527/A527M-85.
- .3 Ductwork shall be "Uni-Seal" single wall, round spiral lock-seam type duct in wall thicknesses listed below.
- .4 Fittings shall be "Uni-Seal" single wall, round fittings suitable for use with "Uni-Seal" ductwork in wall thicknesses as follows:

ROUND SPIRAL LOCK SEAM DUCTWORK - IP			
Diameter		Minimum Steel Gauge	
From	To	Spiral Lock	Fittings
3"	14"	26	22
15"	26"	24	20
27"	36"	22	20
37"	50"	20	18
51"	60"	18	18

ROUND SPIRAL LOCK SEAM DUCTWORK - SI			
Diameter		Minimum Steel Gauge	
From	To	Spiral Lock	Fittings
75	356	0.56	0.70
380	660	0.71	0.86
686	914	0.86	1.01
939	1270	1.01	1.32
1321	1524	1.32	1.62

- .5 Acceptable Manufacturer: "Uni-Seal" spiral lock-seam duct and "Uni-Seal" fittings as manufactured by McGill. Other manufacturers refer to Section 23 01 01 2.3

2.8 FLEXIBLE DUCTWORK

- .1 Flexible ducts shall be factory fabricated to CAN/ULC S110, factory fabricated assembly with a laminated inner liner of aluminum foil, fiberglass and polyester, a galvanized steel helix coil formed to the inner liner, a fiberglass insulation blanket, and a polyethylene outer jacket. Flexible duct shall have a flame resistant rating of 25 or less and a smoke developed rating of 50 or less

FLEXIBLE DUCTWORK - IP		
Pressure rating	Low & Medium Pressure	High Pressure
Maximum positive pressure	6" wg	12" wg

Maximum negative pressure	4"wg	5" wg
Maximum velocity	4000 fpm	5500 fpm
Permeance	0.1 perm	0.1 perm
Operating temperature	-20°F to 250°F	-20°F to 250°F
Maximum thermal conductance	0.23 BTU/Hr-F°	0.23 BTU/Hr-F°
Listed & Labelled	Class 0, Class 1	Class 0, Class 1
Flexmaster type	5	3

FLEXIBLE DUCTWORK - SI		
Pressure rating	Low & Medium Pressure	High Pressure
Maximum positive pressure	3 kPa	6 kPa
Maximum negative pressure	2kPa	2.5 kPa
Maximum velocity	20 m/s	28 m/s
Permeance	0.1 perm	0.1 perm
Operating temperature	-20°F to 250°F	-28.9°C to 121.1°C
Maximum thermal conductance	0.23 BTU/Hr-F°	
Listed & Labelled	Class 0, Class 1	Class 0, Class 1
Flexmaster type	5	3

- .2 Lab Exhaust Systems: Ductwork to be a factory fabricated assembly of neoprene-coated polyester with galvanized steel helix reinforcement. Flexible duct shall be rated for a minimum of 6.0" w.g. positive pressure, 4.0" w.g. negative pressure, 5500 FPM velocity, -65 to 250 degrees F. Flexible duct shall have a flame resistant rating of 25 or less and a smoke developed rating of 50 or less. Uni-flex Model U-LOK 200.
- .3 Accessories: conical spin-in collars with butterfly volume dampers for connections to ductwork, round rigid galvanized steel fittings fabricated to SMACNA Standards and ASHRAE recommendations, bridge and gear clamps.
- .4 Acceptable Manufacturers:
 - .1 Flexmaster

2.9 FIRE BARRIER DUCT WRAP

- .1 Acceptable Manufacturers:
 - .1 3M Fire Protection
- .2 Installation shall be in strict accordance with manufacturers installation instruction.

- .3 3M Fire Barrier Duct Wrap 615+: Lightweight, non-asbestos, high temperature, bio-soluble, calcium-magnesium-silicate (CMS) non-woven blanket, encapsulated in a scrim-reinforced foil, blanket thickness of 1.5 inches (38mm) for ventilation and grease duct applications.
 - .1 Color: White blanket, aluminum foil encapsulated.
 - .2 Weight: 0.9 psf (4.38 kg/m²).
 - .3 Density: 6 pcf nominal.
 - .4 Thermal Conductivity (k-value) at 500 Degrees F (260 Degrees C) (ASTM C411, ASTM C518): 0.48 Btu/(ft² × h × F) (0.07 W/(m × K)).
 - .5 R-Value per ASTM C 518 at ambient (77 F/ 25 C): at least 6.3 (F-ft²-hr / Btu)
 - .6 Service range up to 2000°F (1093°C)
 - .7 Fire Resistance: For use in 3 hour fire resistant systems.
 - .8 Product complies with ASTM E 2336 test standard.
 - .9 Product complies with ISO 6944 test standard.
 - .10 Through-penetration per ASTM E 814 (UL 1479)
 - .11 Non-combustible per ASTM E 136

2.10 DUCT LINING

- .1 AP Armaflex SA Duct Lining (1") (25mm) thick, flexible, closed-cell elastomeric insulation in sheet form meeting following requirements;
 - .1 ASTM C1534 "Specification for Flexible Polymeric Foam Sheet Insulation Used as a Thermal and Sound Absorbing Liner for Duct Systems"
 - .2 CAN/ULC-102.2 and ASTM E84 flame spread index of 25 or less and smoke developed index of less than 50.
 - .3 Maximum thermal conductivity of 0.27 Btu-in./ft²-°F at a mean temperature of 75°F
 - .4 Maximum water absorption rate of 0.2% (by volume) to ASTM C209
 - .5 Maximum vapour transmission rate of 0.08 perm-inches to ASTM E96, Procedure A
 - .6 Approved for installation in air plenums
 - .7 NFPA 90A, NFPA 90B and UL 181 Class 1 specifications.
 - .8 ASTM C411, materials perform up to 250°F
 - .9 ASTM C1071 erosion resistance
 - .10 ASTM G21 and ASTM C1338 fungi resistance
 - .11 ASTM G22 bacterial resistance

3 EXECUTION

3.1 INSTALLATION

- .1 Install and seal ducts to SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- .2 Install ductwork parallel to building lines.
- .3 Support all ductwork from structural members. Where structural bearings do not

- exist, suspend strapping or hangers from steel channels or angles. Provide supplementary structural members. Do not suspend from metal deck.
- .4 Do not break continuity of insulation vapour barrier by hangers or rods.
- .5 Hangers shall be steel angles with supporting rods, locking nuts and washers to following table:

DUCT HANGERS - IP			
Duct Sizes (Largest side)	Angle Size	Rod Size	Spacing
Up to 30"	1" x 1" x 1/8"	1/4" diameter	10 ft
31" to 42"	1-1/2" x 1-1/2" x 1/8"	1/4" diameter	10 ft
43" to 60"	1-1/2" x 1-1/2" x 1/8"	3/8" diameter	10 ft
61" to 84"	2" x 2" 1/8"	3/8" diameter	8 ft

DUCT HANGERS - SI			
Duct Sizes (Largest side)	Angle Size	Rod Size	Spacing
Up to 30"	25 x 25 x 3 mm	6mm diameter	3 m
31" to 42"	40 x 40 x 3 mm	6mm diameter	3 m
43" to 60"	40 x 40 x 3 mm	10mm diameter	3 m
61" to 84"	50 x 50 x 3 mm	10mm diameter	2.5 m

- .6 Vertical ducts passing through floors shall be supported on angles secured to duct bearing on the floor.
- .7 Where ducts pass through walls, floors, openings required to have a fire resistance rating the opening in the construction around the duct shall be filled with an approved fire stop material as per NFPA 90A and fire damper shall also be installed with access doors as per the code.
- .8 Duct Sizes are inside clear dimensions. For lined ducts, maintain sizes inside lining.
- .9 Provide openings in duct work where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- .10 Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- .11 Use crimp joints with or without bead for joining round duct sizes 8" (200 mm) and smaller with crimp in direction of air flow.

- .12 Use double nuts and lock washers on threaded rod supports.
- .13 Connect terminal units to supply ducts directly or with 12" (300 mm) maximum length of flexible duct. Do not use flexible duct to change direction.
- .14 Connect diffusers or light troffer boots to low pressure ducts directly or with 60" (1.5 m) maximum length of flexible duct held in place with strap or clamp.
- .15 Connect flexible ducts to metal ducts with adhesive and metal or nylon straps.
- .16 Ground across flexible connector with No. 2/0 braided copper strap.
- .17 Set plenum doors 6" to 12" (150 to 300 mm) above floor. Arrange door swings so that fan static pressure holds door in closed position.
- .18 During construction provide temporary closures of metal or taped polyethylene on open duct work to prevent construction dust from entering duct work system.
- .19 Install HTL ductwork between duct silencer and mechanical room wall.
- .20 Balancing dampers shall be installed on branches as per locations shown on the drawings and as per the requirements of NEBB and AABC listing/measuring standards.
- .21 Perform duct leakage testing for all ductwork installed under this contract.
- .22 Seams and penetrations in ductwork and plena shall be sealed in accordance with seal classifications as described in SMACNA and ASHRAE.
- .23 Do not begin air balance until system has been completed and is in full working order. Put all heating, ventilating, and air conditioning system and equipment into full operation and continue the operation of same during each working day of balancing procedures. Provide assistance to the Testing and balancing Agency as required.

3.2 HIGH PRESSURE HIGH VELOCITY DUCT FABRICATION

- .1 Construct ductwork in accordance with SMACNA High Velocity Duct Standards for pressures through 6" W.G. (1.5 kPa).
- .2 Seal joints in round ducts and fittings with heat shrink sleeves.
- .3 Seal joints in rectangular ductwork with an approved type sealant during fabrication.
- .4 Seal flanged joints in ductwork with neoprene rubber gaskets.
- .5 Test high pressure ductwork in the presence of the Consultant as outlined by SMACNA.

3.3 WATERTIGHT DUCTWORK

- .1 Spiral ducts and elbows shall not be used for watertight exhaust systems.
- .2 Provide watertight ductwork for:
 - .1 Fresh air intake ducts and plenums
 - .2 Fume hood exhaust
- .3 Form bottom of duct without longitudinal seams.
- .4 All seams and joints welded. Connections to equipment and accessories flanged and gasketed.
- .5 Slope horizontal branch ductwork down toward hood or equipment served.
- .6 Slope header ducts down toward risers.
- .7 Fit base of risers with 6" (150 mm) deep drain and 1-1/4" (32 mm) drain

- connection, with deep seal trap and valved drain line to open funnel drain.
.8 Provide drain in every fresh air intake and exhaust plenum.

3.4 KITCHEN EXHAUST DUCTWORK

- .1 All kitchen exhaust ductwork shall be strictly in accordance with NFPA 96.
- .2 Site measurement shall be taken before fabrication in the factory shall begin.
- .3 The ductwork, joints, hangers, access doors and all other accessories shall be manufactured and installed as per manufacturer's instructions and in accordance with the ULC listing, meeting the requirements of NFPA .
- .4 Install kitchen exhaust ductwork without forming dips or traps which may collect residues. All ductwork shall lead as directly as possible to the exterior of the building.
- .5 Ducts shall be enclosed in a continuous enclosure extending from the ceiling above hood through concealed space to roof so as to maintain integrity of fire separation. Enclosure shall have a fire resistance rating of not less than 1 hour. Openings in enclosure walls shall be protected by approved self-closing fire doors.
- .6 Duct access doors shall be installed at all changes in direction, at the base of all risers, and at any other point as recommended by the manufacturer, in order to facilitate periodic cleaning and inspection. Access doors shall be installed in the sides of the ductwork only.
- .7 The final installation shall be inspected and approved by the duct manufacturer. Contractor to submit letters from manufacturer to authority having jurisdiction verifying undertaking to inspect and final approval.

3.5 CORRIDOR PENETRATION DUCTWORK

- .1 Site measurement shall be taken before fabrication in the factory shall begin.
- .2 The ductwork, joints, hangers, access doors and all other accessories shall be manufactured and installed as per manufacturer's instructions and in accordance with the ULC listing, meeting the requirements of NFPA 96.
- .3 The final installation shall be inspected and approved by the duct manufacturer. Contractor to submit letters from manufacturer to authority having jurisdiction verifying undertaking to inspect and final approval.

3.6 FIRE-RATED DUCT WRAP

- .1 Ductwork required to be fire-rated shall be minimum 24 USga., G-90 galvanized steel, wrapped with 3M Fire Master Duct Wrap 615 consisting of a 1-1/2" (38 mm) thick non-combustible, flexible fireproof blanket, fully encapsulated in a foil scrim and supplied in roll form. The wrap material shall be applied directly onto the installed ductwork strictly in accordance with the manufacturer's instructions and the ULC Listing and Design No., Guide No. 40 U21, 'Fire Resistant Ducts', as tested to ISO Standard 6944.
- .2 Duct construction shall be as per ASHRAE and SMACNA using water tight construction (See 3.1 Watertight Ductwork in Specification). Hangers shall be threaded steel rod and angle iron cradles.
- .3 One layer of wrap shall be applied to ductwork requiring a 1 hour fire resistance rating and two layers shall be applied to ductwork requiring a 2 hour fire resistance rating. Seams and joints to be lapped minimum 3" (75mm), taped and secured with steel banding. Tape and banding to comply with ULC listing and manufacturer's instructions.

- .4 All hangers, support rods, concrete anchors and firestopping of duct penetrations through fire separations shall be in accordance with the ULC Listing and the manufacturer's instructions.

3.7 INSULATED PLENUMS

- .1 Insulated panels shall be installed on a level concrete curb. Spacing of base channel attachments shall be as outlined in the manufacturer's standard details of assembly.
- .2 All assembly trim items shall be constructed of hot-dipped galvanized steel (minimum 18-gauge (1.32 mm) thickness) and furnished in standard lengths to be field cut to the required dimensions. Spacing of sheet metal screws, application of duct sealant, and positioning of trim shall be in accordance with the plenum manufacturer's published erection and installation details.
- .3 All mechanical joints and external trim items shall be sealed with a UL-Classified duct sealant as follows. In order to show that joints have been sealed properly, enough sealant shall be used so that excess sealant is extruded from all completed external joints. Joints and trim shall be sealed with a solvent-based duct sealant that is a neoprene-phenolic mastic formulated to withstand temperatures from -20 to +300 degrees Fahrenheit (-29 to 149°C). Sealant shall be formulated such that surface preparation or solvent cleaning is not necessary. Sealant shall have a UL Classification marking with flame spread of 5 and smoke developed of 0 when applied to 18-gauge (1.32 mm) galvanized steel and a flame spread of 5 and smoke developed of 5 when applied to inorganic reinforced cement board, both at a coverage of 53 sq. ft. per gallon (1.3 m2 per litre). Sealant shall exceed 1,000 hours under ASTM-D572 test conditions (oxygen bomb) without becoming brittle and 500 hours in QUV accelerated-exterior-aging apparatus without degradation (under ASTM-C732 test conditions).
- .4 One personnel access door shall be provided and shall be 24" wide by 60" high (600 mm wide by 1500 mm high). Door shall be the same nominal thickness as the prefabricated standard door panel in which they are mounted and shall be constructed with a solid inner and outer shell (minimum 20-gauge (1.0 mm) thickness). Each door shall be installed in the door panel at the factory and shall have a minimum of two ball-bearing hinges and two wedge-lever door latches. All levers shall be operable from the interior and exterior sides of the door panels. Door shall be installed to open against the air pressure differential.
- .5 Door shall seat against neoprene gasket materials, installed around the entire perimeter of the door frame in such a manner that door operation will provide direct compression with no sliding action between the door and gasket.
- .6 Openings for pipe and conduits shall be field cut to ensure proper positioning. All framing members, collars, and bellmouth fittings shall be insulated, welded, and sealed according to the plenum manufacturer's published installation details.
- .7 Entire wall shall be designed to be removable for equipment access purposes.
- .8 Provide drain in every fresh air intake and exhaust plenum.

3.8 FLEXIBLE DUCTWORK

- .1 Flexible ductwork may be installed for final connections to air outlets provided that not more than 5 ft. (1.5 mm) in length is used for each connection, and where specifically indicated on drawings.
- .2 All fittings used with flexible ductwork shall be rigid round duct.
- .3 Use pre-insulated flexible ductwork where application is to be insulated.

3.9 DUCT CLEANLINESS

- .1 All ductwork shall be handled and installed in accordance with the advanced level described in SMACNA Duct Cleanliness for New Construction Guidelines.
- .2 Ductwork leaving the premises of the manufacturer may include some or all of the following:
 - .1 self-adhesive labels or marking for part(s) identification shall be applied to external surfaces only;
 - .2 exposed mastic sealant;
 - .3 light zinc oxide coating on the metal surface;
 - .4 a light coating of oil on machine formed ductwork;
 - .5 minor protrusions into the airway of rivets, screws, bolts and other jointing devices;
 - .6 internal insulation and associated fasteners;
 - .7 discoloration marks from plasma cutting process.
 - .8 to maintain cleanliness during transportation, all ductwork shall be sealed either by blanking or capping duct ends, bagging small fittings, surface wrapping or shrink wrapping. Care must be taken to prevent damage during transportation and off loading.
- .3 A clean and dry environment where the ductwork is protected from dust must be provided for the storage of ductwork prior to installation. All sealed ends shall be visually examined and if damaged resealed with an appropriate material.
- .4 During installation, the working area shall be clean, dry and the ductwork protected from dust.
- .5 The internal surfaces of the uninsulated ductwork shall be wiped to remove excess dust immediately prior to installation.
- .6 Open ends on completed ductwork and overnight work-in-progress shall be sealed.
- .7 Access covers shall be firmly fitted in position on completion of each section of the work.
- .8 Protective coverings shall only be removed immediately before installation and inspected to determine if additional wipe down is necessary.

3.10 HVAC SYSTEM CLEANING

- .1 Qualifications of HVAC Systems Cleaning Contractor
 - .1 Member of National Air Duct Cleaners Association (NADCA)
 - .2 Supervisor: Air System Cleaning Specialist certified by NADCA
 - .3 Firm: regularly engaged in HVAC system cleaning with minimum 3-years experience
 - .4 Employees: trained in safe use of equipment and individual health protection measures

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- .2 Maintain a copy of all current MSDS documentation and safety certifications for products employed in the cleaning operations at the site at all times. Submit a copy of all MSDS sheets to Owner.
 - .3 Standards: Conform to NADCA Standard ACR 2006, Assessment, Cleaning and Restoration of HVAC Systems and NADCA Guidelines.
 - .4 Scope of HVAC System Cleaning Work;
 - .1 clean each HVAC System and component as follows;
 - .1 interior surfaces of all new ductwork and accessories installed as part of this project
 - .2 interior surfaces of all existing ductwork and accessories that are to remain in service on completion of this project,
 - .3 interior surfaces of all new and existing HVAC System components that are to remain in service on completion of this project, including; air handling units, fans, fan housings, air coils, drain pans, humidifiers, filters, filter frames, intake and exhaust and mixing plenums, air blenders, air outlets and inlets, air terminal units, power ventilators, sound attenuators, reheat coils, turning vanes, dampers, and sensors
 - .2 Verify the cleanliness of each HVAC System and component through visual inspection, video recording and testing indicated hereinafter.
 - .5 Cleaning & Disinfection Requirements;
 - .1 conduct visual/video inspections of HVAC Systems and components without disruption of settled dust or debris and without microbial amplification. Record and submit video inspections before and after cleaning as follows;
 - .1 ducts serving Class 2 areas (laboratory): 25%
 - .2 ducts serving Class 3 areas (classrooms): 10%
 - .2 mark and record position of any and all adjustable devices and ensure that they are re-set to their original position on completion of cleaning and verification work,
 - .3 document and report any and all damage to HVAC Systems and components discovered during inspections to Consultant and to Owner,
 - .4 Cleaning: remove all visible surface contaminants and deposits from each HVAC System and component
 - .5 Disinfection: disinfect all internal surfaces of ductwork, equipment and accessories that serve one or more Class 1 areas.
 - .6 Containment: ensure that dust and debris collected during the cleaning process is contained within the HVAC System and not otherwise dispersed outside of the system.
 - .7 Particulate Collection: high power vacuums with HEPA filtration to 99.97% efficiency on particles greater than 0.3-micron size
 - .8 Odours and Mist control: ensure that odours and mist vapours arising from cleaning operations are contained within the HVAC System and are prevented from escaping to and dispersing outside of the system.
 - .9 Provide adequate access into ductwork for cleaning purposes. Provide access doors conforming to project specifications.
 - .10 Flexible ducts shall be disconnected to provide access for cleaning.
 - .11 Protect components which may be harmed by excessive dirt with filters,
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- or bypass during cleaning.
 - .12 Where mechanical brushing and vacuuming is not appropriate or is not sufficient to clean a component of the system, dismantle and remove the component and clean or replace as appropriate.
 - .13 Ensure that appropriate liquid collection and drainage measures are in place prior to undertaking any washdown procedures.
 - .14 Anti-microbial Agents and Coatings: apply anti-microbial agents where active fungal growth is suspected or where unacceptable levels of fungal contamination exist. Apply anti-microbial treatments and coatings in strict adherence to the manufacturer's written recommendations and registration listings. Application of anti-microbial agents and coatings may be performed only after removal of surface deposits and debris.
 - .6 Cleanliness Verification:
 - .1 Visual Inspection: no visible contaminants present when examined under a bright light (equivalent to 100w incandescent bulb). Maximum 0.75mg/100cm² with no significant local accumulations.
 - .2 Air Coils and reheat coils: restored to within 10% of original design pressure drop
 - .3 In Class 1 areas (critical care) test supply ducts for each room as follows;
 - .1 Microbial Samples: rose bengal agar Hycon contact plates, incubated for 3 days at 37°C with number of micro-organisms counted and reported in both per plate and per cm² concentration levels. Maximum 1 cfu per cm².
 - .2 Bacterial Samples: tryptic soy agar contact plates, incubated for 3 days at 37°C with number of micro-organisms counted and reported in both per plate and per cm² concentration levels. Maximum 1 cfu per cm².
 - .4 Particle Profiling Procedures: In the event of a dispute between Contractor and Owner regarding cleanliness, Contractor shall perform NADCA PP procedures in accordance with Chapter 2 of NADCA Guideline to ACR 2006; Particle Measurement, Air Sampling and Surface Sampling for each supply air system at representative locations selected by Owner and in the discharge plenum of each air handling unit.
 - .7 Report:
 - .1 submit three (3) copies of cleaning report
 - .2 report shall include;
 - .1 certificate of cleanliness from third party inspection service with following minimum qualifications;
 - .1 Environmental Engineer licensed in the province of Ontario or
 - .2 Certified Industrial Hygienist, and
 - .3 minimum 3 years experience in duct cleaning
 - .2 photographic/video record of cleaned surfaces and components
 - .3 comparative record of damage discovered on initial inspection and of remedial measures implemented by others

3.11 DUCT LEAKAGE TESTING

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- .1 Ductwork shall be leak tested in accordance with the SMACNA "HVAC Air Duct Leakage Test Manual". The maximum permitted duct leakage shall be determined by multiplying the leakage factor from paragraph 2.4 above by the surface area of the ductwork in the test zone.
 - .2 Ductwork that exceeds the maximum permitted leakage shall be re-sealed and re-tested.
 - .3 Duct leakage test shall be witnessed and certified by the Systems Verification Agency of section 23 01 05.
 - .4 Record and submit three (3) copies of test results to the Consultant for review prior to application of duct insulation or concealment of ductwork.

3.12 CONTROLS DEVICES

- .1 Install remote sensors such as temperature, pressure and airflow sensors. Supply of sensors and controls wiring will be under Section 25.
- .2 Install remote mounted control dampers for airflow control. Supply of dampers, damper actuators and controls wiring will be under Section 25.
- .3 Install duct type smoke detectors in accordance with manufacturer's instructions. Supply of detectors and fire alarm wiring will be under Division 26

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 23 01 01.

1.2 SECTION INCLUDES

- .1 Air turning devices/extractors
- .2 Backdraft dampers
- .3 Volume Control dampers
- .4 Fire Dampers
- .5 Fire Dampers (Dynamic)
- .6 Duct access doors
- .7 Duct test holes
- .8 Flexible Duct Connections
- .9 Flexible Ductwork
- .10 Hangers and Supports
- .11 Fire Protection Duct Wrap
- .12 Duct Lining
- .13 Duct Sealants
- .14 Motorized dampers
- .15 Actuators

1.3 REFERENCES

- .1 NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
- .2 NFPA 92A - Smoke-Control Systems.
- .3 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- .4 UL 33 - Heat Responsive Links for Fire-Protection Service.
- .5 UL 555 - Fire Dampers.

1.4 SUBMITTALS

- .1 Section 23 01 01: Submittals.
- .2 Shop Drawings for shop fabricated assemblies including balancing dampers, volume control dampers, duct access doors and duct test holes.
- .3 Product Data for shop fabricated assemblies including volume control dampers, duct access doors, duct test holes and hardware used. Include electrical characteristics and connection requirements.
- .4 Manufacturer's Installation Instructions for fire dampers and combination fire and smoke dampers.

1.5 PROJECT RECORD DOCUMENTS

- .1 Section 23 01 01: Submittals for project closeout.
- .2 Record actual locations of access doors.

1.6 REGULATORY REQUIREMENTS

- .1 Products Requiring Electrical Connection: CSA Listed as suitable for the purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

- .1 Transport, handle, store, and protect products.
- .2 Protect dampers from damage to operating linkages and blades.

1.8 EXTRA MATERIALS

- .1 Section 23 01 01: Submittals for project closeout.

2 PRODUCTS

2.1 AIR TURNING DEVICES / EXTRACTORS

- .1 Turning vanes in rectangular duct elbows shall be double walled, multi-blade vanes with blades aligned in short dimension; steel construction; with individually adjustable blades, mounting straps. Acceptable Products: Duro-Dyne, Hart & Cooley.
- .2 Volume extractors: gang operated curved blades, adjustable from full open to full closed positions. Units shall be factory assembled, fabricated from 14 ga. and 22 ga. (2 and .9 mm) steel, with blades on 1" (25 mm) centres, and No. 2 or No. 3 operators to suit application.
- .3 Acceptable Manufacturers: EH Price

2.2 BACKDRAFT DAMPERS.

- .1 Gravity Backdraft Dampers, Size 18" x 18" (450 x 450 mm) or Smaller, Provided with Air Moving Equipment: Air moving equipment manufacturers standard construction.
- .2 Multi-Blade, Parallel Action Gravity Balanced Backdraft Dampers: 1/16" (1.5 mm) thick galvanized steel, or, with centre pivoted blades of maximum 6" (150 mm) width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.
- .3 Acceptable Manufacturers: EH Price.

2.3 VOLUME CONTROL DAMPERS

- .1 Fabricate to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.
- .2 Splitter Dampers:
 - .1 Material: Same gauge as duct to 24" (600 mm) size in either direction, and two gauges heavier for sizes over 24" (600 mm).
 - .2 Blade: Fabricate of single thickness sheet metal to streamline shape, secured with continuous hinge or rod.
 - .3 Operator: Minimum 24" (600 mm) diameter rod in self aligning, universal joint action, flanged bushing with set screw.
- .3 Single Leaf Dampers: fabricated from minimum 20 gauge (1.0 mm) galvanized

- steel, suitably reinforced to prevent vibration and fitted with indicating regulator. Duro-Dyne, Lawson & Taylor, Dyn-Air.
- .4 Multi-Blade Opposed Action Dampers: fabricated from 16 gauge (1.6 mm) galvanized steel, mounted in separate channel frames, reinforced to prevent vibration, and fitted with opposed action linkage hardware. Duro-Dyne "Opax" blade kit, Lawson & Taylor, Dyn-Air
- .5 End Bearings: Except in round ductwork 12" (300 mm) and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon or sintered bronze bearings.
- .6 Quadrants:
 - .1 Provide locking, indicating quadrant regulators on single and multi-blade dampers.
 - .2 On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.
 - .3 Where rod lengths exceed 30" (750 mm) provide regulator at both ends.
- .7 Acceptable Manufacturers: Duro-Dyne, Dyn-Air, Price, Lawson & Taylor

2.4 FIRE DAMPERS

- .1 Manufacturers:
 - .1 Price
- .2 Fire dampers shall be ULC listed, labelled, or Warnock-Hersey label, meet all requirements of NFPA 90A, and constructed and rated in conformance with:
 - .1 CAN4-S112-M82, "Standard for Fire Dampers", when used in a fire separation of not more than 2 hours, and which is not a firewall.
 - .2 CAN4-S104-M80, "Standard Method for Fire Tests of Door Assemblies", when used in a fire separation of more than 2 hours, or used in a firewall.
 - .3 CAN4-S112.2-M84, "Fire Test of Ceiling Firestop Flap Assemblies", when used in a ceiling fire separation.
- .3 Fire dampers shall be galvanized steel channel frame curtain type galvanized steel interlocking blades, minimum 22 gauge (0.9 mm) galvanized steel enclosure, and 160°F (71°C) fusible link standard.
- .4 Fire dampers for horizontal installation in vertical ductwork shall be operated by a stainless steel closure spring and latch.
- .5 Fire damper configuration shall be low resistance type B with blades located outside of the air stream for rectangular ductwork, and type C for round or oval ductwork.
- .6 Ceiling fire dampers shall be ULC labelled, for fire rated membrane type ceilings, galvanized steel construction with heat retardant blanket (non-asbestos) with standard 160°F (71°C) fusible link.
- .7 Thermal blanket shall be ULC labelled, for fire rated membrane type ceilings, to completely enshroud ceiling penetration.
- .8 Fire dampers in stainless steel ductwork shall be of all stainless steel construction.
- .9 Fusible Links: UL 33, separate at 160°F (71°C) with adjustable link straps for combination fire/balancing dampers.

2.5 FIRE DAMPERS (DYNAMIC)

- .1 Dynamic fire dampers tested, constructed and labeled in accordance with the latest edition of UL Standard 555. Dampers shall have a fire rating of 1-1/2 hours or 3 hours and shall meet the requirements of the latest edition of NFPA90A.
- .2 Each damper shall include a 165°F (74°C) fusible link and shall be labeled for use in dynamic systems. The damper shall be rated for dynamic closure at 2000fpm (10.16m/s) and 4 inches w.g. (1 kPa) static pressure and shall be rated to close with airflow in either direction.
- .3 Each dynamic fire damper shall include a steel sleeve and mounting angles furnished by the damper manufacturer to ensure appropriate installation. Submittals information shall include the fire protection rating, maximum velocity/pressure ratings and the manufacturer's UL installation instructions. The dampers shall be installed in accordance with the manufacturer's UL installation instructions.
- .4 Acceptable Product: Price.

2.6 DUCT ACCESS DOORS

- .1 Fabricate to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.
- .2 Fabrication: Rigid and close-fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated duct work, install minimum 1" (25 mm) thick insulation with sheet metal cover.
 - .1 Less Than 12" (300 mm) Square: Secure with sash locks.
 - .2 Up to 18" (450 mm) Square: Provide two hinges and two sash locks.
 - .3 Up to 24" x 48" (600 x 1200 mm): Three hinges and two compression latches with outside and inside handles.
 - .4 Larger Sizes: Provide an additional hinge.
- .3 Access doors with sheet metal screw fasteners are not acceptable.
- .4 Acceptable Manufacturer: Acudor Acorn

2.7 DUCT TEST HOLES

- .1 Provide test ports to suit intended application, (ie. insulated/uninsulated duct, round/rectangular duct).
- .2 Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.
- .3 Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

2.8 FLEXIBLE DUCT CONNECTIONS

- .1 Fabricate to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.
 - .1 MIL-C-20696B Para. 4.4.3, 4.4.4 (Oil and Hydro Carbon resistance)
 - .2 UL Certified NFPA 701 Tests for Flame Propagation of fabrics and film.
 - .3 10/120 ASTM E84 Flame/Smoke rating.
 - .4 -40F to 250F Continuous temperature range.
 - .5 White woven fiberglass colour
 - .6 Galvanized steel conforming to ASTM-A-525 G 60 or better

- .2 Acceptable Manufacturers" Duro-Dyne DDFDC

2.9 FLEXIBLE DUCTWORK

- .1 Manufacturer: Thermaflex M-KC
- .2 Flexible ductwork conforming to underwriters laboratories listed as Class 1 air duct, UL Standard 181 and CUL S110 with no limitations to 14 feet runs.
- .3 Conforms to NFPA 90A and 90B.
- .4 Heavy woven and coated fiberglass cloth core.
- .5 GreenGuard Certified.
- .6 Fiberglass insulating blanket and low permeability outer vapor barrier of fiberglass reinforced metallized film laminate.
- .7 20/50 Flame/Smoke spread rating.
- .8 0.05 Perm vapor transmission rating.

2.10 HANGERS AND SUPPORTS

- .1 Fabricate strap hangers to same material as duct. Hanger configuration to SMACNA details. 20" (500 mm) is maximum duct size to be supported by strap hanger.
- .2 Rod and angle hangers: galvanized steel to SMACNA details.
- .3 Hanger attachments: manufactured concrete inserts, expansion shields and bolted steel clamps. Do not weld rods to steel decks or use powder actuated fasteners.

2.11 DUCT SEALANT

- .1 General: Low VOC, water based sealant, non-toxic, non-combustible, non-flammable, and tested in accordance with CAN4/ULC-S102. Flame spread shall not exceed 25 and smoke developed shall not exceed 50.
- .2 Acceptable Products: Multi-Purpose Duct Sealant as manufactured by Trans Continental Equipment, Duro Dyne SWB Duct Sealer, Iron Grip 601 as supplied by Alpha Sheet Metal Co., or Uni-Grip Duct Sealer from United McGill Corporation.

2.12 MOTORIZED DAMPERS-EXPOSED TO OUTDOOR AIR

- .1 Tamco series 9000 thermally insulated damper as manufactured by T. A. Morrison & Co or equivalent by Ruskin, Nailor, Alumavent/Ventex.
- .2 Extruded aluminum (6063T5) damper frame shall not be less than .080" (2.03mm) in thickness. Damper frame to be 4" (101.6mm).
- .3 Blades to be extruded aluminum (6063T5) profiles, internally insulated with expanded polyurethane foam and shall be thermally broken. Complete blade shall have an insulating factor of R-2.29 and a temperature index of 55.
- .4 Blade seals shall be of extruded EPDM. Frame seals shall be of extruded silicone. Seals to be secured in an integral slot within the aluminum extrusions.
- .5 Maintenance-free bearings are to be composed of a Celcon inner bearing fixed to a 7/16" (11.11mm) aluminum hexagon blade pin, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-

- plastic contact.
- .6 Linkage hardware shall be installed in the frame side and constructed of aluminum and corrosion-resistant, zinc-plated steel, complete with cup-point trunnion screws for a slip-proof grip.
- .7 Dampers are to be designed for operation in temperatures ranging between -72°F (-58°C) and 185°F (85°C).
- .8 Dampers shall be available with either opposed blade action or parallel blade action.
- .9 Leakage shall not exceed 3 cfm/ft² (15.2 l/s/m²) against 1" (.25 kPa) w.g. differential static pressure.
- .10 Pressure drop of a fully open 48" x 48" (1220mm x 1220mm) damper shall not exceed .03" (.007kPa) w.g. at 1000 fpm (5.08 m/s).
- .11 Dampers shall be made to size required without blanking off free area.
- .12 Dampers shall be available in two mounting types: i.e., "Installed in Duct" or "Flanged to Duct".

2.13 MOTORIZED DAMPERS-EXPOSED TO TEMPERED AIR

- .1 Tamco series 1500 enhanced air-foil damper as manufactured by T. A. Morrison & Co or equivalent by Ruskin, Nailor, Alumavent/Ventex.
- .2 Extruded aluminum (6063T5) damper frame shall not be less than .080" (2.03mm) in thickness. Damper frame to be 4" deep.
- .3 Blades to be extruded aluminum (6063T5) profiles. Aluminum end caps are to be press fitted to blade ends, in order to seal hollow interior and reduce air leakage rate.
- .4 Blade and frame seals shall be of extruded silicone. Seals are to be secured in an integral slot within the aluminum extrusions.
- .5 Maintenance-free bearings are to be composed of a Celcon inner bearing fixed to a 7/16" (11.11mm) aluminum hexagon blade pin, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.
- .6 Linkage hardware shall be installed in the frame side and constructed of aluminum and corrosion-resistant, zinc-plated steel, complete with cup-point trunnion screws for a slip-proof grip.
- .7 Dampers are to be designed for operation in temperatures ranging between -72°F (-58°C) and 212°F (100°C).
- .8 Dampers shall be available with either opposed blade action or parallel blade action.
- .9 Leakage shall meet Class 1A at 1" w.g. static pressure differential. Standard air leakage data to be certified under the AMCA Certified Ratings Program.
- .10 Pressure drop of a fully open 48" x 48" (1220mm x 1220mm) damper shall not exceed .02" (.004kPa) w.g. at 1000 fpm (5.08 m/s).
- .11 Dampers shall be made to size required without blanking off free area.
- .12 Dampers shall be available in two mounting types: i.e., "Installed in Duct" or "Flanged to Duct".

2.14 ELECTRONIC DAMPER ACTUATORS

- .1 Manufactured, brand labeled or distributed by BELIMO or approved equivalent.
- .2 Size for torque required for damper seal at load conditions.
- .3 Coupling: V-bolt dual nut clamp with a V-shaped, toothed cradle.
- .4 Mounting: Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.
- .5 Overload Protection: Electronic overload or digital rotation-sensing circuitry without the use of end switches to prevent any damage to the actuator during a stall condition.
- .6 Fail-Safe Operation: Mechanical, spring-return mechanism.
- .7 Power Requirements (Spring Return): 120 V ac, maximum 10 VA at 24-V ac or 8 W at 24-V dc.
- .8 Proportional Actuators shall be fully programmable. Control input, position feedback and running time shall be factory or field programmable by use of external computer software Diagnostic feedback shall provide indications of hunting or oscillation, mechanical overload and mechanical travel. Programming shall be through an EEPROM without the use of actuator mounted switches.
- .9 Temperature Rating: -22 to +122°F (-30 to +50°C)
- .10 Housing: Minimum requirement NEMA type 2 mounted in any orientation.
- .11 Agency Listing: ISO 9001, cULus, and CSA C22.2 No. 24-93.
- .12 The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional.

3 EXECUTION

3.1 PREPARATION

- .1 Verify that electric power is available and of the correct characteristics.

3.2 INSTALLATION

- .1 Install accessories to manufacturer's instructions, NFPA 90A, and follow SMACNA HVAC Duct Construction Standards - Metal and Flexible. Refer to Section 23 31 00 for duct construction and pressure class.
- .2 Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- .3 Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, and elsewhere as indicated. Provide minimum 8" x 8" (200 x 200mm) size for hand access, 18" x 18" (450 x 450 mm) size for shoulder access, and as indicated. Provide 4" x 4" (100 x 100 mm) for balancing dampers only. Review locations prior to fabrication.
- .4 Provide duct test holes where indicated and required for testing and balancing purposes.
- .5 Provide fire dampers, combination fire and smoke dampers at locations indicated, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.

- .6 Install smoke dampers and combination smoke and fire dampers to NFPA 92A.
- .7 Demonstrate re-setting of fire dampers to Owner's representative.
- .8 Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment and supported by vibration isolators. For fans developing static pressures of 1250 Pa and over, cover connections with loaded vinyl sheet, held in place with metal straps.
- .9 Use splitter dampers only where indicated.
- .10 Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.
- .11 Install control dampers supplied under Section 25 as indicated.
- .12 Provide turning vanes where space restrictions prohibit the use of elbows having a minimum inside radius equal to the duct width for horizontal elbows or the duct depth for vertical elbows.
- .13 Provide test ports as required by Balancing Agency to completely test and balance the system. No temporary holes will be permitted in ductwork or flexible connections.

3.3 FIRE DAMPERS

- .1 Provide fire dampers where shown on drawings. In general, fire dampers are required where ducts pass through fire rated assemblies, floors and roofs and ducts entering and leaving duct shafts and mechanical rooms.
- .2 Install fire dampers in strict accordance with manufacturer's installation instructions and in conformance with NFPA 90A.
- .3 Install type A fire dampers anywhere there are extreme space limitations and then only where dimension of duct exceeds 12" (300 mm) in direction of blade closing, and is specifically approved by Consultant.
- .4 Install type B fire dampers for rectangular ductwork.
- .5 Install type C fire dampers for round or oval ductwork.
- .6 Openings for fire dampers must be properly prepared and the fire dampers installed, and secured prior to field review by the Consultant. Notify the Consultant when ready for review. Do not make any duct connections to fire dampers until review is complete and work found correct.
- .7 Support fire dampers from building structure. Submit erection Drawings, approved by all authorities, showing the locations and construction details of all fire dampers before proceeding with any work.
- .8 Install Ceiling Fire Dampers where ducts serve grilles and diffusers in rated ceilings. Support from building structure.
- .9 Install thermal blanket in all fire rated membrane type ceilings. Thermal blanket shall be wrapped and stapled around the unexposed perimeter of diffuser after installation of ceiling damper following manufacturer's installation instructions.
- .10 Use Dynamic Fire Dampers for Systems expected to be Operational during a Fire.

3.4 DUCT ACCESS DOORS

- .1 Provide duct access doors of suitable size in ductwork in the following locations:

- .1 Suction inlet of all fans
- .2 At not more than 12m intervals
- .3 At not more than 6m intervals on the ductwork installed after a high efficiency filter
- .4 At the base of all main risers
- .5 In front of and behind all turning vanes and coils
- .6 At all fire, smoke, and motorized dampers
- .7 At all locations having an internally mounted piece of equipment or device. Provide a section of transparent plexiglass to permit viewing without opening the access doors.
- .8 Where required for duct cleaning.
- .2 Wherever possible, doors shall be mounted to close in direction of air flow.

3.5 DUCT LINING

- .1 Line internal surfaces of all ductwork shown cross hatched on drawings with 1" (25 mm) thick duct lining.
- .2 No allowance has been made in duct sizes indicated for internal lining. Increase duct size 1" (25 mm) all around where lining is to be internally applied.
- .3 Adhere directly to clean, oil-free surfaces with full coverage of flame resistant adhesive.
- .4 Ambient temperature must be between 40°F and 100°F.
- .5 Armaflex:
 - .1 Smooth side shall be exposed to airstream.
 - .2 Butt edges tightly with a compression fit. Overlap the insulation 1/4" at the butt-edges and compress edges into place. Leave a 1/2" wide release liner border at the butt edge.
 - .3 Apply metal nosing to every leading edge for air velocities over 4000-fpm (20.3m/sec.)

3.6 MOTORIZED DAMPERS

- .1 Installation of dampers must be in accordance with current manufacturer's installation guidelines provided with each shipment of dampers.
- .2 Intermediate or tubular steel structural support is required to resist applied pressure loads for dampers that consist of two or more sections in both height and width. See manufacturer's installation guidelines.

3.7 ELECTRONIC DAMPER ACTUATORS

- .1 Provide electronic damper actuators for each motorized damper.
- .2 Power wiring and interconnections to associated fan control will be under Division 26.

END OF SECTION

Part 1 General

1.1 RELATED REQUIREMENTS

- .1 Section [_____].

1.2 REFERENCE STANDARDS

- .1 American Gas Association (AGA)
- .2 American National Standards Institute/Air-Conditioning, Heating and Refrigeration Institute (ANSI/AHRI)
 - .1 ANSI/AHRI 210/240-[08], Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
 - .2 ANSI/AHRI 270-[08], Sound Rating of Outdoor Unitary Equipment.
- .3 Canada Green Building Council (CaGBC)
 - .1 LEED Canada-NC Version 1.0-[2004], LEED (Leadership in Energy and Environmental Design): Green Building Rating System Reference Package For New Construction and Major Renovations (including Addendum [2007]).
 - .2 LEED Canada-CI Version 1.0-[2007], LEED (Leadership in Energy and Environmental Design): Green Building Rating System Reference Guide For Commercial Interiors.
 - .3 LEED Canada 2009 for Design and Construction-[2010], LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.
 - .4 LEED Canada for Existing Buildings, Operations and Maintenance-[2009], LEED Canada 2009 Leadership In Energy and Environmental Design Green Building Rating System Reference Guide.
- .4 CSA Group (CSA)
 - .1 CSA B52-[05], Mechanical Refrigeration Code.
 - .2 CSA C22.1-[12], Canadian Electrical Code, Part 1 (22nd Edition), Safety Standard for Electrical Installations.
- .5 National Fire Protection Association (NFPA)
 - .1 NFPA 90A-[12], Standard for the Installation of Air Conditioning and Ventilating Systems.
- .6 Underwriters Laboratories (UL)
 - .1 UL 1995-[11], Standard for Heating and Cooling Equipment.

1.3 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submit in accordance with Section [01 33 00 - Submittal Procedures].

-
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for [outdoor HVAC equipment] and include product characteristics, performance criteria, physical size, finish and limitations.
 - .3 Shop Drawings:
 - .1 Submit drawings stamped and signed by professional engineer registered or licensed in [Province] [Territory], Canada.
 - .2 Drawings to indicate project layout and dimensions; indicate:
 - .1 Equipment, piping, and connections, together with valves, strainers, control assemblies, thermostatic controls, auxiliaries and hardware, and recommended ancillaries which are mounted, wired and piped ready for final connection to building system, its size and recommended bypass connections.
 - .2 Piping, valves, fitting shipped loose showing final location in assembly.
 - .3 Control equipment shipped loose, showing final location in assembly.
 - .4 [Complete internal panel pneumatic tube piping and wiring and external panel pneumatic tube piping and wiring, both as schematics and as actually assembled].
 - .5 Dimensions, internal and external construction details, recommended method of installation with proposed structural steel support, mounting curb details, sizes and location of mounting bolt holes; include mass distribution drawings showing point loads.
 - .6 Detailed composite wiring diagrams for control systems showing factory installed wiring and equipment on packaged equipment or required for controlling devices of ancillaries, accessories, controllers.
 - .7 Pump and fan performance curves.
 - .8 Details of vibration isolation.
 - .9 Estimate of sound levels to be expected across individual octave bands in dB referred to A rating.
 - .10 Type of refrigerant used.
 - .4 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - .5 Test Reports: submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.
 - .6 Manufacturer's Field Reports:
 - .1 Submit manufacturer's field reports specified.
 - .7 Sustainable Design Submittals:
 - .1 LEED Canada submittals: in accordance with [Section 01 35 21 - LEED Requirements].
-

- .2 Construction Waste Management:
 - .1 Submit project [Waste Management Plan] [Waste Reduction Workplan] highlighting recycling and salvage requirements.
 - .2 Submit calculations on end-of-project recycling rates, salvage rates, and landfill rates demonstrating that [50] [75]% of construction wastes were recycled or salvaged.
- .3 Recycled Content:
 - .1 Submit listing of recycled content products used, including details of required percentages or recycled content materials and products, showing their costs and percentages of [post-consumer] [and] [post-industrial] content, and total cost of materials for project.
- .4 Regional Materials: submit evidence that project incorporates required percentage [_____] % of regional materials and products, showing their cost, distance from project to furthest site of extraction or manufacture, and total cost of materials for project.

1.4 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section [01 78 00 - Closeout Submittals].
- .2 Operation and Maintenance Data: submit operation and maintenance data for [outdoor HVAC equipment] for incorporation into manual.
 - .1 Indicate: brief description of unit, indexed, with details of function, operation, control, and service for components.
 - .2 Provide for units, manufacturer's name, type, year, number of units, and capacity.

1.5 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Section [01 61 00 - Common Product Requirements] [and] [with manufacturer's written instructions].
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials [off ground] [indoors] [in dry location] and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect [outdoor HVAC equipment] from [nicks, scratches, and blemishes].
 - .3 Replace defective or damaged materials with new.
- .4 Develop [Construction Waste Management Plan] [Waste Reduction Workplan] related to Work of this Section and in accordance with Section [01 35 21 - LEED Requirements].

- .5 Packaging Waste Management: remove for reuse [and return] [by manufacturer] of [pallets,] [crates,] [padding,] [and] [packaging materials] as specified in [Construction Waste Management Plan] [Waste Reduction Workplan] in accordance with Section [01 74 19 - Waste Management and Disposal] [and] [Section 01 35 21 - LEED Requirements].

1.6 WARRANTY

- .1 For Work of this Section [23 74 00 - Packaged Outdoor HVAC Equipment], 12 months warranty period is extended to [60] months.
- .2 Contractor hereby warrants that packaged rooftop HAVC units and refrigeration compressors will function and operate in accordance with CCDC 2 GC 24, but for [24] [60] months.

Part 2 Products

2.1 GENERAL

- .1 Roof mounted, self-contained [multizone] [single zone] unit with [gas burner] [electric heating elements] [hot water coil] [and DX refrigeration] and bear label of [CSA], [CGA], [FM], [UL] [and] [ULC].
- .2 Units to consist of cabinet and frame, supply fan, [return fan] heat exchanger, burner [with integral induced draft fan], [heater] control, air filter, refrigerant cooling coil, compressor, condenser coil and fans, motorized outside air damper, return damper, [motorized] [gravity] exhaust damper.
- .3 Prefabricated roof curb to conform to requirements of National Roofing Contractors Association (NRCA), minimum height [450] mm.
- .4 Conform to ANSI/AHRI 210/240, rating for unit larger than 40 kW nominal.

2.2 CABINET

- .1 Cabinets: weatherproofing tested and certified to AGA [rain test standards] and soundproofing tested to AHRI 270, dbA at [_____] m free field.
- .2 Framing and supports: 2 mm thick welded steel, galvanized after manufacture, with lifting lugs [at top of unit].
- .3 Outer casing: weathertight [1.2] [1.0] [0.8] mm thick galvanized steel with baked enamel finish, complete with [flashing].
- .4 Access: [removable] gasketed [hinged doors] [or] [panels] with [quick] [locking door handle type] [screwdriver operated flush cam type] fasteners.
- .5 Insulation: neoprene coated glass fibre on surfaces [where conditioned air is handled,] [50] mm thick, [32] kg/m³ density.

2.3 FANS

- .1 Centrifugal, forward curved impellers, statically and dynamically balanced. [Multi] V-belt drive with adjustable variable pitch motor pulley, [[rubber] [spring] isolated hinge mounted motor] [fan and motor integrally mounted on isolation base, separated from unit casing with flexible connections and spring isolators]. Vibration isolators: [95]% efficiency.

2.4 AIR FILTERS

- .1 [50] mm thick, [_____] % efficiency, metal framed, [replaceable media] [throwaway], [bag] [standard to unit manufacturer].
- .2 To meet NFPA 90A, air filter requirements [type Class 1] [type Class 2].

2.5 ELECTRIC HEATERS

- .1 [Nickel chromium electric resistant type, [_____] W/m² maximum density] [Finned tube, [_____] m² helical coil or expanded strip heating elements].
- .2 Controls:
 - .1 Panel board with [_____] stage modulating [SCR] controller.
 - .2 Indicating light centre.
 - .3 Remote thermostat[s] as indicated.
 - .4 Fuse blocks (one per step unless otherwise specified).
 - .5 [_____] VA built-in control transformer.
 - .6 Thermal cut outs: [[9] manual reset disc types, one per circuit;] [one linear bulb type manual reset] [one linear bulb type automatic reset.]
 - .7 Built-in [unfused] [fused] disconnect switch.
 - .8 Elements control: accessible with protection against no air flow, short and grounds, and of self checking type.
 - .9 High limit temperature control: de-energize heating elements to protect against over heating.
 - .10 Supply fan: start before electric elements are energized and continue operating until bonnet temperature reaches minimum setting. Include switch for continuous fan operation.
 - .11 Conform to CSA C22.1, Canadian Electrical Code.

2.6 HEAT EXCHANGERS AND BURNERS

- .1 Gas fired, multiple flue passes, with primary heating surface of [aluminized] [type [_____] stainless steel,] secondary heating surface, [stainless steel,] [aluminized] tubes.
 - .1 Gas burner: factory mounted, wired and fire tested complete with operating and safety controls.
 - .2 [Forced] [Induced draft] [continuous port steel] [multi-slotted non-clogging cast iron] [in shot] type.
 - .3 Spark ignited pilot with pilot flame safety shut-off.

2.7 HOT WATER COIL

- .1 [Aluminum] [Copper] fins, mechanically bonded to copper tubes.
- .2 Piping: complete with shut off valves, drain valves, unions or flanges.
- .3 Hydrostatically tested to [1.7] MPa.

2.8 REFRIGERATION

- .1 Conform to CSA B52 and UL 1995 requirements.
- .2 Compressor/Condenser Section:
 - .1 [Semi-Hermetic] [Hermetic] compressor[s], vibration isolated with flexible suction and discharge connections, oil sight glass, oil pressure switch, crankcase heater, and [automatic pump down system] with control to liquid line solenoid valve.
 - .2 Fan[s]: propeller type with single piece spun venturi outlets and zinc plated guards. Motor[s]: sequenced for head pressure control.
 - .3 Electrical system: complete with operating controls, oil and refrigerant pressure protection, motor overload protection, weatherproof electrical wiring with [weatherproof, rain tight] disconnect.
 - .4 Include refrigerant piping with [automatic hot gas bypass], sight glass, filter and valves.
 - .5 Condenser: staggered copper tube aluminum fin coil assembly with sub-cooling rows to provide [_____] degrees C sub-cooling.
 - .6 Capacity reduction: [hot gas bypass] [and] [or] [cylinder unloading]. [Hot gas side port distribution]. Provide [fan control] [flooding] for head control for low ambient operation down to [_____] degrees C ambient temperature.
 - .7 Refrigerant: [_____].
- .3 Evaporator:
 - .1 Rated to ANSI/AHRI 210/240.
 - .2 Thermostatic expansion valve, with adjustable super heat [and external equalizer].
 - .3 Coil: [NPS 1/2] [NPS 5/8] od staggered seamless copper tubes expanded into aluminum fins, [_____] rows with [_____] fins per 25 mm, and insulated condensation pan.
 - .4 Cooling coil condensate drain pans: designed to avoid standing water, easily cleaned or removable for cleaning. Drain connection: deep seal trap complete with trap seal primer.

2.9 CONTROLS

- .1 In addition to combustion safety controls, provide [smoke sensors in return to NFPA standards,] low limit on supply and freeze protection on steam and water coils.
- .2 Single Zone Cooling Control:

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- .1 [Zone sensor] [Room thermostat] to activate cooling relay in control circuit cycling compressor. Provide safeties and pressure controls. Condenser fans to operate [in sequence].
 - .2 As back pressure is reduced, hot gas bypass opens to maintain set back pressure.
 - .3 [When call for cooling is satisfied, relay is de-energized closing liquid line solenoid valve [and pumps down]. On two compressor units provide [separate circuits to evaporator and condenser] [and] [_____]manual double pole double throw switch for lead-lag unit choice].
- .3 Multi-Zone Heat-Cool Unit:
- .1 Remote solid state electronic control panel containing "on-off" "summer-winter" selector switches ["heat" "cool" "fan" indicating lights].
 - .2 [Hot deck] temperature: maintained by modulating, outdoor reset [[_____] ratio] controller such that [hot] deck temperature increases [_____]degrees C for each [_____] degrees C increment of outside temperature below [21] degrees C set point (adjustable). [Hot] deck control operation: occurs with selector switch positioning re: Winter-Summer, whenever any [zone] dampers are open past [_____] % position on heating side.
 - .3 Cold deck temperature: at "summer" position, maintained by [cold] deck thermostat operating liquid line solenoid valve[s] as required, with compressor lockout at [14] degrees C, restart [17] degrees C.
 - .4 Freeze protection control: wired in cold deck control circuit to guard against coil frosting and low air flow, with shut off by differential pressure switch or low temperature.
 - .5 Cooling capacity control: provided by hot gas bypass valve modulating to maintain constant suction temperature.
 - .6 Modulating zone thermostats controlling modulating zone damper operators shall maintain zone temperatures.
- .4 Mixed Air Single Zone Unit:
- .1 [Manual] [Automatic] outside [and return] air dampers for fixed outside air quantity.
 - .2 Remote controlled outside [and return] air dampers with damper operator and remote rheostat package for adjusting outside air quantity.
 - .3 Motorized outside, return and [automatic] [power exhaust] [gravity] relief dampers with spring return damper operator and control package to automatically vary outside air quantity. Outside air and exhaust air dampers, normally closed.
 - .4 Tight fitting opposed blade dampers with neoprene or suitable gaskets, [bronze] [synthetic] bushings and 1% maximum leakage.
 - .5 Damper operation: 24 V, spring return motor with gear train sealed in oil, [and heater for operation under [minus 18 degrees C]].

- .6 Mixed air controls: maintain [_____]degrees C [indicated] mixed air temperature, lock out compressor below [14] degrees C ambient, restart [17] degrees C, revert dampers to provide [_____] % fresh air above [21] degrees C adjustable.
- .5 Single Zone Heat-Cool Unit:
 - .1 Low voltage, adjustable room thermostat controls [burner operation,] [heater stages in sequence with delay between stages,] [compressor] [and] [supply fan] to maintain room temperature setting.
 - .2 Thermostat: include system selector switch [day-night] [heat-cool-off] [and fan control switch (on-auto)].
 - .3 Automatic changeover thermostat: with [_____] stage heating and [_____] stage cooling. [Electronic programmable with battery back up].
 - .4 [Provide remote mounted fan control switch on remote panel].
- .6 Night mode: [unit cycles as unit heater with 100% recirculation on winter or summer cycles] [unit off].
- .7 Night set-back: [_____].

2.10 REMOTE PANEL

- .1 Provide remote readout panel [for each unit] containing:
 - .1 Signal lights indicating system status, [heating system failure] [cooling system failure] and dirty filters.
 - .2 Check switches proving signal light operation.
 - .3 System on-off switch [cooling system on-off switch].
 - .4 [Fan on-off switch].
 - .5 [Manual [6] [12] hours timer to override night-set back control] [remote damper control on outside air damper].
- .2 Provide gauges in remote panel indicating outside air, mixed air, return air and discharge air temperatures for each deck before heat exchangers.

2.11 CAPACITY

- .1 As indicated [or as follows]:
- .2 Fan capacity: [_____] L/s at [_____] kPa external static pressure with [_____] [hp] [W] motor.
- .3 [_____] kW rated heating output when heated by [_____] [m³/h] [L/s] natural gas [kW electric heating elements].
- .4 [_____] kW rated total cooling output with [_____] degrees C db [_____] degrees C wb air entering evaporator, [_____] degrees C db condenser ambient air and [_____]kW input.

Part 3 Execution

3.1 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for outdoor HVAC equipment installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of [Departmental Representative] [DCC Representative] [Consultant].
 - .2 Inform [Departmental Representative] [DCC Representative] [Consultant] of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied [and after receipt of written approval to proceed from [Departmental Representative] [DCC Representative] [Consultant]].

3.2 INSTALLATION

- .1 Install as per manufacturers' instructions on roof curbs [provided by manufacturer] [as indicated].
- .2 Manufacturer to certify installation, supervise start-up and commission unit.
- .3 Run drain line from cooling coil condensate drain pan to discharge [over roof drain].

3.3 FIELD QUALITY CONTROL

- .1 Manufacturer's Field Services:
 - .1 Have manufacturer of products supplied under this Section review work involved in handling, installation/application, protection and cleaning of its product[s], and submit written reports, in acceptable format, to verify compliance of work with Contract.
 - .2 Provide manufacturer's field services, consisting of product use recommendations and periodic site visits for inspection of product installation, in accordance with manufacturer's instructions.
 - .3 Schedule site visits to review work at stages listed:
 - .1 After delivery and storage of products, and when preparatory work on which work of this Section depends is complete, but before installation begins.
 - .2 [Twice] during progress of work at [25%] and [60%] complete.
 - .3 Upon completion of work, after cleaning is carried out.
- .2 Obtain reports within [3] days of review and submit immediately to [Departmental Representative] [DCC Representative] [Consultant].
- .3 Performance Verification:
 - .1 General:

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- .1 In accordance with Section [23 08 16 - Cleaning and Start-Up of HVAC Piping Systems], supplemented as specified herein.
 - .2 Rooftop Air Handling Units:
 - .1 Set zone mixing dampers for full cooling, except that where diversity factor forms part of design set that percentage of zone dampers to full heating.
 - .2 Set outside air and return air dampers for minimum outside air.
 - .3 Set face and bypass dampers so face dampers are fully open and bypass dampers are fully closed.
 - .4 Check for smooth, vibration less correct rotation of supply fan impeller.
 - .5 Measure supply fan capacity.
 - .6 Adjust impeller speed as necessary and repeat measurement of fan capacity.
 - .7 Measure pressure drop each component of air handling unit.
 - .8 Set outside air and return air dampers for the percentage of outside air required by design and repeat measurements of fan capacity.
 - .9 Reduce differences between fan capacity at minimum and maximum outside air less than [5] %.
 - .10 Set face and bypass dampers to full bypass and repeat measurement of fan capacity.
 - .11 Reduce difference between fan capacity with F&BPD fully closed to bypass and fully open to bypass to less than [5] %.
 - .12 Reduce difference between fan capacity at full cooling and fan capacity at full heating to less than [5] %.
 - .13 OAD: verify for proper stroking, interlock with RAD.
 - .14 Measure DBT, WBT of SA, RA, EA.
 - .15 Measure air cooled condenser discharge DBT.
 - .16 Measure flow rates (minimum and maximum) of SA, RA, EA, relief air.
 - .17 Simulate maximum cooling load and measure refrigerant hot gas and suction temperatures and pressures.
 - .18 Use smoke test to verify no short-circuiting of EA, relief air to outside air intake or to condenser intake.
 - .19 Simulate maximum heating load and:
 - .20 Measure radiated and discharge sound power levels under maximum heating demand and under maximum cooling demand with compressors running.
 - .21 Verify operating control strategies, including:
 - .22 Set zone mixing dampers for full heating and repeat measurements.
 - .23 Measure leakage past zone mixing dampers by taking temperature measurements. Reduce leakage to less than [5] %.
 - .24 Measure return fan capacity.

- .25 Adjust impeller speed as necessary and repeat measurement of return fan capacity.
- .26 Check capacity of heating unit.
- .27 Measure DX refrigeration system performance as specified Section [_____].
- .28 Refer to other sections of these specifications for PV procedures for other components.
- .3 Start-Up:
 - .1 General: in accordance with Section [23 08 16 - Cleaning and Start-Up of HVAC Piping Systems].
 - .4 Verify accessibility, serviceability of components including motorized dampers, filters coils, fans, motors, operators, humidifiers, sensors, electrical disconnects.
 - .5 Verify accessibility, clean ability, drainage of drain pans for coils, humidifiers.
- .4 Commissioning Reports:
 - .1 In accordance with Section [01 91 13 - General Commissioning Requirements]: reports supplemented as specified herein. Include:
 - .1 Report forms as specified Section [01 91 13 - General Commissioning Requirements]: Report Forms and Schematics.

3.4 DEMONSTRATION

- .1 Training: in accordance with Section [01 91 13 - General Commissioning Requirements]: Training of O&M Personnel, supplemented as specified.

3.5 CLEANING

- .1 Progress Cleaning: clean in accordance with Section [01 74 00 - Cleaning].
 - .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section [01 74 00 - Cleaning].
- .3 Perform cleaning operations in accordance with manufacturer's recommendations.
- .4 Waste Management: separate waste materials for [reuse] [and] [recycling] in accordance with Section [01 74 19 - Waste Management and Disposal] [01 35 21 - LEED Requirements].
 - .1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Read and conform to:
 - .1 The Contract CCDC 2-2008, Stipulated Price Contract as amended,
 - .2 Division 1 requirements and documents referred to therein.
- .2 Section 25 01 01 applies to and governs the work of all Sections of Division 25.
- .3 The technical Sections of this Division are generally divided into units of work for the purpose of ready reference. The division of the work among subcontractors is not the Consultant's responsibility and the Consultant assumes no responsibility to act as an arbiter and/or to establish subcontract limits between any Sections of the work..
- .4 The specifications are integral with the drawings which accompany them. Neither is to be used alone. Any item or subject omitted from one but implied in the other is fully and properly required.
- .5 Wherever differences occur in the tender documents, the most onerous condition governs. Base the bid on the most costly arrangement.

1.2 DEFINITIONS

- .1 The following are definitions of words found in this specification and on associated drawings under this Division:
 - .1 "Concealed" - locations hidden from normal sight in furred spaces, shafts, ceiling spaces, walls, and partitions.
 - .2 "Exposed" - mechanical work normally visible to building occupants.
 - .3 "Furnish" - (and its derivatives) has the same meaning as the term "Supply".
 - .4 "Install" - (and its derivatives) - receive, store and handle at the site, mount and support and connect all required services. Includes adjustment and calibration, testing, commissioning, inspection by authorities having jurisdiction & documentation.
 - .5 "Provide" - (and its derivatives) - supply, install in place, connect the associated required services ready for operation, adjust and calibrate, test, commission, warrant, and document. Includes inspection by authorities having jurisdiction.
 - .6 "Supply" - (and its derivatives) purchase and deliver to the site for installation. Includes submittals, manufacturer's field inspection and warranty.
 - .7 "Wet" - locations exposed to moisture, requiring special materials and arrangement.

1.3 WORK INCLUDED

- .1 Products and methods mentioned or shown in the Contract Documents complete with incidentals necessary for a complete operating installation. Provide all tools,

- equipment and services required to do the work.
- .2 Cutting and patching of new or existing work
- .3 Identification of equipment, valves, dampers and controllers
- .4 Motors required for equipment supplied under this Division.
- .5 Take such measures and include in Bid Price for the proper protection of the existing building and its finishes at all times during alterations and construction of the new addition. Coordinate this protective work with all trades.
- .6 Refer to Mechanical/Electrical Equipment Schedule for extent of wiring and electrical characteristics.
- .7 Verify the correct operation of each equipment item provided and/or altered and each system in total and obtain the Owner's approval prior to starting and/or returning to operation.

1.4 SUBMITTALS

- .1 Approval Drawings: Prepare and submit drawings necessary for approval to any authority having jurisdiction, and obtain two (2) copies of approved drawings for retention by Consultant prior to commencement of work under this Division.
- .2 Shop Drawings: Prepare and submit two (2) copies of shop drawings of major equipment items (including those items specifically indicated under Part 1: General of each Section), to the Consultant for review. The Consultant will return one copy, marked with comments and his review stamp as he deems appropriate. Prepare the necessary number of copies of the returned set and distribute to the Owner, the Prime Consultant, the General Contractor, the site, and to subcontractors and suppliers.
 - .1 Clearly indicate manufacturer's and supplier's names, catalogue model numbers, details of construction, accurate dimensions, capacities and performance. Prior to submission check and certify as correct, shop drawings and data sheets. Do not order equipment until a copy of the shop drawings, reviewed by Consultant, has been returned to Contractor.
 - .2 Clearly indicate the weight, location, method of support and anchor point forces and locations for each piece of equipment on shop drawings.
 - .3 The Consultant will not review shop drawings that fail to bear the Contractor's stamp of approval or certification.
 - .4 Read the following in conjunction with the wording on the shop drawing review stamp applied to each and every drawing submitted:
"This review by the Consultant is for the sole purpose of ascertaining conformance with general design concept. This review shall not mean that the Consultant approves the detail design inherent in the shop drawings, responsibility for which shall remain with the Contractor submitting same, and such review shall not relieve the Contractor of his responsibility for errors or omissions in the shop drawings or of his responsibility for meeting all requirements of the Contract Documents. The Contractor is responsible for dimensions to be confirmed and correlated at the job site, for information that pertains solely to fabrication processes or to techniques of construction and installation and for coordination of the work of all sub trades."
- .3 Composite Wiring Diagrams: Prepare and submit three (3) copies of complete

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- composite wiring diagrams of each specific control system. Indicate all electrical equipment and wiring, both internal and external, for review and coordination of trades.
- .4 Contractor's Material and Test Certificates: Prepare and submit certificates for each system installed. Where certificates are prescribed by regulations, codes or standards ensure they conform to the requirements of those documents (eg. NFPA-standards). Include a copy of each certificate in the Operation and Maintenance manual. Certificates shall include the following:
- .1 description of the system (description and type),
 - .2 description of the tests conducted and results observed, including re-testing, where necessary,
 - .3 description of any corrective measures undertaken,
 - .4 description of materials used (pipe and fittings),
 - .5 list of witnesses for each test conducted,
 - .6 date system left ready for service,
 - .7 signature of installing Contractor.
- .5 Directories & Schematics
- .1 Submit five (5) copies of a neat typewritten directory indicating the valve number, related service, and location of each valve under this Division.
 - .2 Submit five (5) copies of system control schematics for each mechanical system indicating relative locations of equipment and control devices.
 - .3 Enclose one (1) copy of each directory/schematic under glass in a neat polished 18" x24" (460 mm x 610 mm) metal frame, complete with mounting clips.
- .6 Maintenance Data and Operating Instructions
- .1 Submit three (3) copies of Operation and Maintenance Manual individually bound in hard backed three-ring binders.
 - .2 Ensure the binder spines have typewritten lettering as follows:
OPERATION & MAINTENANCE MANUAL
for
TCDSB
[Insert date of submission]
Division 25 00 00
 - .3 Provide a list of names, addresses and telephone numbers of equipment suppliers, installing contractors, general contractors, architect and Consultant. Include special telephone numbers for service departments on normal and emergency call basis.
 - .4 Provide descriptive literature (shop drawings) of each manufactured item. Include a bill of material with purchase order numbers and vendor's identification of equipment orders for each item.
 - .5 Include copies of start-up reports and checklists and all certificates issued with respect to this contract.
 - .6 Ensure operating instructions include the following:
 - .1 General description of each mechanical system.
 - .2 Step by step procedure to follow in putting each piece of equipment into service.
 - .3 Schematic control diagrams for each separate mechanical system, control thermometers, freezestats, firestats, pressure

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- gauges, automatic valves, and refrigeration accessories. Mark correct operating settings for each control device on these diagrams.
- .4 Diagram of the electrical control system indicating the wiring of all related electrical components such as PE and EP switches, firestats, freezestats, fuses, interlocks, electrical switches and relays.
- .5 Drawings of each control panel including temperature control and electrical panels, completely identifying all components on the panels and their function.
- .7 Ensure maintenance instructions include the following:
- .1 Manufacturer's maintenance instructions for each item of mechanical equipment installed under this Division. Instructions shall include installation instructions, parts numbers and lists, name of supplier and maintenance and lubrication instructions.
- .2 Summary list of each item of mechanical equipment requiring lubrication, indicating the name of the equipment item, location of all points of lubrication, type of lubricant recommended, and frequency of lubrication.
- .3 Equipment directory indicating name, model, serial number and nameplate data of each item of equipment supplied, and system with which it is associated.
- .4 Balancing and testing reports.
- .5 Copy of valve directory.
- .8 As-Built Records: Prepare and submit complete as-built records prior to Substantial Performance of the Contract. Refer to paragraph 3.2.5 and to Division 1 for requirements.
- .9 Requests for Shut-Down: Obtain permission for systems shut-down and/or service interruption from the Owner prior to disruption of any system or service in use by the Owner. Employ the Owner's standard form of request where available. Refer to Division 1 for additional requirements.
- .10 Requests for Start-up: Obtain permission from the Owner to start-up or to return to service any item of equipment, system or service installed new or previously shut-down. Refer to Division 1 for additional requirements.

1.5 QUALITY ASSURANCE

- .1 Conform to minimum requirements or better of provincial and local codes, where existing, and to requirements of local inspection authorities for execution of work under this Division.
- .2 Ensure materials supplied under this Division conform to minimum requirements and recommendations or better of applicable standards of the following:
- .1 ANSI American National Standards Institute
- .2 ASA American Standards Association
- .3 ASHRAE American Society of Heating, Refrigerating, and Air Conditioning Engineers
- .4 ASME American Society of Mechanical Engineers
- .5 ASTM American Society of Testing and Materials
- .6 CAN2 National Standard of Canada (Published by CGSB)

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| .7 | CAN3 | National Standard of Canada (Published by CSA) |
| .8 | CGSB | Canadian General Standards Board |
| .9 | CSA | Canadian Standards Association |
| .10 | EEMAC | Electrical & Electronic Manufacturer's Association of Canada |
| .11 | NBC | National Building Code of Canada |
| .12 | NEBB | National Environmental Balancing Bureau |
| .13 | NFPA | National Fire Protection Association |
| .14 | NEMA | National Electrical Manufacturers Association |
| .15 | OBC | Ontario Building Code |
| .16 | OFC | Ontario Fire Code |
| .17 | OFM | Ontario Fire Marshall |
| .18 | ULC | Underwriter's Laboratories of Canada Ltd |
| .19 | UL | Underwriter's Laboratories (including cUL) |
- .3 Use latest editions and amendments in effect on date of Bid call subject to requirements of OBC.
- .4 Arrange and pay for permits and inspections by authorities having jurisdiction, required in the undertaking of this Division. Make modifications required by authorities.
- .5 All tradesmen employed on the project shall hold valid trade certificates/licenses and shall make a copy available for review by the Consultant and/or Owner when requested.

1.6 PRODUCT DELIVERY, HANDLING AND STORAGE

- .1 Immediately after letting of contract, review material and equipment requirements for this work, determine supply and delivery dates for all items, and notify Consultant of any potential delays in completion of this project in order that remedial action may be taken.
- .2 Store neatly out of the way and protected from damage and theft, materials and equipment supplied under this Division that are received at the site by this Division.

1.7 JOB CONDITIONS

- .1 Visit site and examine existing conditions which may affect work of this Division.
- .2 Examine all Contract Documents to ensure that work of this Division may be satisfactorily completed.
- .3 Notify Consultant upon discovery of conditions which adversely affect work of this Division. No allowance will be made after letting of contract for any expenses incurred through failure to do so.
- .4 Submission of a bid confirms that the Contract Documents and site conditions are accepted without qualifications, unless exceptions are specifically noted in the Bid.

1.8 INTERRUPTIONS

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

- .2 Prior to interrupting any existing service notify the Owner and Consultant, in writing, at least 7 days in advance, and obtain written authorization. Do not interrupt any existing service without Consultant's specific authorization. Refer to Division 1 for requirements.
- .3 Arrange time and duration of interruption through the Owner's Physical Plant Department. Include in Bid Price for all overtime or premium time hours necessary to minimize duration of service interruption.
- .4 Test and verify the proper operation of existing equipment and systems that are shut down due to work of this project, prior to returning to service.
- .5 Assume responsibility for consequential costs on failure to obtain permission to shut-down and/or start-up any item of equipment, system or service.

1.9 WARRANTY

- .1 Refer to Division 1 and to Section 21 01 01 General Requirements.
- .2 Arrange with each manufacturer/supplier to extend warranties as necessary to coincide with warranty period or those periods specified.
- .3 Make submissions necessary to register product warranties to the benefit of the Owner.
- .4 Submit to Consultant, prior to Substantial Performance of the Contract, manufacturer's written warranties covering periods longer than one year or offering greater benefits than required in specifications and in the Owner's name.

1.10 EXTRAS AND CREDITS

- .1 Accompany all price submissions requested by Consultant for extra work, or work to be deleted, with a complete cost breakdown as follows:
 - .1 Materials, quantities and unit costs including any applicable contractors trade discount clearly identified.
 - .2 Labour hours and unit costs.
 - .3 Total materials and labour costs.
 - .4 Overhead and profit mark-ups in accordance with the General Conditions of the Contract.

2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- .1 Ensure materials and equipment provided under this Division are new and free from defects and bear labels of approval as required by codes referred to in this Division and/or by inspection authorities.
- .2 Ensure apparatus and equipment provided under this Division bears manufacturer's nameplate indicating name of manufacturer, model number or type, size, capacity, CRN, and other pertinent information. Ensure nameplates are easily read and clearly visible, with openings provided where equipment is insulated.
- .3 Ensure manufacturers and suppliers of equipment or materials under this Division determine if their products are composed of any hazardous materials. If they are, the products are suitably labeled and supplied with Material Safety Data

sheets. Obtain the Owner's approval in writing to bring hazardous materials onto the site prior to doing so.

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

2.2 ACCEPTABLE PRODUCTS

- .1 First item named or specified by catalogue number meets specifications regarding performance, quality of material and workmanship, and is acceptable to the Consultant.
- .2 Items, other than first named, meeting specifications regarding quality of materials and workmanship are acceptable to the Consultant, only, if they also meet performance and/or capacities specified and can be accommodated within the space allotted.
- .3 General approval indicated by inclusion of other manufacturers named is subject to final review of shop drawings, performance data and test reports.

2.3 EQUIVALENTS AND ALTERNATIVES

- .1 Suppliers wishing approval for additional equipment items as equivalent to those specified must submit complete description, technical and performance data to Consultant at least ten (10) working days prior to Bid closing date. Such equivalent equipment, if accepted, to conform to specifications with regard to all details, accessories, modifications, features and performance. Deviations from specifications must be stated in writing at time of submission for approval.
- .2 Bid Prices shall include only products specified or approved equivalents. Contractors may propose unsolicited alternatives to the products specified. Alternative proposals shall be submitted in sealed envelope at time of general contract Bid submission and shall include full description and technical data, and a statement of the related increase or decrease in Bid Price should alternatives be accepted. All additional costs associated with unsolicited alternative proposals such as larger motor starters, larger power feeders, space revisions to associated equipment, controls, etc. shall be included in alternative price. Prior approval by Consultant is not required for unsolicited alternative proposals.
- .3 Where the Contractor uses equipment other than that first named, on which the design is based, he shall be responsible for all details of installation including equipment size, arrangement, fit, and maintenance of all required clearances. Contractor shall prepare and submit revised layouts to indicate arrangement of all affected piping, ductwork, conduit, lighting, equipment, etc. Failure by Contractor to provide such drawings will be considered indication that original arrangements and space allocations are adequate. All additional costs associated with equivalent equipment such as larger motor starters, larger power feeders, space revisions to associated equipment, controls, etc. shall be included in Bid Price.

2.4 SUBSTITUTIONS DURING PROGRESS OF WORK

- .1 If during the progress of work, specified products are not obtainable, equivalent or similar products by other manufacturers may be permitted by Consultant.
- .2 Apply, in writing, to Consultant for substitution of any products, indicating the following:
 - .1 Manufacturer's name, model number, details of construction, accurate dimensions, capacities and performance of proposed products.
 - .2 Reason for substitution.
 - .3 Any revisions to the contract price made necessary by substitution.
 - .4 Any revisions to the contract time made necessary by substitution.
 - .5 Any revisions to layout, arrangement or services made necessary by substitution.
- .3 No substitutions will be permitted without written authorization from the Consultant.

2.5 CONSULTANT'S REVIEW

- .1 The consultants will review and evaluate unsolicited alternatives and substitutions proposed by the Contractor. Such review and evaluation work will be undertaken by the Consultant on an additional fee basis. The Contractor shall reimburse the Owner for all costs associated with such reviews and evaluations.
- .2 The Contractor shall also reimburse the Owner for any and all costs incurred in updating Contract Documents to reflect such changes.

3 EXECUTION

3.1 RELATIONSHIP WITH OTHER TRADES

- .1 Cooperate with other trades whose work affects or is affected by work of this Division to ensure satisfactory installation and to avoid delays.
- .2 Provide materials to be built-in, such as sleeves, anchors, and inserts, together with templates and/or measurements, promptly when required by other trades.
- .3 Provide structural supports for equipment to be mounted on or in walls, supported above floors and/or suspended from the structure.

3.2 INSTALLATION REQUIREMENTS

- .1 The Consultant's drawings and instructions govern the location of all items. Prepare fully coordinated installation drawings prior to installation.
- .2 Install equipment neatly to the satisfaction of the Consultant. Unless noted otherwise install products and services to follow building planes. Ensure installation permits free use of space and maximum headroom.
- .3 Confirm the exact location of outlets, fixtures and connections. Confirm location of outlets for equipment supplied under other Divisions.
- .4 Install equipment and apparatus to allow free access for maintenance, adjustment and eventual replacement.
- .5 Install metering and/or sensing devices to provide proper and reliable sampling of quantities being measured. Install instruments to permit easy observation.
- .6 Provide suitable shielding and physical protection for devices.
- .7 Install products and services in accordance with the manufacturer's requirements

- and/or recommendations.
- .8 Provide bases, supports, hangers and fasteners. Secure products and services so as not to impose undue stresses on the structure and systems.
- .9 Do not use powder activated tools except as permitted by the Prime Consultant and the Owner's workplace health and safety policies.
- .10 Ensure that the load onto structures does not exceed the maximum loading per square metre indicated on the structural drawings or as directed by the Consultant.

3.3 CONTRACT DRAWINGS

- .1 The drawings of this Division are performance drawings and indicate general arrangement of the work. They are diagrammatic except where specific details are given.
- .2 Obtain accurate dimensions from the architectural and structural drawings, or by measurement. Location and elevation of services are approximate. Verify them before construction is undertaken.
- .3 Make changes where required to accommodate structural conditions, (beams, columns, etc.). Obtain Consultant's approval before proceeding.
- .4 Adjust the location of materials and/or equipment as directed without adjustment to contract price, provided that the changes are requested before installation and do not affect material quantity. Note that outlets and/or equipment may be relocated up to 10 feet (3 m) in any direction without a change to the contract price.
- .5 Note that the layout and orientation of the ceiling outlets on the architectural reflected ceiling drawings may differ from that shown on the mechanical drawings. Make the installation in accordance with the latest architectural ceiling drawings. Provide the equipment as specified and/or shown on the documents of this Division.
- .6 The drawings of this Division are intended for tender pricing. The quantities and quality to be included in the bid price shall be based on the layout and specifications as shown on the mechanical documents. If there is a difference in quantity between the architectural and drawings of this Division, base the contract price on the greater quantity.
- .7 Prepare installation (construction) drawing to reflect the latest architectural ceiling layout.

3.4 RECORD DRAWINGS

- .1 Maintain project "as-built" record drawings. Obtain white prints from the Consultant for this purpose and pay printing costs. Identify each set as "Project Record Copy".
- .2 Record deviations from contract documents caused by site conditions or by changes ordered by the Consultant. Record deviations in red ink clearly and accurately, using industry standard drafting procedures consistent with quality and standards of Consultants documents.

- .3 Record deviations as work progresses throughout the execution of this contract. Maintain record drawings on site in clean, dry, legible condition, making them available for periodic review by the Consultant.
- .4 Record location of concealed services, particularly underground services. Before commencing any backfilling, obtain accurate measurements and information concerning correct location and depth of services.
- .5 Transfer records from the "Project Record Copy" to a DVD in Autocad format matching the Consultant's documents. Arrange computer file in layers to exactly match the layering system of the Consultant.
- .6 Submit the "Project Record Copy" on one or more DVD with white prints of each drawing to the Consultant at the time of Substantial Performance.

3.5 INSTRUCTION

- .1 Instruct and familiarize Owner's operating personnel with the various mechanical systems. Arrange instruction for each system separately.
- .2 Provide instruction for each system on two separate occasions, coordinated with the Owner's staff operating schedule, in order that interested personnel may arrange to attend.
- .3 Ensure each instruction period includes, but is not limited to the following;
 - .1 a classroom seminar with operating manuals, product and system drawings and such other audio/visual aids as may be appropriate,
 - .2 instruction during the classroom seminar by the manufacturer's representative regarding the proper operating and maintenance procedures for each item of equipment,
 - .3 demonstration of the proper operating procedures for each item of equipment,
 - .4 explanation of the purpose and function of all safety devices provided,
 - .5 demonstration of all measures required for safe and proper access for operation and maintenance.
- .4 Provide a period of follow-up instruction (on two occasions) approximately one month after completing Owner's instruction to clarify and reinforce earlier instructions.
- .5 Submit a letter from the Owner's management staff indicating the instruction has been given satisfactorily to the Consultant prior to substantial completion of the project.

3.6 COMMISSIONING

- .1 Refer to Section 25 08 00 Commissioning.
- .2 The Contractor shall start-up and completely commission all equipment and systems installed and/or modified under this contract. Commissioning work shall be completed to the satisfaction of the Consultant prior to acceptance of the Work or any part thereof.
- .3 Commissioning shall conform to CAN/CSA Z318.0 Commissioning of Health Care Facilities
- .4 The Commissioning Team shall be comprised of;
 - .1 Representatives of the Commissioning Coordinator (Commissioning

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- Agent)
- .2 The individual, company or agency undertaking the work of each Section,
 - .3 Representatives of the Contractor and his sub-contractors as required,
 - .4 Representatives of equipment manufacturers,
 - .5 Representatives of the Consultants,
 - .6 Representatives of the Owner.
- .5 The Contractor and his sub-contractors shall each assign an individual representing each of the relevant trades to the commissioning team and shall ensure that representatives of the equipment manufacturers are present during the relevant commissioning tasks.
- .6 The Contractor shall provide all necessary labour, materials, equipment, testing apparatus and incidentals necessary to completely start-up, verify, test and commission each system provided as part of the Work.
- .7 Each Section shall prepare Check Sheets in accordance with the standards listed above and shall issue them to the commissioning team for use during the commissioning process.
- .8 Three (3) copies of commissioning manuals shall be provided, bound in hard cover D-ring binders with transparent cover on front and spine personalized to indicate;
- .1 name and logo of Health Care Facility,
 - .2 name of the project,
 - .3 the Owner's project number,
 - .4 identification of the system commissioned,
 - .5 the date that the system was commissioned.
- .9 Commissioning manuals shall include machine printable index dividers to organize each manual by system and by commissioning stage.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 25 01 01.

1.2 COMMON WORK RESULTS

- .1 Section 25 05 00 applies to and governs all work of Division 25.

1.3 REFERENCE STANDARDS

- .1 Provide all work in accordance with requirements of Regulatory Agencies and conform to:
 - .1 Local and district by-laws, regulations and published engineering standards.
 - .2 the Ontario Building Code (OBC) as amended,
 - .3 the Ontario Fire Code (OFC) as amended,
 - .4 the Ontario Electrical Safety Code (OESC).
 - .5 Regulations for Construction Projects under The Occupational Health and Safety Act.
- .2 Conform to following National Research Council Canada publications:
 - .1 National Building Code of Canada (NBC) and Supplements to National Building Code of Canada
 - .2 National Fire Code of Canada (NFC).
- .3 Conform to following National Fire Protection Association publications:
 - .1 NFPA 70 National Electrical Code (NEC)

1.4 FIELD QUALITY CONTROL

- .1 All work, materials, and equipment shall comply with the rules and regulations of applicable local, provincial and federal codes and standards.
- .2 Contractor shall continually monitor the field installation for code compliance and quality of workmanship.

1.5 QUALIFICATIONS

- .1 Firestop Sealant Manufacturer: Company specializing in manufacture of sealants with minimum three years documented product development, testing, and manufacturing experience.
- .2 Firestop components and assemblies shall be ULC listed and tested in accordance with ULC S115 Standard Method of Fire Test for Firestop Systems.

1.6 SUBMITTALS

- .1 Submit shop drawings in accordance with Section 25 01 01.1.5.2, for the following items:

- .1 firestopping compounds and applications schedule
- .2 access doors

1.7 DELIVERY, STORAGE, AND HANDLING

- .1 Transport, handle, store, and protect products. refer to Division 1 requirements as well.
- .2 Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

1.8 WASTE MANAGEMENT & DISPOSAL

- .1 Separate and recycle waste materials in accordance with Division 1 Waste Management and Disposal, and with the Contractor's Waste Reduction Workplan.
- .2 Place materials defined as hazardous or toxic waste in designated containers.
- .3 Ensure emptied containers are sealed and stored safely for disposal away from children.

1.9 WARRANTY

- .1 Provide extended coverage five year warranty for motors larger than 20 HP (15 kW).

2 PRODUCTS

2.1 ELECTRICAL COMPONENTS AND WIRING

- .1 Conform to requirements of Division 26 for all wiring, conduits and raceways, boxes, and cable trays included in Division 25.
- .2 All pre-wired equipment provided by Sections under Division 25 shall conform to requirements of Division 26. Ensure that all pre-wired electrical equipment is CSA approved. Arrange and pay for special approval where this is not possible.
- .3 Communication and control wiring and power supplies specified as conforming to NEC Class 1, Class 2 and Class 3 wiring practices must also conform to OESC Section 16 requirements.

2.2 COMMUNICATION AND CONTROL WIRING

- .1 General:
 - .1 Provide copper wiring, plenum cable, and raceways as specified in the applicable Sections of Division 26 unless otherwise noted herein.
 - .2 All insulated wire to be copper conductors, ULC labeled for 90°C minimum service.
- .2 Wire Sizing and Insulation

- .1 Wiring shall comply with minimum wire size and insulation based on services listed below:

Service	Minimum Gage/Type	Insulation Class
AC 24V Power	12 Ga Solid	600 Volt
DC 24V Power	10 Ga Solid	600 Volt
Class 1	14 Ga Stranded	600 Volt
Class 2	18 Ga Stranded	300 Volt
Class 3	18 Ga Stranded	300 Volt

- .2 Provide plenum-rated cable when open cable is permitted in supply or return air plenum.
- .3 Power Wiring:
- .1 115V power circuit wiring above 100 feet distance shall use minimum 10 gage.
- .2 24V control power wiring above 200 feet distance shall use minimum 12 gage.
- .4 Control Wiring:
- .1 Digital Input/Output wiring shall use Class 2 twisted pair, insulated.
- .2 Analog inputs shall use Class 2 twisted shielded pair, insulated and jacketed and require a grounded shield.
- .3 Actuators with tri-state control shall use Class 3 conductor with same characteristics
- .5 Communication Wiring
- .1 Ethernet Cable shall be minimum CAT5e and as required for system components.
- .2 Secondary level network shall be 24 gage, TSP, low capacitance cable
- .6 Approved Cable Manufacturers: Wiring from the following manufacturers which meet the above criteria shall be acceptable:
- .1 Anixter
- .2 Belden
- .3 Cerco

2.3 POWER SUPPLIES AND LINE FILTERING

- .1 Control transformers shall be ULC listed. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.
- .2 DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0

mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand a 150% current overload for at least three seconds without trip-out or failure.

- .1 Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
- .2 Line voltage units shall be ULC recognized and CSA approved.
- .3 Power line filtering: Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component. Surge protection shall have the following at a minimum:
 - .1 Dielectric strength of 1000 volts minimum
 - .2 Response time of 10 nanoseconds or less
 - .3 Transverse mode noise attenuation of 65 dB or greater
 - .4 Common mode noise attenuation of 150 dB or better at 40 Hz to 100 Hz.

2.4 FIRESTOPPING COMPOUNDS

- .1 Manufacturer: 3M products indicated.
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Dow Corning
 - .2 John Manville
 - .3 Hilti Firestop Systems
- .3 Fire Rated Sealants: intumescent material, synthetic elastomers, capable of expanding up to 8 to 10 times when exposed to temperatures of 250°F (121°C) or higher. ULC listed and labelled.

2.5 NAMEPLATES

- .1 Provide laminated plastic plates with black face and white centre of minimum size 3-1/2" x 1-1/2" x 3/32" (90 x 40 x 2 mm) nominal thickness, engraved with 1/4" (6 mm) high lettering. Use 1" (25 mm) lettering for major equipment.
- .2 Fasten nameplates securely in conspicuous place. Where nameplates cannot be mounted on cool surface, provide standoffs.
- .3 Identify equipment type and number and service of areas or zone of building served.
- .4 For each item of equipment supplied and/or installed under this Division which may be started automatically or remotely, provide a red lamacoid plate, 2-1/2" x 9" (60 x 230 mm), reading:
"WARNING. THIS EQUIPMENT IS AUTOMATICALLY
CONTROLLED AND MAY START AT ANY TIME."

2.6 TAGS

- .1 Plastic Tags: Laminated three-layer plastic with engraved black letters on

- light contrasting background colour. Tag size minimum 1-1/2" (40 mm) diameter. OR
- .2 Metal Tags: Brass, aluminum or stainless steel with stamped letters; tag size minimum 1-1/2" (40 mm) diameter with smooth edges.
- .3 Charts: Typewritten letter size list in anodized aluminum frame.

3 EXECUTION

3.1 INSPECTION

- .1 Inspect installed work of other trades and verify that such work is complete to point where work under this Division may properly commence.
- .2 Verify that work of this Division may be executed in accordance with pertinent codes and regulations, specifications, drawings, and referenced standards.
- .3 Review drawings and verify dimensions at the site. Report discrepancies immediately to Consultant before proceeding with any construction work or shop drawings.

3.2 ELECTRICAL COMPONENTS AND WIRING

- .1 Coordinate all wiring requirements with other Divisions. Line voltage wiring from power distribution panels to starters and from starters to motors will be provided under Division 26. All other field wiring for equipment shall be included under Division 25.

3.3 PROTECTION

- .1 Protect finished and unfinished work by tarpaulins, or other covering, from damage due to execution of work under this Division.
- .2 Repair to satisfaction of Consultant, damage to building resulting from failure to provide such protection.

3.4 FIRESTOPPING

- .1 All openings in fire separations and fire rated assemblies for service penetrations shall be protected with ULC listed service penetration firestop systems (SP).
- .2 The service penetration firestop system shall have F and FT ratings equal to or greater than ratings specified by the Architect for the fire separation (F) and firewall (FT) joint firestop systems (JF).
- .3 All components employed in the service penetration firestop system shall conform to the ULC listing.
- .4 Refer to architectural drawings for ratings of fire separations and assemblies.

3.5 SUPPORT AND ATTACHEMENT

- .1 Support and attach raceways and equipment from load bearing structures such as beams, joists, reinforced concrete slabs and concrete block walls.
- .2 Do not support from or attach to steel roof deck and/or wall or ceiling finishes.

3.6 INSTALLATION PRACTICES

- .1 BMS Wiring
 - .1 All conduit, wiring, accessories and wiring connections required for the installation of the Building Management System, as herein specified, shall be provided by the BMS Contractor unless specifically shown on the Electrical Drawings under Division 26 Electrical. All wiring shall comply with the requirements of applicable portions of Division 26 and all local and national electric codes, unless specified otherwise in this section.
 - .2 All BMS wiring materials and installation methods shall comply with BMS manufacturer recommendations.
 - .3 Class 2 Wiring
 - .1 All Class 2 (24VAC or less) wiring shall be installed in conduit unless otherwise specified.
 - .2 Class 2 wiring in concealed accessible locations shall be FT-6 plenum rated.
 - .3 Class 2 wiring not installed in conduit shall be supported every 5' from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements.
 - .4 Class 2 signal wiring and 24VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.
 - .5 Provide for complete grounding of all applicable signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops.
- .2 BMS Line Voltage Power Source
 - .1 120-volt AC circuits used for the Building Management System shall be taken from panel boards and circuit breakers provided under Division 26.
 - .2 Circuits used for the BMS shall be dedicated to the BMS and shall not be used for any other purposes.
 - .3 DDC terminal unit controllers may use AC power from motor power circuits.
- .3 BMS Raceway
 - .1 All wiring shall be installed in conduit or raceway except as noted elsewhere in this specification. Minimum control wiring conduit size 1/2".

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- .2 Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used as approved by the Architect.
 - .3 All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.
 - .4 Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.
 - .4 Penetrations
 - .1 Provide fire stopping for all penetrations used by dedicated BMS conduits and raceways.
 - .2 All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.
 - .3 All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.
 - .4 Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.
 - .5 BMS Identification Standards
 - .1 Node Identification. All nodes shall be identified by a permanent label fastened to the enclosure. Labels shall be suitable for the node location.
 - .2 Cable types specified in Item A shall be color coded for easy identification and troubleshooting.
 - .6 BMS Panel Installation
 - .1 The BMS panels and cabinets shall be located as indicated at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer's recommendations.
 - .2 The BMS contractor shall be responsible for coordinating panel locations with other trades and electrical and mechanical contractors.
 - .7 Input Devices
 - .1 All Input devices shall be installed per the manufacturer recommendation
 - .2 Locate components of the BMS in accessible local control panels wherever possible.
 - .8 HVAC Input Devices - General
 - .1 All Input devices shall be installed per the manufacturer recommendation
 - .2 Locate components of the BMS in accessible local control panels wherever possible.
 - .3 The mechanical contractor shall install all in-line devices such as temperature wells, pressure taps, airflow stations, etc.
 - .4 Input Flow Measuring Devices shall be installed in strict compliance with ASME guidelines affecting non-standard

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- approach conditions.
- .5 Outside Air Sensors
 - .1 Sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air conditions accurately.
 - .2 Sensors shall be installed with a rain proof, perforated cover.
 - .6 Water Differential Pressure Sensors
 - .1 Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device.
 - .2 Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.
 - .3 The transmitters shall be installed in an accessible location wherever possible.
 - .7 Medium to High Differential Water Pressure Applications (Over 21" w.c.):
 - .1 Air bleed units, bypass valves and compression fittings shall be provided.
 - .8 Building Differential Air Pressure Applications (-1" to +1" w.c.):
 - .1 Transmitters exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.
 - .2 The interior tip shall be inconspicuous and located as shown on the drawings.
 - .9 Air Flow Measuring Stations:
 - .1 Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct.
 - .2 Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.
 - .10 Duct Temperature Sensors:
 - .1 Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
 - .2 The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.
 - .3 For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.
 - .4 The sensor shall be mounted to suitable supports using factory approved element holders.
 - .11 Space Sensors:
 - .1 Shall be mounted per ADA requirements.
 - .2 Provide lockable tamper-proof covers in public areas and/or where indicated on the plans.
 - .12 Low Temperature Limit Switches:

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- .1 Install on the discharge side of the first water coil in the air stream.
 - .2 Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by 1 foot of sensor.
 - .3 For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream.
 - .13 Air Differential Pressure Status Switches:
 - .1 Install with static pressure tips, tubing, fittings, and air filter.
 - .14 Water Differential Pressure Status Switches:
 - .1 Install with shut off valves for isolation.
 - .9 HVAC Output Devices
 - .1 All output devices shall be installed per the manufacturers' recommendation. The mechanical contractor shall install all in-line devices such as control valves, dampers, airflow stations, pressure wells, etc.
 - .2 Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke.
 - .3 Control Dampers: Shall be opposed blade for modulating control of airflow. Parallel blade dampers shall be installed for two position applications.
 - .4 Control Valves: Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI. The maximum pressure drop for steam applications shall be 7 PSI.
 - .5 Electronic Signal Isolation Transducers: Whenever an analog output signal from the Building Management System is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input a signal from a remote system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between systems. Signals shall provide optical isolation between systems

3.7 WIRING

- .1 All control and interlock wiring shall comply with provincial electrical codes, standards and Division 26.
- .2 All NEC Class 1 wiring shall be ULC Listed in approved conduit according to OESC and Division 26 requirements.
- .3 All low-voltage wiring shall meet NEC Class 2 requirements. Low-voltage power circuits shall be sub-fused when required to meet NEC Class 2 current limitations.
- .4 Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved

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- cables not in conduit may be used provided that cables are ULC Listed for the intended application. For example, cables used in ceiling plenums shall be ULC Listed specifically for that purpose.
- .5 All wiring in mechanical, electrical, or service rooms-or where subject to mechanical damage- shall be installed in conduit.
 - .6 Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).
 - .7 Do not install wiring in conduit containing tubing.
 - .8 Where plenum rated cable is run exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 3 m (10 ft) intervals.
 - .9 Where plenum rated cable is used without conduit, it shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical conduits, piping, or ceiling suspension systems.
 - .10 All wire-to-device connections shall be made at a terminal block or wire nut. All wire-to-wire connections shall be at a terminal strip or wire nut.
 - .11 All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
 - .12 Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, this Division shall provide step-down transformers or interposing relays.
 - .13 All plenum rated wiring shall be installed as continuous lengths, with no splices permitted between termination points
 - .14 All wiring in conduit shall be installed as continuous lengths, with no splices permitted between termination points or junction boxes.
 - .15 Maintain fire rating at all penetrations. Install plenum wiring in sleeves where it passes through walls and floors.
 - .16 Size and type of conduit and size and type of wire shall be the responsibility of the contractor, in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.
 - .17 Include one pull string in each conduit 3/4 in. or larger.
 - .18 Control and status relays are to be located in designated enclosures only. These enclosures can include packaged equipment control panel enclosures unless they also contain Class 1 starters.
 - .19 Conceal all conduit, except within mechanical, electrical, or service rooms. Install conduit to maintain a minimum clearance of 15 cm (6 in.) from high-temperature equipment (e.g., steam pipes, gas vents or flues).
 - .20 Secure conduit with conduit clamps fastened to the structure and spaced according to code requirements. Conduit and pull boxes may not be hung on flexible duct strap or tie rods. Conduits may not be run on or attached to ductwork.
 - .21 Adhere to this specification's Division 26 requirements where conduit crosses building expansion joints.
 - .22 This Division shall terminate all control and/or interlock wiring and shall
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maintain updated (as-built) wiring diagrams with terminations identified at the job site.

- .23 Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 1 m (3 ft) in length and shall be supported at each end. Flexible metal conduit less than ½ in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.
- .24 Conduit must be adequately supported, properly reamed at both ends, and left clean and free of obstructions. Conduit sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

3.8 COMMUNICATION WIRING

- .1 This Division shall adhere to the items listed in the "Wiring" article 3.14.
- .2 All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.
- .3 Do not install communication wiring in raceway and enclosures containing NEC Class 1 or other Class 2 wiring.
- .4 Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.
- .5 Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.
- .6 When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lightning arrestor shall be installed according to the manufacturer's instructions.
- .7 All runs of communication wiring shall be unspliced length when that length is commercially available.
- .8 All communication wiring shall be labeled to indicate origination and destination data.
- .9 Grounding of coaxial cable shall be in accordance with OESC and NEC regulations on "Communications Circuits, Cable, and Protector Grounding."

3.9 INPUT/OUTPUT INTERFACE

- .1 Hardwired inputs and outputs may tie into the system through building or application specific controllers.
- .2 Each controller location to provide 15% spare I/O with a minimum of 1 point of each type.
- .3 All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause

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- no damage to the controller.
- .4 Binary inputs shall allow the monitoring of On/Off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.
 - .5 Pulse accumulation input objects. This type of object shall conform to all the requirements of binary input objects and also accept up to 10 pulses per second for pulse accumulation.
 - .6 Analog inputs shall allow the monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with-and field configurable to- commonly available sensing devices.
 - .7 Binary outputs shall provide for On/Off operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers shall have three-position (On/Off/Auto) override switches and status lights. Outputs shall be selectable for either normally open or normally closed operation.
 - .8 Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC, 4 to 20 mA or 0-20 PSI signal as required to provide proper control of the output device. Analog outputs shall not exhibit a drift of greater than 0.4% of range per year.
 - .9 Tri-State Outputs. Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point floating devices shall be limited to zone control and terminal unit control applications (VAV terminal units, duct-mounted heating coils, zone dampers, radiation, etc.). Control algorithms shall run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.
 - .10 System Object Capacity. The system size shall be expandable to at least twice the number of input/ output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

3.10 INSTALLATION OF SENSORS

- .1 General:
 - .1 Install sensors in accordance with the manufacturer's recommendations.
 - .2 Mount sensors rigidly and adequately for the environment within which the sensor operates.
 - .3 Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.

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- .4 All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.
 - .5 Sensors used in mixing plenums and hot and cold decks shall be of the averaging type.
 - .6 Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across the full face of the coil.
 - .7 All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.
 - .8 Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.
 - .2 Room Instrument Mounting
 - .1 Room instruments, including but not limited to wall mounted thermostats and sensors located in occupied spaces shall be mounted 53 inches above the finished floor unless otherwise shown.
 - .3 Instrumentation Installed in Piping Systems
 - .1 Thermometers and temperature sensing elements installed in liquid systems shall be installed in thermowells.
 - .2 Gauges in piping systems subject to pulsation shall have snubbers.
 - .3 Gauges for steam service shall have pigtail fittings with isolation valve.
 - .4 Averaging Temperature Sensing Elements
 - .1 Sensing elements shall be installed in a serpentine pattern.
 - .2 Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
 - .5 Relative Humidity Sensors
 - .1 Relative humidity sensors in supply air ducts shall be installed at least 3m (10 feet) downstream of humidity injection elements.

3.11 ACTUATORS

- .1 Mount and link control damper actuators according to manufacturer's instructions.
 - .1 To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
 - .2 Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
 - .3 Provide all mounting hardware and linkages for actuator installation.

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- .2 Electric/Electronic
 - .1 Dampers: Actuators shall be direct mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° available for tightening the damper seals. Actuators shall be mounted following manufacturer's recommendations.
 - .2 Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.
 - .3 Identification of Tubing and Wiring
 - .1 All wiring and cabling including that within factory-fabricated panels shall be labeled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.
 - .2 Permanently label or code each point of field terminal strips to show the instrument or item served.
 - .3 All pneumatic tubing shall be labeled at each end within 5 cm (2 in.) of termination with a descriptive identifier.

3.12 IDENTIFICATION OF HARDWARE AND WIRING

- .1 All wiring and cabling, including that within factory-fabricated panels shall be labeled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.
- .2 Permanently label or code each point of field terminal strips to show the instrument or item served.
- .3 Identify control panels and major control components on outside with minimum 1 cm (½ in.) letters on laminated plastic nameplates.
- .4 Identify all other control components with permanent labels. All plug-in components shall be labeled such that removal of the component does not remove the label.
- .5 Identify room sensors relating to terminal box or valves with nameplates.
- .6 Manufacturers' nameplates and ULC or CSA labels are to be visible and legible after equipment is installed.
- .7 Identifiers shall match record documents.
- .8 Degrease and clean surfaces to receive adhesive for identification materials.
- .9 Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer (VOC content not to exceed 680 g/L).
- .10 Install tags with corrosion resistant chain.
- .11 Clearly identify abandoned services left in place as "ABANDONED".
- .12 For each item of equipment which may be started automatically or remotely, add a red lamacoid plate, 2-3/8" x 9" (60 x 230 mm), reading:
"WARNING. THIS EQUIPMENT IS AUTOMATICALLY CONTROLLED. IT MAY START AT ANY TIME."

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- .13 Provide colour coded self-adhesive dots to locate control devices and panels located above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

3.13 EQUIPMENT TESTING AND INSPECTION

- .1 Test operation of equipment installed under this Division according to instructions in appropriate articles of this Division. Make any required adjustments or replacements to ensure equipment is operating as intended. Retest equipment requiring adjustment or replacement.
- .2 Pay all fuel consumption charges for equipment under testing and during commissioning.
- .3 Conduct tests before application of external insulation and before concealment of piping or ductwork.
- .4 Arrange and pay for inspections by authorities as required by code and complete any changes or alterations required by such inspections.
- .5 Conduct tests in the presence of:
 - .1 Authorized inspector(s) for authorities having jurisdiction.
 - .2 The Consultant.
 - .3 The Owner's Representative.
- .6 Notification must be given at least 48 hours in advance of tests being conducted, to all persons required to be present.

3.14 ADJUST AND CLEAN

- .1 Clean up all debris resulting from their activities daily. Remove all cartons, containers, crates, etc. as soon as their contents have been removed. Collect and sort waste and deposit in designated locations.
- .2 At the completion of work in any area, clean all work keeping it free from dust, dirt, and debris. Check all equipment furnished under this Division for paint damage. Repair any factory-finished paint that has been damaged to match the adjacent areas. Any equipment item, cabinet or enclosure that has been deformed shall be replaced with new material and painted to match adjacent areas.
- .3 Lubricate mechanical equipment installed under this Division.
- .4 Test and adjust control devices, instrumentation, valves, dampers, etc. installed under this Division after cleaning of systems and leave in perfect order ready for operation.
- .5 Remove from the premises upon completion of work of this Division, debris, surplus, and waste materials resulting from operations.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 25 01 01 and Section 01 91 00.

1.2 COMMISSIONING AGENT

- .1 The commissioning agent, **EcoVert** (CA), has been contracted directly by the Owner for this project. The CA has overall responsibility for planning and coordinating the commissioning process. Commissioning involves all parties to the design and construction process, including the Contractor and his sub-contractors and suppliers.

1.3 DESCRIPTION OF WORK

- .1 The purpose of the commissioning process is to provide the owner/operator of the facility with assurance that the plumbing systems have been installed according to the contract documents, and operate within the performance guidelines set out in the design intent documents and these specifications. The CA will provide the Owner with an unbiased, objective view of the system's installation, operation, and performance. The commissioning process does not take away or reduce the responsibility of the installing contractors to provide a finished product, installed and fully functional in accordance with the contract documents.
- .2 Commissioning is intended to enhance the quality of system start up and aid in the orderly completion and transfer of systems for beneficial use of owner. The CA will be the leader of the commissioning team, planning and coordinating all commissioning activities in conjunction with the design professionals, construction manager, subcontractors, manufacturers and equipment suppliers.
- .3 The General Contractor and Division 21, 22, 23, 25, 26, 27 and 28 sub-contractors are responsible for cooperating, and coordinating their work, with the CA. They shall also be responsible for carrying out all the physical activities required for installation of components and systems, and operating them during the commissioning process as required in this Section.

1.4 RELATED DOCUMENTS

- .1 Drawings and General Requirements of the contract, including General and Supplementary General Conditions, General Requirements and applicable Sections of Divisions 21, 22, 23, 25, 26, 27 and 28 apply to work of this Section.
- .2 Refer to specification section Appendix C.

1.5 REFERENCES

- .1 Ontario Building Code (OBC).
- .2 Ontario Fire Code (OFC).
- .3 ASHRAE Guideline 0 The Commissioning Process,
- .4 NFPA Standards and Guidelines

1.6 SYSTEMS TO BE COMMISSIONED

- .1 The following Integrated Automation Systems shall be commissioned as part of the Work of this contract;
- .2 Building Automation System (BAS)
- .3 Building Management System (BMS)
- .4 Energy Management and Control System (EMCS)
- .5 Facility Management System (FMS)

2 PRODUCTS

2.1 COMMISSIONING AUTHORITY

- .1 The commissioning authority shall consist of representatives of the following:
 - .1 Owner and the Owner's Operating and Maintenance Staff
 - .2 Architect
 - .3 Mechanical Design Engineer
 - .4 Electrical Design Engineer
 - .5 Commissioning Agent (CA)
 - .6 General Contractor
 - .7 Fire Protection Subcontractor
 - .8 Mechanical Subcontractor
 - .9 Controls Subcontractor
 - .10 Electrical Subcontractor
 - .11 Testing, Adjusting and Balancing Agency
 - .12 Related Subcontractors and Suppliers.

2.2 SYSTEMS START-UP/VERIFICATION CHECKLISTS

- .1 The Appendix specification section contains the system start-up and verification checklists as listed below:

2.3 FUNCTIONAL PERFORMANCE TEST CHECKLISTS

- .1 The Appendix specification section contains functional performance test checklists as listed below:

3 EXECUTION

3.1 COMMISSIONING AGENT'S RESPONSIBILITIES

- .1 The Commissioning Agent shall:
 - .1 Plan, organize and implement the commissioning process as

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- specified herein;
 - .2 Prepare the commissioning plan, ensure its distribution for review and comment;
 - .3 Revise the commissioning plan as required during construction;
 - .4 Chair commissioning meetings, and prepare and distribute minutes to all commissioning team members, whether or not they attended the meeting;
 - .5 In conjunction with the General Contractor, coordinate commissioning activities among all contractors, sub-trades and suppliers;
 - .6 Monitor system verification checks, and ensure the results are documented as the checks are done;
 - .7 Monitor controls point-to-point checks done by the controls contractor, and ensure the results documented as the checks are done;
 - .8 Observe all start-ups and initial system operations tests and checks;
 - .9 Direct the contractors to operate equipment and systems as required to ensure that all required functional performance tests are carried out for verification purposes;
 - .10 Witness all functional performance tests and document the results;
 - .11 Prepare and submit a commissioning report which documents all checks and tests done throughout the commissioning process, and the results obtained from each; and
 - .12 Ensure all required O&M manuals, instructions and demonstrations are provided to the owner's designated operating staff.

3.2 MECHANICAL ENGINEER'S RESPONSIBILITIES

- .1 The Mechanical Engineer will review the commissioning plan, and will participate, as appropriate, in on-site commissioning meetings.
- .2 During the acceptance phase of the commissioning process, the Mechanical Engineer may be on site to review commissioning documentation, to witness functional performance tests, and to analyze the installation and its performance.

3.3 OWNER'S RESPONSIBILITIES

- .1 The Owner will ensure the availability of operating staff for all scheduled instructions and demonstration sessions. This staff will possess sufficient skills and knowledge to operate and maintain the installation following attendance at these sessions. The owner will also ensure the appropriate involvement of the Electrical Engineer, Architect, and any other consultants as required, in the commissioning process.

3.4 GENERAL CONTRACTOR'S RESPONSIBILITIES

- .1 The General Contractor has responsibility to ensure the overall completion of the work. In this regard, he shall;
 - .1 Participate as required in the Integrated Automation Systems Commissioning process,
 - .2 Ensure the Division 25 sub-contractor performs all assigned commissioning responsibilities as specified in 3.5,
 - .3 Ensure the Division 26 contractor performs all assigned commissioning responsibilities as specified in 3.6,
 - .4 Ensure the cooperation and participation in the commissioning process of all other sub-contractors as applicable.
- .2 The General Contractor shall assign a representative to the commissioning team, and submit the person's name to the commissioning agency, within one (1) month of the award of the contract. The representative shall have the authority to make decision on behalf of the general contractor as they relate to the organization and scheduling of Integrated Automation Systems commissioning. The representative shall facilitate communications among all contractors and suppliers and other commissioning team members, and shall foster the necessary cooperative action. One specific responsibility shall be to attend commissioning meetings, and ensure action items arising from them are attended to as required to allow the commissioning process to proceed on schedule.
- .3 In the event that any scheduled equipment or system start-ups or functional performance tests are terminated because the CA or the mechanical engineer discover deficient or incomplete work, or due to the non-attendance of required contractor or supplier personnel, the contractor or sub-contractor responsible for the termination shall also be responsible for paying reasonable costs of time and travel expenses of any or all of the following representatives who were physically present for the purpose of witnessing the start-up or the FPT: the CA, the mechanical engineer, the electrical engineer, and the owner. The owner may provide a statement to the General Contractor identifying the specific activity that was terminated, the scheduled date, and a list of those in attendance, along with their reasonable time and travel expense costs.

3.5 DIVISION 25 SUBCONTRACTOR'S RESPONSIBILITIES

- .1 With respect to Integrated Automation Systems commissioning, the controls contractor shall:
 - .1 Include cost for commissioning requirements in the quoted price.
 - .2 Review design for controllability with respect to equipment selected for the project;
 - .1 Review and confirm in writing that a proper hardware specification exists to permit functional performance testing as required by specification and sequence of operation.
 - .2 Review and confirm in writing that proper safeties and interlocks are included in design.
 - .3 Ensure the proper sizing of control valves and actuators,

- based on design pressure drops. Ensure that control valve authority will result in capacity control as specified. Include valve sizing and authority information in submittal to mechanical engineer.
- .4 Ensure the proper sizing of control dampers. Ensure damper authority to control air flows as specified. Review and confirm in writing proper damper positioning for mixing to prevent stratification. Ensure correct actuator vs. damper movement for smooth operation. Include damper sizing, control authority and actuator selection data in submittal to mechanical engineer.
 - .5 Ensure the proper selection of sensor ranges, and include data with submittal to mechanical engineer.
 - .6 Clarify all questions concerning sequences of operation with the mechanical engineer.
 - .3 Attend commissioning meetings scheduled by the CA.
 - .4 Provide the following submittals to the CA for review:
 - .1 Hardware and software submittals.
 - .2 Control panel construction shop drawings.
 - .3 Diagrams showing all control points, sensor locations, point names, actuators, controllers and where necessary, points of access, all superimposed on diagrams of the physical equipment.
 - .4 Narrative description of all control sequences for each piece of equipment controlled.
 - .5 Logic diagrams showing the logic flow of all control sequences.
 - .6 A list of all control points, including analog inputs, analog outputs, digital inputs and digital outputs. Include the values of all parameters for each system point. Provide a separate list for each stand-alone control unit.
 - .7 A complete control language program listing including all software routines employed in operating the control system. Also, provide a program write-up, organized in the same manner as the control software. This narrative shall describe the logic flow of the software and the functions of each routine and sub-routine. It should also explain individual math or logic operations that are not clear from reading the software listing.
 - .8 Hardware operation and maintenance manuals.
 - .9 Application software and project applications code manuals.
 - .5 Inspect, check, and confirm the proper installation and performance of controls/BAS hardware and software provided by others.
 - .6 Integrate installation and programming scheduling with construction and commissioning schedules.

- .7 Inspect, check and confirm the correct installation and operation of input and output field points and devices through documented and signed off point-to-point checkouts.
- .8 Provide thorough training to operating personnel on hardware operations and programming, and the application program for the system, in accordance with the O&M staff training program in the commissioning plan.
- .9 In conjunction with the Division 23 sub-contractor, demonstrate system performance to the CC including all modes of system operation (e.g. occupied, unoccupied, emergency) during the functional performance tests (FTP). If improper functionality, incomplete work, or other deficiencies affecting system performance are discovered, the FPTs will be stopped by the CC. Those responsible for deficient or incomplete work will be responsible for costs in accordance with 3.4 in this Section.
- .10 Provide control system technician to assist during system verification and functional performance testing.
- .11 Provide support and coordination with CA on all interfaces between controls and CA scopes of work. Provide, at no additional cost to the CA and commissioning agencies, all devices, such as portable operator's terminals and all software for the CA agency to use in completing CA procedures.

3.6 DIVISION 26 SUBCONTRACTOR'S RESPONSIBILITIES

- .1 With respect to Integrated Automation Systems commissioning, the electrical contractor shall:
 - .1 Include cost for Integrated Automation Systems commissioning requirements in the quoted price.
 - .2 Review design with respect to providing power to the Integrated Automation Systems equipment:
 - .1 Verify that proper hardware specifications exist for functional performance and sequence of operation required by specification.
 - .2 Verify that proper safeties and interlocks are included in the design of electrical connections for Integrated Automation Systems equipment.
 - .3 Attend commissioning meetings scheduled by the CA.
 - .4 Schedule work so that required electrical installations are completed, and systems verification checks and functional performance tests can be carried out on schedule.
 - .5 Inspect, check and confirm in writing the proper installation and performance of all electrical services provided.
 - .6 Provide electrical system technicians to assist during system verification and functional performance testing as required by the CA.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 23 01 01 and 01 91 00.

1.2 COMMISSIONING AGENT

- .1 The commissioning agent (CA) has been contracted directly by the Owner for this project. The CA has overall responsibility for planning and coordinating the commissioning process. Commissioning involves all parties to the design and construction process, including the Contractor and his sub-contractors and suppliers.

1.3 DESCRIPTION OF WORK

- .1 The purpose of the commissioning process is to provide the owner/operator of the facility with assurance that the plumbing systems have been installed according to the contract documents, and operate within the performance guidelines set out in the design intent documents and these specifications. The CA will provide the Owner with an unbiased, objective view of the system's installation, operation, and performance. The commissioning process does not take away or reduce the responsibility of the installing contractors to provide a finished product, installed and fully functional in accordance with the contract documents.
- .2 Commissioning is intended to enhance the quality of system start up and aid in the orderly completion and transfer of systems for beneficial use of owner. The CA will be the leader of the commissioning team, planning and coordinating all commissioning activities in conjunction with the design professionals, construction manager, subcontractors, manufacturers, and equipment suppliers.
- .3 The General Contractor and Division 21, 22, 23, 25, 26, 27 and 28 sub-contractors are responsible for cooperating, and coordinating their work, with the CA. They shall also be responsible for carrying out all the physical activities required for installation of components and systems and operating them during the commissioning process as required in this Section.

1.4 RELATED DOCUMENTS

- .1 Drawings and General Requirements of the contract, including General and Supplementary General Conditions, General Requirements, and applicable Sections of Divisions 21, 22, 23, 25, 26, 27 and 28 apply to work of this Section.
- .2 Refer to specification section Appendix C.

1.5 REFERENCES

- .1 Ontario Building Code (OBC).
- .2 Ontario Fire Code (OFC).
- .3 ASHRAE Guideline 0 The Commissioning Process,

1.6 SYSTEMS TO BE COMMISSIONED

- .1 The following HVAC work shall be commissioned as part of the Work of this contract:
- .2 Air handling (AC-01) Unit
- .3 Energy Recovery (ERU-01) Unit
- .4 Energy Recovery (ERU-02) Unit
- .5 Heating Boiler
- .6 Fan Coil Systems
- .7 Ductwork Systems
- .8 Hydronic systems
- .9 Controls, Point-to-Point
- .10 Duct pressure testing

2 PRODUCTS

2.1 COMMISSIONING AUTHORITY

- .1 The commissioning authority shall consist of representatives of the following:
 - .1 Owner and the Owner's Operating and Maintenance Staff
 - .2 Architect
 - .3 Mechanical Design Engineer
 - .4 Electrical Design Engineer
 - .5 Commissioning Consultant (CC)
 - .6 General Contractor
 - .7 Fire Protection Subcontractor
 - .8 Mechanical Subcontractor
 - .9 Controls Subcontractor
 - .10 Electrical Subcontractor
 - .11 Testing, Adjusting and Balancing Agency
 - .12 Related Subcontractors and Suppliers.

2.2 SYSTEMS START-UP/VERIFICATION CHECKLISTS

- .1 The Appendix specification section contains the system start-up and verification checklists as listed below:
- .2 Air handling (AC-01) Unit
- .3 Energy Recovery (ERU-01) Unit
- .4 Energy Recovery (ERU-02) Unit
- .5 Heating Boiler
- .6 Fan Coil Systems
- .7 Ductwork Systems
- .8 Hydronic systems
- .9 Controls, Point-to-Point
- .10 Duct pressure testing

2.3 FUNCTIONAL PERFORMANCE TEST CHECKLISTS

- .1 This Appendix specification section contains functional performance test

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- checklists as listed below:
- .2 Air handling (AC-01) Unit
 - .3 Energy Recovery (ERU-01) Unit
 - .4 Energy Recovery (ERU-02) Unit
 - .5 Heating Boiler
 - .6 Fan Coil Systems
 - .7 Ductwork Systems
 - .8 Hydronic systems
 - .9 Controls, Point-to-Point
 - .10 Duct pressure testing

3 EXECUTION

3.1 COMMISSIONING CONSULTANT'S RESPONSIBILITIES

- .1 The Commissioning Consultant shall:
 - .1 plan, organize and implement the commissioning process as specified herein;
 - .2 prepare the commissioning plan, ensure its distribution for review and comment;
 - .3 revise the commissioning plan as required during construction;
 - .4 chair commissioning meetings, and prepare and distribute minutes to all commissioning team members, whether or not they attended the meeting;
 - .5 in conjunction with the General Contractor, coordinate commissioning activities among all contractors, sub-trades and suppliers;
 - .6 monitor system verification checks, and ensure the results are documented as the checks are done;
 - .7 monitor controls point-to-point checks done by the controls contractor, and ensure the results documented as the checks are done;
 - .8 observe all start-ups and initial system operations tests and checks;
 - .9 direct the contractors to operate equipment and systems as required to ensure that all required functional performance tests are carried out for verification purposes;
 - .10 witness all functional performance tests and document the results;
 - .11 prepare and submit a commissioning report which documents all checks and tests done throughout the commissioning process, and the results obtained from each; and
 - .12 ensure all required O&M manuals, instructions and demonstrations are provided to the owner's designated operating staff.

3.2 MECHANICAL ENGINEER'S RESPONSIBILITIES

- .1 The Mechanical Engineer will review the commissioning plan, and will participate, as appropriate, in on-site commissioning meetings.
- .2 During the acceptance phase of the commissioning process, the Mechanical Engineer may be on site to review commissioning documentation, to witness

functional performance tests, and to analyze the installation and its performance.

3.3 OWNER'S RESPONSIBILITIES

- .1 The Owner will ensure the availability of operating staff for all scheduled instructions and demonstration sessions. This staff will possess sufficient skills and knowledge to operate and maintain the installation following attendance at these sessions. The owner will also ensure the appropriate involvement of the Electrical Engineer, Architect, and any other consultants as required, in the commissioning process.

3.4 GENERAL CONTRACTOR'S RESPONSIBILITIES

- .1 The General Contractor has responsibility to ensure the overall completion of the work. In this regard, he shall;
 - .1 participate as required in the HVAC Systems Commissioning process,
 - .2 ensure the HVAC contractor performs all assigned commissioning responsibilities as specified in 3.5,
 - .3 ensure the testing, adjusting and balancing agency performs all assigned commissioning responsibilities as specified in 3.6,
 - .4 ensure the Division 25 sub-contractor performs all assigned commissioning responsibilities as specified in 3.7,
 - .5 ensure the Division 26 sub-contractor performs all assigned commissioning responsibilities as specified in 3.8,
 - .6 ensure the cooperation and participation in the commissioning process of all other sub-contractors as applicable.
- .2 The General Contractor shall assign a representative to the commissioning team, and submit the person's name to the commissioning agency, within one (1) month of the award of the contract. The representative shall have the authority to make decision on behalf of the general contractor as they relate to the organization and scheduling of HVAC commissioning. The representative shall facilitate communications among all contractors and suppliers and other commissioning team members and shall foster the necessary cooperative action. One specific responsibility shall be to attend commissioning meetings and ensure action items arising from them are attended to as required to allow the commissioning process to proceed on schedule.
- .3 In the event that any scheduled equipment or system start-ups or functional performance tests are terminated because the CC or the mechanical engineer discover deficient or incomplete work, or due to the non-attendance of required contractor or supplier personnel, the contractor or sub-contractor responsible for the termination shall also be responsible for paying reasonable costs of time and travel expenses of any or all of the following representatives who were physically present for the purpose of witnessing the start-up or the FPT: the CC, the mechanical engineer, the electrical engineer, and the owner. The owner may provide a statement to the General Contractor identifying the specific activity that was terminated, the scheduled date, and a list of those in attendance, along with their reasonable time and travel expense costs.

3.5 HVAC SUBCONTRACTOR'S RESPONSIBILITIES

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- .1 The HVAC sub-contractor, and all the sub-contractors and suppliers within Division 23, shall cooperate with the commissioning consultant (CA), and other commissioning team members, to facilitate the successful completion of the commissioning process.
 - .2 The contractor shall assign a representative to the commissioning team, and submit the person's name to the commissioning agency, within one (1) month of the award of the contract. The representative shall have the authority to make decisions on behalf of the mechanical contractor as they relate to the organization and scheduling of HVAC commissioning. The representative shall ensure communications between Division 23 contractors and supplies and all other commissioning team members and shall foster the necessary cooperative action. One specific responsibility shall be to attend commissioning meetings and ensure action items arising from them are attended to as required to allow the commissioning process to proceed on schedule.
 - .3 The HVAC sub-contractor, and all mechanical sub-contractors and supplies, shall cooperate with the Commissioning Agency in carrying out the HVAC commissioning process. In this context, the HVAC sub-contractor shall:
 - .1 include in their quotes the cost of participating in the commissioning process as specified herein.
 - .2 Ensure the Division 25 sub-contractor performs HVAC commissioning responsibilities as listed in 3.7.
 - .3 Provide instruction and demonstrations for the Owner's designated operating staff, in conjunction with the commissioning agency and mechanical engineer, and with the participation of qualified technicians from major equipment suppliers and the controls contractor.
 - .4 Include requirements for submittal data. O&M data, and training information in each purchase order or sub-contract written.
 - .5 Ensure cooperation and participation of specialty sub-contractors such as sheet metal, piping, refrigeration, and water treatment as applicable.
 - .6 Ensure participation of major equipment manufacturing in appropriate start-up, testing and training activities.
 - .7 Attend commissioning meetings scheduled by the CA.
 - .8 Notify the CA a minimum of two weeks in advance of scheduled equipment and system start-ups, so that the CA may witness system verifications, and equipment and system start-ups.
 - .9 Provide sufficient personnel to assist the CA as required during system verification and functional performance testing.
 - .10 Prior to set-up, inspect, check and confirm the correct and complete installation of all equipment and systems for which system verification checklists are included in the commissioning plan. Document the results of all inspections and checks on the checklists and sign them. If deficient or incomplete work is discovered, ensure corrective action is taken and re-check until the results are satisfactory and the system is ready for safe start-up.
 - .11 Notify the CA a minimum of two weeks in advance, of the time for start of the TAB work. Attend the initial TAB meeting for review of the TAB procedures.
 - .12 Provide equipment and systems start-up resources as specified and

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- required. If during an attempted equipment or system start-up, deficient or incomplete work is discovered that would preclude safe operation, the start-up shall be aborted until corrective action has been taken. Ensure such action is taken and verified before re-scheduling a new start-up. Those responsible for deficient or incomplete work will be responsible for costs in accordance with 3.4 in this Section.
- .13 Carry-out performance checks to ensure that all equipment and systems fully functional and ready for the CA to witness formal functional performance tests (FPTs).
 - .14 Operate equipment and systems for FPTs in accordance with the commissioning plan and as directed by the commissioning agency. If improper functionality, incomplete work, or other deficiencies affecting system performance are discovered, the FPTs will be stopped by the CC. Those responsible for deficient or incomplete work will be responsible for costs in accordance with 3.4 in this Section. Ensure that all corrections necessary for full and complete system operation as specified are completed; then with the ATC contractor and other applicable sub-contractors, carry-out functional performance checks to confirm correct operation before applying to the CA to re-schedule the FPTs for the system in question.
 - .15 Prepare preliminary schedule for mechanical system orientation and inspections. O&M Manual submission, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up TAB, and task completion for use by the CA. Update schedule as appropriate throughout the construction period.
 - .16 Attend initial O&M staff training session.
 - .17 Conduct mechanical system orientation and inspection at the equipment placement completion stage.
 - .18 Update drawings to as-built condition and review with the CA.
 - .19 Gather O&M data on all equipment and assemble in binders as required by the commissioning specification. Submit to CA prior to the completion of construction.
 - .20 Participate in, and schedule vendors and contractors to participate in the O&M staff training sessions as set-up by the CA.
 - .21 Provide written notification to the general contractor (or construction manager) and CA that the following work has been completed in accordance with the contract documents and the equipment, systems and sub-systems are operating as required.
 - .1 HVAC equipment including all fans, air handling units, dehumidification units, ductwork, dampers, terminals, and all Division 23 equipment.
 - .2 Refrigeration equipment, pumping systems and heat rejection equipment.
 - .3 Fire-stopping in the fire-rated construction, including fire and smoke damper installation, caulking, gasketing and sealing of smoke barriers.
 - .4 Seismic restraints installed to specification; a certification from the seismic restraint engineer meets this requirement.
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- .5 Dedicated smoke control systems including stairway pressurization and atrium systems.
- .6 Non-dedicated systems using the air-handling units for smoke control.
- .7 Fire detection and smoke detection devices furnished under other divisions of this specification as they affect the operation of the smoke control systems.
- .8 That the building control system is functioning to control HVAC equipment and smoke control systems as specified.
- .22 Provide a complete set of as-built drawings and O&M manuals to the CA.

3.6 TAB AGENCY'S RESPONSIBILITIES

- .1 With respect to HVAC commissioning, the TAB agency shall:
 - .1 Include costs for HVAC commissioning requirements in the quoted price.
 - .2 Attend commissioning meetings scheduled by the CA prior to , and during, on-site TAB work being done.
 - .3 Submit proposed TAB procedures to the CA and mechanical engineer for review and acceptance.
 - .4 Attend the TAB planning meeting scheduled by the CA. Be prepared to discuss the procedures that shall be followed in testing, adjusting and balancing the HVAC system.
 - .5 At the completion of the TAB work, submit the final TAB report to the mechanical contractor, submittal will be to the mechanical contractor, with general contractor, CA, and mechanical engineer notified
 - .6 Participate in verification of the TAB report by the CA for verification or diagnostic purposes. This will consist of repeating a sample (normally 10% to 20%) of the measurements contained in the TAB report as directed by the CA.
 - .7 Participate in O&M personnel training sessions as scheduled by the CA.

3.7 CONTROLS SUBCONTRACTOR'S RESPONSIBILITIES

- .1 With respect to HVAC commissioning, the controls contractor shall:
 - .1 Include cost for commissioning requirements in the quoted price.
 - .2 Review design for controllability with respect to equipment selected for the project;
 - .1 Review and confirm in writing that a proper hardware specification exists to permit functional performance testing as required by specification and sequence of operation.
 - .2 Review and confirm in writing that proper safeties and interlocks are included in design.
 - .3 Ensure the proper sizing of control valves and actuators, based on design pressure drops. Ensure that control valve authority will result in capacity control as specified. Include valve sizing and authority information in submittal to mechanical engineer.
 - .4 Ensure the proper sizing of control dampers. Ensure damper authority to control air flows as specified. Review and confirm in

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- writing proper damper positioning for mixing to prevent stratification. Ensure correct actuator vs. damper movement for smooth operation. Include damper sizing, control authority and actuator selection data in submittal to mechanical engineer.
 - .5 Ensure the proper selection of sensor ranges and include data with submittal to mechanical engineer.
 - .6 Clarify all questions concerning sequences of operation with the mechanical engineer.
 - .3 Attend commissioning meetings scheduled by the CC.
 - .4 Provide the following submittals to the CC for review:
 - .1 Hardware and software submittals.
 - .2 Control panel construction shop drawings.
 - .3 Diagrams showing all control points, sensor locations, point names, actuators, controllers and where necessary, points of access, all superimposed on diagrams of the physical equipment.
 - .4 Narrative description of all control sequences for each piece of equipment controlled.
 - .5 Logic diagrams showing the logic flow of all control sequences.
 - .6 A list of all control points, including analog inputs, analog outputs, digital inputs and digital outputs. Include the values of all parameters for each system point. Provide a separate list for each stand-alone control unit.
 - .7 A complete control language program listing including all software routines employed in operating the control system. Also, provide a program write-up, organized in the same manner as the control software. This narrative shall describe the logic flow of the software and the functions of each routine and sub-routine. It should also explain individual math or logic operations that are not clear from reading the software listing.
 - .8 Hardware operation and maintenance manuals.
 - .9 Application software and project applications code manuals.
 - .5 Inspect, check, and confirm the proper installation and performance of controls/BAS hardware and software provided by others.
 - .6 Integrate installation and programming scheduling with construction and commissioning schedules.
 - .7 Inspect, check and confirm the correct installation and operation of input and output field points and devices through documented and signed off point-to-point checkouts.
 - .8 Provide thorough training to operating personnel on hardware operations and programming, and the application program for the system, in accordance with the O&M staff training program in the commissioning plan.
 - .9 In conjunction with the mechanical contractor, demonstrate system performance to the CC including all modes of system operation (e.g. occupied, unoccupied, emergency) during the functional performance tests (FTP). If improper functionality, incomplete work, or other deficiencies affecting system performance are discovered, the FTPs will be stopped by the CC. Those responsible for deficient or incomplete
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- work will be responsible for costs in accordance with 3.2 in this Section.
 - .10 Provide control system technician to assist during system verification and functional performance testing.
 - .11 Provide support and coordination with TAB contractor on all interfaces between controls and TAB scopes of work. Provide, at no additional cost to the TAB and commissioning agencies, all devices, such as portable operator's terminals and all software for the TAB agency to use in completing TAB procedures.

3.8 ELECTRICAL SUBCONTRACTOR'S RESPONSIBILITIES

- .1 With respect to HVAC commissioning, the electrical contractor shall:
 - .1 Include cost for HVAC commissioning requirements in the quoted price.
 - .2 Review design with respect to providing power to the HVAC equipment:
 - .1 Verify that proper hardware specifications exist for functional performance and sequence of operation required by specification.
 - .2 Verify that proper safeties and interlocks are included in the design of electrical connections for HVAC equipment.
 - .3 Attend commissioning meetings scheduled by the CC.
 - .4 Schedule work so that required electrical installations are completed, and systems verification checks and functional performance tests can be carried out on schedule.
 - .5 Inspect, check and confirm in writing the proper installation and performance of all electrical services provided.
 - .6 Provide electrical system technicians to assist during system verification and functional performance testing as required by the CC.

END OF SECTION

1 GENERAL

1.1 REFERENCES

.1 The General Conditions of the Contract, the Supplementary Conditions, and all Sections of Division 01 apply to and are a part of this Section of the Specification.

1.2 APPLICATION

.1 This Section specifies requirements that are common to electrical work Sections of the Specification, and it is a supplement to each Section and is to be read accordingly.

1.3 DEFINITIONS

.1 The following are definitions of words found in electrical work Sections of the Specification and on associated drawings:

- .1 "concealed" – means work hidden from normal sight in furred spaces, shafts, tunnels, ceiling spaces, underground, walls and partitions
- .2 "exposed" – means work normally visible, including work in equipment rooms and similar spaces
- .3 "provide" (and tenses of provide) – means supply and install complete.
- .4 "install" (and tenses of install) – means install and connect complete
- .5 "supply" – means supply only
- .6 "finished area" - means any area or part of an area which receives a finish such as paint, or is factory finished
- .7 "governing authority" and/or "regulatory authority" and/or "Municipal authority" – means all government departments, agencies, standards, rules and regulations that apply to and govern the electrical work and to which the work must adhere
- .8 "Consultant" – means the Architect or Consulting Engineer who has prepared the Contract Documents on behalf of the Owner
- .9 "O&M" – means Operating and Maintenance

.2 Wherever the words "indicated", "shown", "noted", "listed", or similar words or phrases are used in the specification they are understood, unless otherwise defined, to mean that the product referred to is "indicated", "shown", "listed", or "noted" on the drawings.

.3 Wherever the words "approved", "satisfactory", "as directed", "submit", "permitted", "inspected" or similar words or phrases are used in the specification or on the drawings they are understood, unless otherwise defined, to mean that work or product referred to is "approved by", "inspected by", etc., the Consultant.

.4 In the electrical specification, singular may be read as plural, and vice-versa.

.5 "Owner": means Building Owner as defined in the Contract or the Owner's designated representative.

.6 "Wet": means wet areas requiring special materials. Where indicated on drawings and/or specified herein. Includes but not limited to pools, whirlpools, showers, etc.

1.4 METRIC AND IMPERIAL MEASUREMENTS

.1 Both Metric and Imperial units of measurement are indicated in the electrical

Specification.

1.5 EXAMINATION OF SITE AND DOCUMENTS

.1 When estimating the cost of the work and prior to submitting a bid for the work, carefully examine all of the bid documents and visit the site to determine and review all existing site conditions that will or may affect the work, and include for all such conditions in the bid price.

.2 Report to the Consultant, prior to bid submittal, any existing site condition that will or may affect performance of the work as per the drawings and specifications. Failure to do so will not be grounds for additional costs.

1.6 DRAWINGS AND SPECIFICATION

.1 Review the electrical work drawings in conjunction with all other structural, architectural, sprinkler, mechanical, etc., drawings and, where applicable, the Code Consultant's report.

.2 The electrical drawings are performance drawings, diagrammatic, and show approximate locations of equipment and connecting services. Any information regarding accurate measurement of the building are to be taken at the site. Do not scale the drawings, and do not use the drawings for prefabrication work.

.3 The drawings are intended to convey the scope of work and do not show architectural and structural details. Provide, at no extra cost to this Contract, all offsets, fittings, transformations, and similar products required as a result of obstructions and other architectural and structural details but not shown on the drawings.

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

.5 Sections of the electrical specification are not intended to delegate functions nor to delegate work and supply of materials to any specific trade, but rather to generally designate a basic unit of work, and the Sections are to be read as a whole.

.6 The electrical specification does not generally indicate the specific number of items or extent of material required. The specification is intended to provide product data and installation requirements. It is necessary to refer to drawing schedules, layouts, schematic diagrams, riser diagrams, and details to determine correct quantities.

.7 The electrical drawings and specification are intended to be cooperative. Perform all work that is shown, specified, or reasonably implied on the drawings but not mentioned in the specification, or vice-versa, as though fully covered by both.

.8 In the case of discrepancies or conflicts between the drawings and specification, the documents will govern in the following order:

- .1 The specification
- .2 Drawings of larger scale
- .3 Drawings of smaller scale
- .4 Drawings of later date when the scale of the drawings is the same.

.9 When the scale and date of the drawings are the same, or when the discrepancy exists within the specification, the most costly arrangement will take precedence.

.10 In the case of discrepancies between the drawings and specifications, the documents will govern in the order specified in the General Conditions, however, when the scale and date of the drawings are the same, or where the discrepancy exists within the specification, the most costly arrangement will take precedence.

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

1.7 PLANNING AND LAYOUT OF THE WORK, AND ASSOCIATED DRAWINGS

.1 Properly plan, coordinate, and establish the locations and routing of services with all subcontractors affected prior to installation such that the services will clear each other as well as any obstructions. Unless otherwise specified, the order of right-of-way for services is to be as follows:

- .1 piping requiring uniform pitch
- .2 piping 100 mm (4") dia. and larger
- .3 large air ducts (main runs)
- .4 electrical cable tray and bus duct
- .5 conduit 100 mm (4") dia. and larger
- .6 piping less than 100 mm (4") dia.
- .7 smaller branch ductwork
- .8 conduit less than 100 mm (4") dia.

.2 Unless otherwise shown or specified, conceal all work in finished areas, and conceal work in partially finished or unfinished areas to the extent made possible by the area construction. Install conduit, cable tray, and similar services as high as possible to conserve headroom and/or ceiling space. Notify the Consultant where headroom or ceiling space appears to be inadequate prior to installation of the work.

.3 Revise or alter the arrangement of work that has been installed without proper coordination, study and review, even if it was completed in accordance with the Contract Documents, in order to conceal the work behind finishes, or to allow the installation of other work, at no additional cost. In addition, pay for the cost of alterations in other work required by the alterations to the electrical work.

.4 All outlet boxes, junction boxes, pullboxes, equipment and similar products, particularly such products located above suspended ceilings, must be located for easy access for servicing and/or removal. Products which do not meet this location requirement are to be relocated to an accessible location at no additional cost.

.5 Layout Drawings: Do not use the Contract Drawing measurements for prefabrication and layout of work. Locations and routing are to generally be in accordance with the Contract Drawings, however, layout drawings are to be prepared for all such work. Use established bench marks for both horizontal and vertical measurements. Coordinate with and make allowances for the work of other trades, accurately layout the work, and be entirely responsible for all work installed in accordance with layout drawings.

.6 Interference Drawings: Prepare dimensioned working interference drawings, supplementary to the Contract Drawings for all areas where multiple services and/or equipment occur, or where the work due to architectural and structural considerations requires special study and treatment. Review interference drawings with the Consultant before the work is installed. Where this Contractor's work has been installed in such areas without preparation of interference drawings and conflicts occur, revise this work to suit at no additional cost.

1.8 COORDINATION OF THE WORK

.1 Review all the Contract Documents and coordinate the work with the work of all subcontractors. Coordination requirements are to include, but not be limited to, the following:

- .1 written notification of all concrete work such as housekeeping pads, bases, etc., required for electrical work, and including required dimensions, operating weight of equipment, location, etc.
- .2 depth and routing of excavation required for electrical work, and requirements for bedding and backfill

1.9 PHASING OF THE WORK

.1 Phasing of the work is required to maintain the existing building in operation, all as specified in Division 01. Include all costs for phasing the work including all required "off hours" premium time labour costs.

1.10 QUALITY ASSURANCE

- .1 All electrical work is to be done by journeyman tradesmen who perform only the work that their certificates permit, or by apprentice tradesmen under direct on site supervision of an experienced journeyman tradesman. The use of apprentice tradesmen is to be limited and the journeyman/apprentice ratio is subject to the Consultant's approval.
- .2 All journeyman tradesmen are to have valid trade certificates available at the site for review by the Consultant at any time.
- .3 An experienced and qualified superintendent is to be on-site at all times when electrical work is being performed.

1.11 EQUIPMENT AND MATERIALS

- .1 Unless otherwise specified, all equipment and materials are to be new.
- .2 All equipment is to be installed in accordance with the manufacturer's published instructions, unless specified otherwise in the specification or on the drawings.
- .3 Where price, quality, and local service facilities are equivalent, preference will be given to products produced in the locality of the work or by producers located in the locality of the work. The decision as to the equality of products rests solely with the Owner.

1.12 EQUIPMENT AND MATERIAL MANUFACTURERS

- .1 Equipment and materials selected, scheduled or specified on the drawings or in the specification have been selected to establish a performance and quality standard, and, in some cases, a dimensional standard for the Project. In most cases acceptable manufacturers are listed for any product specified by manufacturer's name and model number. Bid Prices shall include only products specified or approved equivalents. Contractors may propose unsolicited alternatives to the products specified. Alternative proposals shall be submitted in sealed envelope at time of General Contract Bid submission and shall include full description and technical data, and a statement of the related increase or decrease in Bid Price should alternatives be accepted. All additional costs associated with unsolicited alternative proposals such as larger motor starters, larger power feeders, space revisions to associated equipment, controls, etc. shall be included in the alternative proposals. Prior approval by consultant is not required for unsolicited alternative proposals.
- .2 Where Contractor uses equipment other than that first named, on which the design is based, he shall be responsible for all details of installation including equipment size, arrangement, fit, and maintenance of all required clearances. Contractor shall prepare and

submit revised layouts to indicate arrangement of all affected piping, ductwork, conduit, lighting, equipment, etc. Failure by Contractor to provide such drawings will be considered indication that original arrangements and space allocations are adequate. All additional costs associated with equivalent equipment such as larger motor starters, larger power feeders, space revisions to associated equipment, controls, etc. shall be included in Bid Price.

.3 If products supplied by a manufacturer named as acceptable are used in lieu of the products specified by first named manufacturer's name and model number, ensure that the product is equivalent in performance and operating characteristics (including energy efficiency if applicable) to the specified product. Pay for any additional costs and changes to associated or adjacent work resulting from the use of products supplied by a manufacturer other than the first named specified manufacturer. In addition, in equipment spaces where products named as acceptable are used in lieu of the specified products and the dimensions of such products differ from the specified products, prepare and submit for review, accurately dimensioned layouts of the rooms affected to prove that all the equipment in the room will fit properly.

.4 Do not supply products of different types that have been "bulked" by a supplier who has quoted a lump sum price for the "bulked" products.

.5 The Consultant will review and evaluate unsolicited alternatives and substitutions proposed by the Contractor. Such review and evaluation work will be undertaken by the Consultant on an additional fee basis. The Contractor shall reimburse the Owner for all costs associated with such reviews and evaluations. The Contractor shall also reimburse the Owner for any and all costs incurred in updating Contract Documents to reflect such changes.

1.13 SUBSTITUTED OR ALTERNATIVE PRODUCTS

.1 Products supplied by a manufacturer/supplier other than a manufacturer listed as acceptable may be considered for acceptance by the Consultant if requested in writing a minimum of ten (10) full working days prior to the bid closing date. Requests may be made by letter, by fax, or by email. Telephone requests will not be considered.

.2 Each request for acceptance of a proposed substitution or alternative product must be accompanied by detailed catalogue and engineering data, fabrication information, and performance characteristics to permit the Consultant to make an informed decision.

.3 Pay for any additional costs and changes to associated or adjacent work resulting from the use of products supplied by a substituted or alternative or other than first named manufacturer. In addition, in equipment spaces where substituted or alternative or other than first named products are used in lieu of the specified first named products and the dimensions of such products differ from the specified first named products, prepare and submit for review, accurately dimensioned layouts of the rooms affected to prove that all the equipment in the room will fit properly.

.4 The Consultant's decision regarding any proposed substitution or alternative product is final.

1.14 CODES, REGULATIONS, AND STANDARDS

.1 All Codes, Regulations, and Standards referred to in this Section are the latest edition of the Codes, Regulations, and Standards in effect at the time of tendering this Project.

.2 All work is to be in accordance with requirements with Codes, Regulations, and Standards applied by governing authorities.

.3 Where any governing Code, Regulation, or Standard requires preparation and submission of special details or drawings for review they are to be prepared and submitted. Pay

all associated costs associated with these submittals.

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

.5 Requirements of the Contract Documents are to take precedence when they are more stringent than codes, ordinances, standards, and statutes.

1.15 PERMITS, FEES, AND CERTIFICATES

.1 Apply for, obtain and pay for all permits required to complete the electrical work.

.2 Submit to the Consultant, all approval/inspection certificates issued by governing authorities to confirm that the work as installed is in accordance with the rules and regulations of the governing authorities. Pay any costs associated with issue of the certificates.

.3 Include a copy of all approval/inspection certificates in each operating and maintenance manual.

1.16 WORKPLACE SAFETY

.1 Comply with requirements of the Workplace Hazardous Materials Information System (WHMIS) regarding the use, handling, storage and disposal of hazardous materials. Submit WHMIS MSDS (Material Safety Data Sheets) for all products where required, and maintain one copy at the site in a visible and accessible location available to all personnel.

.2 Comply with all requirements of Occupational Health and Safety Regulations and all other regulations pertaining to health and safety, including worker's compensation/ insurance board and fall protection regulations.

1.17 SHOP DRAWINGS AND PRODUCT DATA SHEETS

.1 Prior to supplying any products to the site, submit for review, shop drawings and/or product data sheets indicating in detail the design, construction, and performance of products as requested in Sections of this Specification. The number of copies of shop drawings and/or product data sheets will be as later directed.

.2 Wherever possible, shop drawings and/or product data sheets are to be 216 mm x 280 mm (8½" x 11"), 216 mm x 356 mm (8½" x 14"), or 356 mm x 432 mm (11" x 17") single side white bond paper with sufficient clear space for review stamps and comments.

.3 Each shop drawing or product data sheet is to be properly identified with the project name and the product drawing or specification reference, i.e. "Panelboard A", and all shop drawing or product data sheet dimensions are to be either SI or Imperial to match dimensions on the drawings.

.4 Where any item of equipment is required by Code or Standard or By-Law to meet a specific energy efficiency level, or any other specific requirement, ensure that this requirement is clearly indicated on the submission.

.5 Carefully review each shop drawing and product data sheet prior to submittal to ensure that the proposed product is correct, as per the Electrical Supplementary Bid Form as applicable, and meets with all requirements of the Project. Endorse each copy of each shop drawing or product data sheet "CERTIFIED TO BE IN ACCORDANCE WITH ALL REQUIREMENTS" and include the company name, the submittal date, and the signature of an officer of the company to indicate your review and approval as above.

.6 The Consultant will review shop drawings and product data sheets and will indicate the

review status by stamping the shop drawings and product data sheets as follows:

- .1 "Reviewed" or "Reviewed As Modified" to indicate that his review is final and no re-submittal is required
- .2 "Revise and Resubmit" to indicate that the submission is rejected and is to be revised in accordance with comments marked on the shop drawings and product data sheets by the Consultant and re-submitted
- .7 The Consultant will retain one or two copies of each shop drawing or product data sheet submission.
- .8 The following is to be read in conjunction with the wording on the Consultant's review stamp applied to each and every electrical work shop drawing or product data sheet submitted:
 - .1 "This review is for the sole purpose of ascertaining conformance with the general design concept. This review does not approve the detail design inherent in the shop drawings, responsibility for which remains with the Contractor, and such review does not relieve the Contractor of the responsibility for errors or omissions in the shop drawings or of his responsibility for meeting all requirements of the Contract Documents. The Contractor is responsible for dimensions to be confirmed and correlated at the job site, for information that pertains solely to fabrication processes or to techniques of construction and installation, and for coordination of the work of all sub-trades."
- .9 Submit preliminary short circuit study with distribution equipment shop drawings in sufficient detail to include and provide ratings for all components and wiring and be in conformance with Section 26 05 73.
- .10 Provide final commissioning report with record drawings.
- .11 Provide draft copy of all manuals 100 days prior to expected date of completion of work for review by Owner.
- .12 Prepare copies of all schematics for training purposes and submit to Owner for review 30 days prior to demonstration and training purposes.

1.18 CHANGES OR REVISIONS TO THE WORK

- .1 Whenever the Consultant proposes in writing to make a change or revision to the design, arrangement, quantity or type of any work from that required by the Contract Documents, prepare and submit to the Consultant for approval, a quotation being your proposed cost for executing the change or revision.
- .2 The Contractor's quotation is to be a detailed and itemized estimate of all product, labour, and equipment costs associated with the change or revision, plus overhead and profit percentages and all applicable taxes and duties.
- .3 The following requirements apply to all quotations submitted:
 - .1 when the change or revision involves deleted work as well as additional work, the cost of the deleted work (less overhead and profit percentages but including taxes and duties) is to be subtracted from the cost of the additional work before overhead and profit percentages are applied to the additional work
 - .2 material costs are not to exceed those published in local estimating price guides
 - .3 costs for journeyman and apprentice labour must not exceed prevailing rates at the time of execution of the Contract and listed in the

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- Supplementary Bid Form and must reflect the actual personnel performing the work
 - .4 the cost for the site superintendent must not exceed 10% of the total hours of labour estimated for the change or revision, and the change or revision must be such that the site superintendent's involvement is necessary
 - .5 costs for rental tools and/or equipment are not to exceed local rental costs
 - .6 Refer to the General Conditions of the Contract, the Supplementary Conditions and all Sections of Division 01 for allowable percentages for overhead and profit.
 - .7 the overhead percentage will be deemed to cover all quotation costs other than actual site labour and materials, and rentals
 - .8 all quotations, including those for deleted work, must include a figure for any required change to the Contract time
- .4 Quotations submitted that are not in accordance with requirements specified above will be rejected and returned for re-submittal. Failure to submit a proper quotation to enable the Consultant to expeditiously process the quotation and issue a Change Order will not be grounds for any additional change to Contract time.
- .5 If, in the Contractor's opinion, changes or revisions to the work should be made, inform the Consultant in writing and, if the Consultant agrees a Notice of Change will be issued.
- .6 Do not execute any change or revision until written authorization for the change or revision has been obtained.

1.19 NOTICE FOR REQUIRED FIELD REVIEWS

- .1 Whenever there is a requirement for the Consultant to perform a field review prior to concealment of any work, to inspect/re-inspect the work for deficiencies prior to Substantial Performance, for commissioning demonstrations, and any other such field review, give the Consultant adequate notice in writing.
- .2 If the Consultant is unable to attend a field review when requested, arrange an alternative date and time.
- .3 Do not conceal work until the Consultant advises that it may be concealed.
- .4 When the Consultant is requested to perform a field review and the work is not ready to be reviewed, reimburse the Consultant for all time and travel expenses.

1.20 SCAFFOLDING, RIGGING, AND HOISTING

- .1 Unless otherwise specified or directed, supply, erect and operate all scaffolding, rigging, hoisting equipment and associated hardware required for the work of this Division. Immediately remove from the site all scaffolding, rigging, and hoisting equipment when no longer required.
- .2 Do not place major erection loads on any portion of the structure without approval from the Consultant.

1.21 TRIAL USAGE

- .1 When directed by the Consultant, promptly arrange, pay for, and perform site tests on any piece of equipment or any system for such reasonable lengths of time and at such times as may be required to prove compliance with the Specification and governing Codes and

Regulations, prior to Substantial Performance of the work.

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

.3 All tests are not to be construed as evidence of acceptance of the work, and it is agreed and understood that no claim for damage will be made for injury or breakage to any part or parts of the equipment or system due to the test where such injuries or breakage were caused by faulty parts and/or workmanship of any kind.

.4 When, in the Consultant's opinion, tests indicate that equipment, products, etc., are defective or deficient, immediately remove such equipment and/or products from the site and replace them with acceptable equipment and/or products, at no additional cost.

1.22 PROJECT CLOSEOUT SUBMITTALS

.1 Prior to application for Substantial Performance of the Project, submit all required documentation specified, including the following:

- .1 Operating and Maintenance Manuals
- .2 as-built record drawings and associated data
- .3 extended warranties for equipment as specified
- .4 identified keys for mechanical equipment and/or panels for which keys are required
- .5 other data or products specified

1.23 OPERATING AND MAINTENANCE MANUALS

.1 Submit, prior to application for Substantial Performance, 3 hard copies of operating and maintenance manuals consolidated in black hardcover 3 "D" ring binders, each binder sized to include approximately 25% spare space for future data, and identified permanently on binder spine with the Project name, "ELECTRICAL OPERATING AND MAINTENANCE MANUAL" wording, and the date. Manuals are to include the following:

- .1 an Introduction sheet listing the Consultant's, Contractor's, and Subcontractor names, street addresses, telephone and fax numbers, and e-mail addresses. Include special telephone numbers for service departments on normal and emergency call basis.
- .2 a Table of Contents sheet, and corresponding index tab sheets. Use plastic tab indices for all sections of the manual with separate sections for each different type of equipment item.
- .3 a copy of each "Reviewed" or "Reviewed As Modified" shop drawing or product data sheet, with manufacturer's/supplier's name, telephone and fax numbers, email address, and the email address for local source of parts and service
- .4 operating data, which is to include:
 - .1 Description of each system and its controls
 - .2 System schematic wiring diagrams; mark correct operating settings for each device on these diagrams
 - .3 Operation instruction for each system and each component
 - .4 Description of actions to be taken in event of equipment failure; step by step procedure to follow in putting each piece of equipment into service.
 - .5 Drawings of each control panel completely identifying all

- components on the panels and their functions.
- .6 Include Owner's equipment numbers on all equipment submitted.
- .7 Diagram of the electrical system indicating the wiring of all related electrical components such as fuses, interlocks, electrical switches and relays
- .5 Maintenance data, which is to include:
 - .1 manufacturer's maintenance instructions, servicing maintenance, operation and trouble-shooting instructions for each item of equipment; list parts numbers and lists, name of supplier and maintenance and lubrication instructions
 - .2 schedules of tasks, frequency, tools required, and task time
 - .3 complete parts lists with numbers
 - .4 balancing and testing reports
 - .5 where fuses with maximum let-through current are indicated, provide manufacturer's fuse curve data in Operating and Maintenance Manuals showing fuse coordination with system interrupting capacity at that location in the system
- .6 performance data, which is to include:
 - .1 equipment and system start-up data sheets
 - .2 equipment performance verification test results, and commissioning report
- .2 Submit, prior to application for Substantial Performance, four digital versions of the hard copy manual using the latest version of Adobe Acrobat Portable Document Format and enhanced with bookmarks, internet links, and internal document links. The digital copies are to be copied to CDR with custom labels which indicate the project name, date, the Consultant's name, and "Operating & Maintenance Manual for Electrical Systems". Provide one additional digital version copy for Consultant's use.

1.24 RECORD "AS-BUILT" DRAWINGS

- .1 Obtain PDF's from the Consultant for the production of record "AS-BUILT" drawings and pay for costs of reproduction and transmission costs. As work progresses at the site, clearly mark in red in a neat and legible manner on a set of white prints of the drawings, all significant changes and deviations from the routing of services and locations of equipment shown on the Contract Drawings and resulting from the issue of Addenda, Site Instructions, Change Orders, and job conditions. Use notes marked in red as required. Maintain the white print red line as-built set at the site for the exclusive use of recording as-built conditions, keep the set up-to-date at all times, and ensure that the set is always available for periodic review. The as-built set is also to include the following:
 - .1 the location of all work such as junction boxes and pullboxes concealed in inaccessible locations
 - .2 the locations of control devices with identification for each
 - .3 for underground work, record dimensions, invert elevations, all offsets, fittings, and locate dimensions from benchmarks that will be preserved after construction is complete
 - .4 the location of all concealed services terminated for future extension
- .2 When work on site is complete, transfer all the as-built red line information from the site as-built drawings to a recordable and identified CAD disc with CAD work of equal quality to the

Contract Drawings. Obtain a CAD disc as described below.

.3 The electrical drawings have been prepared on a computer aided drafting system. Obtain and pay for an electronic version of the drawings from the Consultant for use in producing final as-built drawings.

.4 Prior to inspection for Total Performance of the work, submit for review, the red line site as-built white prints, a CAD disc of the as-built drawings, and a bound set of white prints (of equal quality to the Contract Drawings) made from the disc. The Consultant will review the drawings and, if necessary, return the disc and the marked-up white prints for corrections or further revisions, in which case complete the corrective and/or revision work and resubmit the disc and white prints until they are determined to be acceptable.

1.25 PROGRESS PAYMENT BREAKDOWN

.1 Within 15 working days of written notification of award of contract submit a breakdown of the cost of the electrical work to assist the Consultant in reviewing and approving monthly progress payment claims.

.2 The payment breakdown is subject to the Consultant's approval and progress payments will not be processed until an approved breakdown is in place. The breakdown is to include one time claim items such as mobilization and demobilization, insurance, bonds (if applicable), shop drawings and product data sheets, commissioning including testing, and project closeout submittals.

1.26 REQUIREMENTS FOR CONTRACTOR RETAINED ENGINEERS

.1 All professional engineers retained by this Contractor to perform consulting services with regard to his work are to be members in good standing with the local Association of Professional Engineers, and are to carry and pay for errors and omissions professional liability insurance in compliance with requirements of the governing authorities in the locale of the work.

.2 This Contractor's retained engineer's professional liability insurance is to protect his Consultants and Sub-Consultants, and their respective servants, agents, and employees against any loss of damage resulting from the professional services rendered by his Consultants, Sub-Consultants, and their respective servants, agents, and employees in regards to the work of this Contract.

.3 Liability insurance requirements are as follows:

- .1 coverage is to be a minimum of \$1,000,000.00 inclusive of any one occurrence, or as indicated in the Division 0.
- .2 the insurance policy is not to be cancelled or changed in any way without the insurer giving the Owner a minimum of thirty days written notice
- .3 liability insurance is to be obtained from an insurer registered and licensed to underwrite such insurance in the location of the work
- .4 evidence of the required liability insurance in such forms as may be required is to be issued to the Owner, the Owner's Consultant, and Municipal Authorities as required prior to commencement of your Consultant's services

1.27 GENERAL RE: INSTALLATION OF EQUIPMENT

.1 Unless otherwise specified all equipment is to be installed in accordance with the equipment manufacturer's recommendations and instructions, and requirements of governing

Codes, Standards, and Regulations.

.2 Ensure that proper access and code required service clearances are maintained around equipment, and, where applicable, access space for future equipment removal or replacement is not impeded.

1.28 EXTENDED WARRANTIES

.1 All extended warranties specified in electrical work Sections of the Specification are to be full parts and labour warranties, at the site, and in accordance with requirements of the Contract warranty, but direct from the equipment manufacturer/supplier to the Owner. Submit signed and dated copies of extended warranties which clearly state requirements specified above.

1.29 CONTRACTOR'S MATERIAL AND TEST CERTIFICATES

.1 Submit Contractor's Material and Test Certificates for each system installed. Certificates shall include:

- .1 description of the system (designation and type),
 - .2 description of the tests conducted and results observed, including re-testing where necessary,
 - .3 description of any corrective measures undertaken,
 - .4 description of materials used,
 - .5 list of witnesses for each test conducted,
 - .6 date system left ready for service,
 - .7 signature of installing Contractor.
- .2 Where certificates are prescribed by regulations, codes or standards, they shall conform to the requirements of those documents (eg. NFPA Standards, Electrical Safety Authority (ESA) Standards). A copy of each certificate shall be included in the Operating and Maintenance manuals.

1.30 PRODUCT DELIVERY, HANDLING AND STORAGE

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

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

1.31 WARRANTY

.1 Refer to General Conditions.

.2 Arrange with each manufacturer/supplier to extend warranties as necessary to coincide with warranty period or those periods specified.

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

.4 Submit to Consultant, prior to Substantial Performance of the Contract, manufacturer's written warranties covering periods longer than one year or offering greater benefits than required in specifications and in the Owner's name.

1.32 PROTECTION

- .1 Protect finished and unfinished work by tarpaulins, or other covering, from damage due to execution of work under this Division.
- .2 Repair to satisfaction of Consultant, damage to building resulting from failure to provide such protection.

1.33 EQUIPMENT AND SYSTEM MANUFACTURER'S CERTIFICATION

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

1.34 EQUIPMENT AND SYSTEM START-UP

- .1 When installation of equipment/systems is complete but prior to commissioning, perform start-up for equipment/systems as specified in electrical work Sections in accordance with the following requirements:
- .2 Under direct on-site supervision and involvement of the equipment/system manufacturer's representative, start-up the equipment/systems, make any required adjustments, document the procedures, leave the equipment/systems in proper operating condition, and submit a complete set of start-up documentation sheets signed by the manufacturer/supplier and the Contractor.

1.35 EQUIPMENT AND SYSTEM COMMISSIONING

- .1 After successful start-up and prior to Substantial Performance, commission the electrical work. Commissioning work is the process of the Contractor demonstrating to the Owner and Consultant, for the purpose of final acceptance by means of successful and documented functional performance testing, that all systems and/or subsystems are capable of being operating and maintained to perform in accordance with requirements of the Contract Document, as further described below.

- .1 Operational Performance Testing: The Contractor is to test, adjust and operate components, equipment, systems and /or subsystems after start-up but before functional performance testing, to confirm that all components, equipment, systems and/or subsystems operate in accordance with requirements of the Contract Documents, including all modes and sequences of control and monitoring, interlocks ,and responses to emergency conditions. The Contractor is to complete commissioning data sheets to document successful operational performance testing.
- .2 Functional Performance Testing: The Contractor is to repeat successful operational performance testing with complete commissioning data sheet documentation by the Contractor in the presence of the Consultant and Owner to validate and verify that the equipment, systems and subsystems are complete in all respects, function correctly, and are ready for acceptance.
- .3 Submittals: The Contractor is to submit final commissioning data sheets, and other required submittals. NOTE: Ref: paragraph .3. Use

only if a Commissioning Agent is required and commissioning is specified in section 16095 – 26 03 20.

.2 Commissioning and the use of an independent Commissioning Agent is specified in the electrical work Section entitled Electrical Work Commissioning. Carefully read the Electrical Work Commissioning Section and include for all specified requirements.

1.36 EQUIPMENT AND SYSTEM O & M DEMONSTRATION AND TRAINING

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

.2 Train the Owner's designated personnel in all aspects of operation and maintenance of equipment and systems as specified in electrical work Sections of the Specification. All demonstrations and training is to be performed by qualified technicians employed by the equipment/system manufacturer/supplier.

.3 For each item of equipment and for each system for which training is specified, prepare training modules as specified below. Operating and Maintenance Manuals are to be used during the training sessions, and training modules are to include:

- .1 Operational Requirements and Criteria: Requirements and criteria are to include but not be limited to equipment function, stopping and starting, safeties, operating standards, operating characteristics, and limitations.
- .2 Troubleshooting: Troubleshooting is to include but not be limited to diagnostic instructions, test and inspection procedures.
- .3 Documentation: Documentation is to include but not be limited to equipment/system warranties, and manufacturer's supplier's parts and service facilities, telephone numbers, email addresses, and the like.
- .4 Maintenance: Maintenance requirements are to include but not be limited to inspection instructions, types of cleaning agents to be used as well as cleaning methods, preventative maintenance procedures, and use of any special tools.
- .5 Repairs: Repair requirements are to include but not be limited to diagnostic instructions, disassembly, component removal and repair instructions, instructions for identifying parts and components, and review of any spare parts inventory.

1.37 SPECIAL TOOLS AND SPARE PARTS

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

.2 Provide one set of special tools required to service equipment as recommended by manufacturers.

.3 Prepare a complete itemized list of special tools and spare parts and submit to consultant for review. List will be used as a checklist and should include provision for sign off by Owner on receipt.

2 EXECUTION

Not Applicable

END OF SECTION

1 GENERAL

1.1 APPLICATION

- .1 This Section specifies products, common criteria and characteristics, and methods and execution that are common to one or more electrical work Sections of the Specification, and it is intended as a supplement to each Section and is to be read accordingly.

1.2 SUBMITTALS

- .1 Submit the following for review:
 - .1 Product data sheets: submit for:
 - .1 Firestopping and smoke seal products
 - .2 Waterproofing seal assemblies
 - .3 Electrical work identification products
 - .2 Sleeve and formed opening location drawings: upon notification of award of Contract begin to prepare accurately dimensioned drawings to locate all required electrical work sleeves, formed openings, and recesses in poured concrete work, and submit the drawings prior to concrete work commencing. Provide a copy of approved sleeving drawings to the reinforcement detailer well in advance of planned pours.
 - .3 Access door locations: submit white prints of architectural reflected ceiling plan drawings and elevation drawings to indicate proposed access door locations in walls and ceilings in finished areas.
 - .4 Samples: submit a sample of each proposed type of access door, and samples of materials and any other items as specified in electrical work Sections of the Specification
 - .5 List of equipment nameplates: submit a list of equipment identification nameplates indicating proposed wording and sizes.
 - .6 Waste management and reduction plan: submit a waste management and reduction plan prior to commencing work and as per requirements specified in this Section
 - .7 Additional submittals: submit any other submittals specified in this Section or other electrical work Sections of the Specification

2 PRODUCTS

2.1 SLEEVES

- .1 Galvanized Sheet Steel: Minimum #16 Gauge galvanized steel with an integral flange at one end to secure the sleeve to formwork construction.
- .2 Polyethylene: Factory fabricated, flanged, high density polyethylene sleeves with reinforced nail bosses.
- .3 Galvanized Steel Pipe – Waterproof: Schedule 40 mild galvanized steel pipe with a welded-on square steel anchor and water stop plate at the sleeve midpoint.
- .4 Galvanized Steel or Cast-Iron Pipe: Schedule 40 mild galvanized steel pipe, or Class 4000 cast iron pipe, cut to length.

2.2 FIRESTOPPING AND SMOKE SEAL MATERIALS

- .1 Asbestos-free elastomeric materials tested, listed and labelled by ULC in accordance with CAN4-S115 and CAN/ULC-S01 for installation in ULC designated firestopping and smoke seal systems to provide a positive fire, water and smoke seal, and a fire-resistance rating (flame, hose stream and temperature) not less than the fire resistance rating of surrounding construction.
- .2 Materials are to be compatible with abutting dissimilar materials and finishes and complete with primers, damming and back-up materials, supports and anchoring devices in accordance with the firestopping manufacturer's recommendations and the ULC tested assembly.
- .3 Multi-Cable Transits: UL/ULC listed and labelled multi-cable transits sized to the fire barrier opening and to suit the number of cables/conduits involved, and to provide a minimum two-hour water-tight fire and smoke seal. Each assembly is to be complete with a stainless-steel frame, cadmium plated compression bolts, proper end packing, compression plates, steel stay plates, and fire rated neoprene insert blocks.

2.3 WATERPROOFING SEAL MATERIALS

- .1 Modular, mechanical seal assemblies consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the conduit, duct, etc., and the sleeve or wall opening, assembled with stainless steel bolts and pressure plates and designed so that when the bolts are tightened the links expand to seal the opening watertight. The seal assemblies are to be selected to suit the conduit, duct, etc., size and the sleeve size or wall opening size. Acceptable products are:
 - .1 Thunderline Corp. (Power Plant Supply Co.) "LINK SEAL" Model S
 - .2 The Metraflex Co. "MetraSeal" type ES

2.4 ESCUTCHEON PLATES

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

2.5 ACCESS DOORS

- .1 Prime coat painted steel (unless otherwise specified) flush access doors, each complete with a minimum #16-Gauge frame, minimum #18-gauge door panel, heavy-duty rust-resistant concealed hinges, a positive locking screwdriver lock, and mounting and finishing features to suit the particular construction in which it is to be installed.
- .2 Access door sizes are to suit the concealed work for which they are supplied, and wherever possible they are to be of a standard size for all applications, but in any case they are to be minimum 300 mm x 300 mm (12" x 12") for hand entry and 600 mm x 600 mm (24" x 24") for body entry.
- .3 Access doors in fire rated construction are to be ULC listed and labelled and of a

- rating to maintain the fire separation integrity.
- .4 Where access doors are located in surfaces where special finishes are required, they are to be of a recessed door type capable of accepting the finish in which they are to be installed so as to maintain the final building surface appearance throughout, and constructed of stainless steel with a #4 finish.

2.6 ELECTRICAL WORK IDENTIFICATION MATERIALS

- .1 Equipment Nameplates: Minimum 3 mm (1/8") thick 2-ply laminated, engraved, coloured plastic plates, minimum 12 mm x 50 mm (1/2" x 2") for smaller items such as single phase starters and disconnect switches, minimum 25 mm x 65 mm (1" x 2 1/2") for equipment, and minimum 50 mm x 100 mm (2" x 4") for panelboards and similar items. Additional requirements are as follows:
- .1 Unless otherwise specified or required, nameplates are to be white with black wording, except for emergency power system equipment nameplates which are to be red with white wording.
- .2 Each nameplate is to be complete with bevelled edges and wording is to be as large as possible and completely identify the equipment and its use with no abbreviations.
- .3 Wording is generally to be as per the drawings, i.e. LIGHTING PANEL A, and is to include the building area/zone served, but must be reviewed and approved by the Consultant prior to engraving
- .4 Supply stainless steel self-tapping screws for securing nameplates in place.
- .5 Nameplates for equipment suspended above floor level or generally not within easy viewing from floor level are to be increased in size so as to be easily readable from floor level.
- .2 Self-Adhesive Labels: Equal to Brother "P-Touch" or Thomas & Betts Canada Ltd. "EZCODE" Model EZL500 electronic labelling system self-adhesive labels with size and colour as directed, and permanently printed circuit identification nomenclature which is to be approved by the Consultant prior to producing the labels.
- .3 Warning Signs: Equal to Thomas & Betts Canada Ltd. "BP" Series 250 mm x 355 mm (10" x 14") semi-rigid vinyl signs with corner screw holes, the required printed wording (generally red on a white background with black trim) and pressure sensitive adhesive pads on the back.
- .4 Conduit and Armoured Cable Identification: Equal to Brady Canada minimum 50 mm (2") wide self-adhesive coloured vinyl tape.
- .5 Conductor Terminations: Equal to Electrovert Ltd. slip-on "Z" type.

2.7 WALL MOUNTING EQUIPMENT BACKBOARDS

- .1 Construction grade fir plywood, G1S, 20 mm (3/4") thick, with width and length as indicated on the drawings or as required for the equipment to be mounted. Each backboard is to be coated on all surfaces with a white flame retardant primer for a flame spread rating in accordance with Code requirements.

2.8 FASTENING AND SECURING HARDWARE

- .1 Concrete Inserts: Zinc alloy cast-in-place or “wood-knocker” type formwork anchors for single or double runs of conduit, cable tray, etc., and for equipment, and Unistrut Ltd. or equal multi type inserts for runs of three or more conduits, etc, or where a grid support system is required.
- .2 Concrete Fasteners: Equal to wej-it Fastening Systems anchors or self-drilling anchors, or, for light loads, lead plugs and screws.
- .3 Masonry Fasteners: Equal to wej-it Fastening Systems expansion shields and machine bolts, or, for light loads, lead plugs and screws.
- .4 Gypsum Board Fasteners: Two-wing spring toggles, for light loads only.
- .5 Structural Steel: Equal to Erico International Corp. “CADDY” beam clamps to suit the application.

2.9 ELECTRICAL ENCLOSURES

- .1 Unless otherwise specified herein or on the drawings, NEMA, EEMAC, and CSA enclosures for transformers, switchgear, switchboards, panelboards, disconnect switches, starters, motor control centres, and similar equipment are to be as follows:
 - .1 Indoor in sprinklered areas – type 2
 - .2 Indoor in high humidity/washdown areas – type 4 water-tight
 - .3 Indoor in corrosive environments – type 4X 304 stainless-steel
 - .4 Indoor explosion-proof (Class 1, Groups C & D) – type 7
 - .5 Outdoor – type 3R rain-proof
 - .6 Indoor in non-hazardous areas except as noted above – type 1

3 EXECUTION

3.1 GENERAL

- .1 Manufacturer's Instructions: For all materials and equipment, ensure that the manufacturers' installation instructions are followed unless otherwise specified herein or on the drawings, and unless such instructions contradict governing codes and regulations.
- .2 Cleaning: Clean all conduit and equipment prior to installation. Temporarily cap or plug ends of conduits/ducts which are open and exposed during construction.
- .3 Surfaces To Receive Your Work: Inspect surfaces and structure prepared by other trades before performing your work. Verify that surfaces or the structure to receive your work have no defects or discrepancies which could result in poor application or cause latent defects in installation and workmanship. Report defects in writing. Installation of your work will constitute acceptance of such surfaces as being satisfactory.
- .4 Repair of Finished Surfaces: For factory applied finishes, repaint or refinish all surfaces damaged during shipment and installation. The quality of the repair work is to match the original finish. This requirement also applies to galvanized finishes.
- .5 Work In High Humidity Areas: Where electrical work is located in high humidity areas or other “wet” areas where ferrous metal products will be subject to corrosion and protection for such products is not specified, provide finishes on

- the products to protect against corrosion or provide products which will not corrode in the environment, i.e. galvanized hanger and support hardware, aluminium cable tray, etc.
- .6 Accessibility: Locate all work to permit easy access for service or maintenance as required and/or applicable. Locate all junction boxes and pull boxes, and any other equipment which will or may need access, maintenance or repairs and which are installed in accessible construction to be easily accessible from access doors. Where boxes and similar conduit and conductor system accessories occur in vertical services in shafts, conduit/conductor spaces or partitions, locate the accessories at the floor level.

3.2 GENERAL CONDUIT & CONDUCTOR SYSTEM INSTALLATION REQUIREMENTS

- .1 Unless otherwise specified, locate and arrange horizontal conduit and conductors above or at the ceiling on floors on which they are shown, arranged so that under consideration of all other work in the area, the maximum ceiling height and/or usable space is maintained.
- .2 Unless otherwise specified, install all conduit and conductors concealed in finished spaces, and concealed to the degree possible in partially finished and unfinished spaces. Refer to and examine the Architectural drawings and room finish schedules to determine finished, partially finished, and unfinished areas. Note that walls which are painted are considered finished.
- .3 Conduit and main distribution conductors may be exposed in electrical and mechanical rooms unless otherwise specified or indicated on the drawings or specified in the Specification.
- .4 Install all exposed conduit and conductors parallel to building lines and to each other. Neatly group and arrange all exposed work.
- .5 Do not install conduit and conductors within 150 mm (6") of "hot" piping or equipment unless the conduit and conductors are associated with the equipment.
- .6 All conduit and conductors must be supported from the structure, not from ceiling hangers, piping, ductwork, cable tray, and similar mechanical or electrical products.
- .7 All isolated ground circuits must contain separate phase, neutral, and ground conductors (i.e. common neutral configuration is not acceptable). For all non-isolated ground circuits feeding non-linear loads, use of a common neutral configuration is optional but neutral conductors must be oversized to 175% of phase conductor ampacity and circuit breakers in the panelboards are to be located adjacent to each other. All conductors for the common neutral must be in the same conduit.

3.3 INSTALLATION OF SLEEVES

- .1 Where conduits, round ducts, and armoured cables pass through concrete and/or masonry surfaces provide sleeves as follows:
- .2 In poured concrete slabs, unless otherwise specified - minimum 16 gauge flanged galvanized steel or, where permitted by governing authorities, factory fabricated plastic sleeves.
- .3 In concrete or masonry walls - Schedule 40 galvanized steel pipe or Class 4000

-
- cast iron pipe, cut to length.
- .4 Waterproof Sleeves: Sleeves in waterproofed slabs or walls are to be lengths of Schedule 40 mild galvanized steel pipe with a water stop. Provide waterproof sleeves in the following locations:
- .1 In mechanical room floor slabs, except where on grade
 - .2 In slabs over mechanical, fan, electrical and telephone equipment rooms or closets
 - .3 In all floors equipped with waterproof membranes
 - .4 In the roof slab
 - .5 In waterproof walls
- .5 Size sleeves, unless otherwise specified, to leave 12 mm ($\frac{1}{2}$ ") clearance around the conduit, duct, or cable.
- .6 Pack and seal the void between the sleeves and the conduit, duct, or cable for the length of the sleeves as follows:
- .1 Fire rated construction: pack sleeves in fire rated construction as specified in the article below entitled "INSTALLATION OF FIRESTOPPING AND SMOKE SEAL MATERIALS"
 - .2 Non-fire rated construction: pack sleeves in non-fire rated interior construction with mineral wool and seal both ends of the sleeves with non-hardening silicone base caulking compound
 - .3 Exterior walls above grade: pack sleeves in exterior walls above grade with mineral wool and seal both ends of the sleeves water-tight with approved non-hardening silicone base caulking compound unless mechanical type seals have been specified
 - .4 Exterior walls below grade: seal sleeves in exterior walls below grade (and any other wall where water leakage may be a problem) with link type mechanical seals as specified below
- .7 Where sleeves are required in masonry work, accurately locate and mark the sleeve location, and hand the sleeves to the mason for installation.
- .8 Terminate piping used for sleeves that will be exposed so that the sleeve is flush at both ends with the building surface concerned so that the sleeve may be completely covered by an escutcheon plate, except for sleeves in waterproof floors which are to terminate 100 mm (4") above the finished floor.
- .9 "Gang" type sleeving will not be permitted.
- .10 Where sleeves are provided for future piping, or where piping has been removed from existing sleeves, cap and seal both ends of the sleeved opening. Where the sleeve is located in fire rated construction, ensure that the sleeve is sealed with firestopping material.

3.4 INSTALLATION OF WATERPROOF MECHANICAL SEALS

- .1 Provide watertight link type mechanical seals for conduit, round ducts, and/or conductors through exterior wall openings where shown and/or specified.
- .2 Assemble and install each mechanical seal in accordance with the manufacturer's instructions.
- .3 After installation, periodically check each mechanical seal installation for leakage and, if necessary, tighten link seal bolts until the seal is completely watertight.

3.5 RECTANGULAR OPENINGS

- .1 Openings for cable tray, multiple conduits and/or cables and similar rectangular openings will be provided in poured concrete work, masonry, drywall and other building surfaces by the trade responsible for the particular construction in which the opening is required.

3.6 INSTALLATION OF FIRESTOPPING AND SMOKE SEAL MATERIALS

- .1 Where electrical work penetrates fire rated construction, provide ULC listed and labelled firestopping and smoke seal materials installed in accordance with requirements of CAN4-S115 and CAN/ULC-S101-M to seal the penetrations.
- .2 Work is to be performed only by a specialist company using tradesmen experienced in firestopping and smoke seal work.
- .3 When firestopping and smoke seal work is complete, obtain from the specialist firm who performed the work a letter certifying that all required firestopping and smoke seal work has been completed in strict accordance with requirements of the Building Code, ULC requirements, any other applicable local Municipal Codes or Regulations, and the instructions of the firestopping and smoke seal manufacturer. Submit the letter to the Consultant.

3.7 INSTALLATION OF CABLE AND CONDUIT TRANSITS

- .1 Provide fire rated UL/ULC listed transits in rectangular openings in fire rated slabs and walls where cable tray or multiple conduits, ducts, and/or cables penetrate the fire barrier.

3.8 INSTALLATION OF ESCUTCHEON PLATES

- .1 Provide escutcheon plates suitable secured over all exposed conduit, duct, and armoured cable passing through finished building surfaces. A finished building surface is any surface with a factory finish or that receives a site applied finish.
- .2 Install the plates so that they are tight against the building surface concerned, and ensure that the plates completely cover sleeves and/or openings, except where waterproof sleeves extend above floors, in which case the plate is to fit tightly around the sleeve.

3.9 INSTALLATION OF FASTENING AND SECURING HARDWARE

- .1 Provide all fastening and securing hardware required for electrical work to maintain installations attached to the structure or to finished floors, walls and ceilings in a secure and rigid manner capable of withstanding the dead loads, live loads, superimposed dead loads, and any vibration of the installed products.
- .2 Use fasteners compatible with structural requirements, finishes and types of products to be connected. Do not use materials subject to electrolytic action or corrosion where conditions are liable to cause such action.
- .3 Where the floor, wall or ceiling construction is not suitable to support the loads, provide additional framing or special fasteners to ensure proper securement to the structure that is to support the products. Provide reinforcing or connecting

- supports where required to distribute the loading to the structural components.
- .4 Obtain written consent before using explosive actuated fastening devices. If consent is obtained, comply with requirements of CSA Standards CAN3-Z166.1 and 2.
- .5 Do not attach fasteners to steel deck without written consent from the Consultant.

3.10 SUPPLY OF ACCESS DOORS

- .1 Supply access doors to give access to all electrical work which may need maintenance or repair but which is concealed in inaccessible construction, except as otherwise specified herein or on the drawings.
- .2 Locate access doors as inconspicuously as possible in walls and partitions and arrange electrical work such that it is clearly within view and accessible for inspection and servicing, and to suit access door locations shown on the reviewed and approved white prints of reflected ceiling plan and elevation drawings submitted as per Part 1 of this Section.
- .3 Group work wherever possible to ensure the minimum number of access doors is required. Access doors will be installed by the trades responsible for the particular type of construction in which the doors are required.
- .4 Submit a sample of each proposed access door for review prior to ordering.

3.11 ELECTRICAL WORK IDENTIFICATION

- .1 General: The following requirements apply to electrical work identification:
 - .1 the size and wording of identification nameplates must be approved by the Consultant prior to manufacture. Provide shop drawings of all nameplates and labels for review and comment.
 - .2 identification wording for equipment is to follow drawing nomenclature for the equipment, unless otherwise specified.
 - .3 secure nameplate to equipment with stainless steel screws unless such a practice is prohibitive, in which case use epoxy cement applied to cleaned surfaces.
 - .4 locate equipment nameplates in the most conspicuous and readable location.
 - .5 for multi-cell or multiple component equipment, provide a main nameplate and a smaller nameplate for each component to identify its name and service.
 - .6 Colour code: comply with OESC-4-036.
- .2 Distribution Equipment: Provide identification nameplates for new each piece of equipment, including items such as substations, switchgear, switchboards, distribution panels, and similar products. Identification to include registration plates, ULC and CSA approvals, size, equipment model, manufacturers name, serial number, voltage, phase.
- .3 Terminal Cabinets, Pull Boxes, Junction Boxes, etc.: Clearly identify main pull and junction boxes by spray painting the outside surface of the covers. Paint colours are to be as specified below for conduit and conductor identification. For communication systems, i.e. intercom, TV, etc., provide a nameplate on the painted cover to identify the system involved.

- .4 Transformers: Provide a nameplate to identify the transformer, its capacity, and primary and secondary voltages. Include ULC and CSA approvals, equipment model, manufacturers name, serial number.
- .5 Lighting Switches and Receptacles: Unless otherwise specified identify the source panel and circuit number by means of an identification label applied to the wall above the device and inside the outlet box for each device.
- .6 Conduit & Cable: Colour code conduit and armoured cable by means of 25 mm (1") wide primary colour plastic adhesive backed tape or neatly applied suitable paint with, where scheduled, a 20 mm ($\frac{3}{4}$ ") wide auxiliary colour at points where the conduit or cable enters a wall, ceiling or floor, at least once in each room or accessible ceiling space, at each access door location, and elsewhere at maximum 15 m (45') intervals. Unless otherwise specified herein or on the drawings, colours are to be as follows:

SERVICE	PRIMARY COLOUR	SECONDARY COLOUR
Up to 250 volts	Yellow	
Up to 600 volts	Yellow	Green
Up to 5 kV	Yellow	Blue
Up to 15 kV	Yellow	red
Up to 28 kV	Yellow	Black
Telephone	Green	
Other communication systems	Green	Blue
Fire Alarm	Red	
Emergency Voice	Red	Blue
Security Systems	Red	Yellow
Isolated Power	Orange	

- .10 Wire and Cable Terminations: Identify both ends of wire and cable terminations with the same unique number. Where numbers are not indicated or specified, assign a number and record them.

3.12 FINISH PAINTING OF ELECTRICAL WORK

- .1 Finish paint exposed electrical work as specified and/or scheduled in accordance with requirements of the painting Section in Division 09.

3.13 GENERAL ELECTRICAL WORK TESTING

- .1 In addition to tests required by Codes and Regulations, or tests specified in other electrical work sections of the specification, perform the following:
- .1 after all luminaires, switches, receptacles, motors, signals, and similar electrical items are installed, whether as part of the electrical work or as

- part of the work of other sections of the specification (telephone system excepted), test all work to ensure that there are no grounds or crosses.
- .2 establish proper motor rotation, measure full load running currents, and check overload elements, and report any discrepancies to the Consultant.
- .3 demonstrate to the Consultant that branch circuit voltage drop is within specified limits.
- .4 ensure that all devices are commissioned and operable.

3.14 BRANCH CIRCUIT BALANCING

- .1 Connect all branch circuits to panelboards to balance the actual loads (wattage) to within 5%. If required, transpose branch circuits to achieve this requirement.
- .2 When requested by the Consultant, and after the building is occupied, perform tests to demonstrate that branch circuit balancing has been achieved.

3.15 ELECTRICAL WIRING WORK FOR MECHANICAL WORK

- .1 Unless otherwise specified or indicated, the following electrical wiring work for mechanical equipment is to be done as part of the electrical work:
 - .1 "line" side power wiring to motor starters or disconnects, and "load" side wiring from the starters or disconnects to the equipment.
 - .2 "line" side power wiring to pre-wired power and control panels and variable frequency drives, and "load" side power wiring from the panels and VFD's to the equipment
 - .3 Provision of receptacles for plug-in equipment
 - .4 Provision of disconnect switches for all motors that are in excess of 10 m (30') from the starter location, or that cannot be seen from the combination disconnect/starter location, and all associated power wiring
 - .5 All motor starter interlocking in excess of 24 volts.
 - .6 Wiring from motor winding thermistors in motors 30 HP and larger to motor starter contacts
 - .7 Provision of dedicated 120 volt, 15A-1P circuits terminated in junction boxes in mechanical equipment rooms for automatic control and building automation system wiring connections to be made as part of the automatic controls work.
 - .8 120-volt power connections to electrical receptacles integral with small ceiling exhaust fans, including wiring through light switches or speed controllers
 - .9 120-volt wiring connections to lighting fixture/switch combinations integral with air handling units
 - .10 120-volt wiring connections to duplex receptacles integral with air handling unit control panels
 - .11 120/208-volt wiring connections to electric heating units integral with air handling units.
- .2 Mechanical wiring work not listed above or specified herein or on the drawings to be done as part of the electrical work will be done as part of the mechanical work.

3.16 INTERRUPTION TO AND SHUT-DOWN OF ELECTRICAL SERVICES AND SYSTEMS

- .1 Co-ordinate all shut-down and interruption to existing electrical systems with the Owner. Generally, shut-downs may be performed only between the hours of 12:00 midnight until 6:00 a.m.
- .2 Upon award of a Contract, submit a list of anticipated shut-down times and their maximum duration.
- .3 Prior to each shut-down or interruption, inform the Owner and Consultant in writing **3** working days in advance of the proposed shut-down or interruption and obtain written approval to proceed. Do not shut down or interrupt any system or service without such written approval.
- .4 Perform work associated with shut-downs and interruptions as continuous operations to minimize the shut-down time and to reinstate the systems as soon as possible, and, prior to any shut-down, ensure that all materials and labour required to complete the work for which the shut-down is required are available at the site.
- .5 Coordinate with the Owner all start-up of existing electrical systems which have been shut-down.
- .6 Include in Bid Price for all overtime or premium time hours necessary to minimize duration of service interruptions.

3.17 EQUIPMENT BASES, SUPPORTS AND CURBS

- .1 Concrete Housekeeping Pads: Unless otherwise specified or required, set all floor mounted equipment on minimum 100 mm (4") high reinforced concrete housekeeping pads 200 mm (8") clear of the equipment on each side and end, or a minimum of 200 mm (8") from the centreline of equipment anchor bolts to the edge of the base, whichever is larger. Conform to the following requirements:
 - .1 supply dimensioned drawings and equipment base templates, and provide anchor bolts for proper setting and securing of equipment on pads.
 - .2 place anchor bolts during the concrete pour and be responsible for all required levelling, alignment, and grouting of the equipment.
 - .3 as a minimum, use wire mesh reinforcement, however, for pads for large heavy equipment, use reinforcement as per structural drawing details
- .2 Structural Steel Stands/Supports: For equipment not designed for base mounting, where required, provide welded, cleaned and prime coat painted structural steel stands or supports conforming to the following requirements:
 - .1 all stands and supports, except those for small equipment, are to be designed by a structural engineer registered in the jurisdiction of the work, and stamped and signed design drawings with calculations are to be submitted as shop drawings for review.
 - .2 all steel stands are to be flange bolted to concrete housekeeping pads.
- .3 Equipment Curbs
 - .1 Provide 100 mm (4") high concrete curbs around all openings through floors for electrical and system risers. Ensure joint between curb and floor is watertight and maintains integrity of floor membrane where applicable.

3.18 CUTTING, DRILLING, AND PATCHING FOR ELECTRICAL WORK

- .1 Provide all cutting, drilling and patching of the building for the installation of the work. Perform all cutting and drilling with proper tools and equipment. Confirm the exact location of cutting and drilling with the Consultant prior to commencing the cutting and/or drilling work.
- .2 Patch surfaces, where required, to exactly match existing finishes using tradesmen skilled in the particular trade or application worked on.
- .3 Where new conduits, conductors, etc., pass through existing construction, core drill an opening. Size openings to leave 12 mm (1/2") clearance around the conduit conductor, etc.
- .4 Prior to drilling or cutting an opening in poured concrete construction, determine the location, if any, of existing services concealed in the construction to be drilled or cut. X-ray or Ferro Scan test the walls or slabs required.
- .5 The contractor will be responsible for the repair of any damage to existing services, exposed or concealed, caused as a result of this cutting or drilling work.
- .6 Where drilling is required in waterproof slabs, size the opening to permit snug and tight installation of a sleeve which is sized to leave 12 mm (1/2") clearance around the conduit, duct, etc. Provide a sleeve in the opening. Sleeves are to be Schedule 40 galvanized steel pipe with a flange at one end and a length to extend 100 mm (4") above the slab. Secure the flange to the underside of the slab and caulk the void between the sleeve and slab opening with proper non-hardening silicone base caulking compound to produce a water-tight installation.
- .7 Ensure that cutting and patching of roofs and reinforced concrete structures is executed by specialists familiar with the materials affected, and is performed in a manner to neither damage nor endanger the work. Coordinate and supervise such cutting and patching.

3.19 PACKING AND SEALING CORE DRILLED OPENINGS

- .1 Pack and seal the void between the conduit, conductor, etc., opening and the conduit, conductor, etc., for the length of the opening as follows:
 - .1 non-fire rated interior construction: pack openings in non-fire rated interior construction with mineral wool and seal both ends of the opening with non-hardening silicone base caulking compound to produce a water-tight seal
 - .2 Fire rated construction: pack and seal openings in fire rated walls and slabs as specified in this Section
 - .3 Exterior walls above grade: pack sleeves in exterior walls above grade with mineral wool and seal both ends of the sleeves water-tight with approved non-hardening silicone base caulking compound unless mechanical type seals have been specified
 - .4 Exterior walls below grade: seal sleeves in exterior walls below grade (and any other wall where water leakage may be a problem) with link type mechanical seals as specified below.

3.20 FLASHING FOR ELECTRICAL WORK PENETRATING THE ROOF

- .1 Provide all required flashing work, including counter-flashing, for electrical work penetrating and/or set in the roof.
- .2 Perform flashing work in accordance with requirements of drawing details, and requirements specified in Division 07.

3.21 INSTRUCTIONS TO OWNER

- .1 Instruct the Owner's designated representatives in all aspects of the operation and maintenance of electrical systems and equipment, on two separate occasions.
- .2 Arrange and pay for the services at the site, for the length of time required, of qualified technicians and other manufacturer's representatives to instruct on specialized portions of the installation.
- .3 Ensure each instruction period includes, but is not limited to the following;
 - .1 a classroom seminar with operating manuals, product and system drawings and such other audio/visual aids as may be appropriate,
 - .2 instruction during the classroom seminar by the manufacturer's representative regarding the proper operating and maintenance procedures for each item of equipment,
 - .3 demonstration of the proper operating procedures for each item of equipment,
 - .4 explanation of the purpose and function of all safety devices provided,
 - .5 demonstration of all measures required for safe and proper access for operation and maintenance.
- .4 Provide a period of follow-up instruction (on two occasions) approximately one month after completing Owner's instruction to clarify and reinforce earlier instructions.
- .5 Submit, prior to Substantial Performance, a complete list of systems for which instructions were given, stating for each system:
 - .1 date instructions were given to the Owner's staff.
 - .2 duration of instruction
 - .3 names of persons instructed.
 - .4 other parties present (manufacturer's representatives, etc.)
- .6 Obtain the signatures of the Owner's staff to verify they properly understood the system installation, operation and maintenance requirements and have received operating and maintenance manuals and record drawings.

3.22 CLEANING ELECTRICAL WORK

- .1 Refer to cleaning requirements specified in Division 01.
- .2 Clean all electrical work prior to application for Substantial Performance of the work.

3.23 USE OF ELECTRICAL SYSTEMS FOR TEMPORARY POWER AND LIGHTING

- .1 Permanent electrical systems in the building may be used for temporary power and lighting during construction subject to the owner's conditions.
- .2 Each entire system is complete, tested, and commissioned.
- .3 Building has been closed in and areas are clean and will not thereafter be

-
- subjected to dust-producing processes.
 - .4 There is no possibility of damage from any cause.
 - .5 All systems are operated as per the manufacturer's recommendations or instructions and are monitored on a regular and frequent basis.
 - .6 Warranties are not affected in any way.
 - .7 Regular preventive and all other manufacturer's recommended maintenance routines are performed.
 - .8 before Substantial Performance, each entire system is to be refurbished, cleaned internally and externally, and restored to "as-new" condition, and lighting fixture lamps are replaced.
 - .9 energy costs are to be paid by the Contractor.]

3.24 MAINTAINING EQUIPMENT PRIOR TO ACCEPTANCE

- .1 Maintain all equipment in accordance with the manufacturer's printed instructions prior testing and commissioning.

3.25 CONNECTIONS TO OTHER EQUIPMENT

- .1 Carefully examine the Contract Documents during the bidding period and include for electrical work connections to equipment requiring such connections.

3.26 WASTE MANAGEMENT AND DISPOSAL

- .1 Separate and recycle waste materials in accordance with requirements of Canadian Construction Association Standard Document CCA 81, A Best Practices Guide to Solid Waste Reduction.
- .2 Prepare a waste management and reduction plan and submit a copy for review prior to work commencing at the site.
- .3 Place materials defined as hazardous or toxic waste in designated containers.
- .4 Ensure emptied containers are sealed and stored safely for disposal.

3.27 REQUIREMENTS FOR BARRIER FREE ACCESS

- .1 Include for all applicable requirements for barrier free access in accordance with requirements of the OBC, whether shown on the drawings or not.

END OF SECTION

1 GENERAL

1.1 APPLICATION

- .1 This Section specifies requirements, criteria, methods and execution for electrical demolition work that are common to one or more electrical work Sections, and it is intended as a supplement to each Section and is to be read accordingly.

1.2 SUBMITTALS

- .1 Submit documentation to confirm that hazardous materials have been properly removed and stored, recycled, or disposed of as applicable.

2 PRODUCTS

Not Applicable

3 EXECUTION

3.1 DISCONNECTION AND REMOVAL AND/OR RELOCATION OF EXISTING ELECTRICAL WORK

- .1 Where indicated on the drawings, disconnect and remove existing obsolete electrical work. Disconnect at the point of supply, remove obsolete connecting services and conductors, and make the system safe. Cut back obsolete conduit behind finishes and cap water-tight unless otherwise specified.
- .2 Relocate existing items as indicated. Include for new boxes, conduit, conductors, etc., as required, and test all relocated work as for new work. Provide blank coverplates on existing obsolete boxes which are to remain in position. Material and finish of blank coverplates is to match existing coverplates in the area.
- .3 The scope and extent of the demolition or revision work is only generally indicated on the drawings. Determine the scope, extent and cost of the work at the site during the bidding period site visit(s). Claims for extra costs for demolition work not shown or specified but clearly visible or ascertainable at the site during bidding period site visits will not be allowed.
- .4 If any re-design is required due to discrepancies between the electrical drawings and site conditions, notify the Consultant who will issue a Site Instruction. If, in the opinion of the Consultant, discrepancies between the electrical drawings and actual site conditions are of a minor nature, the required modifications are to be done at no additional cost.
- .5 Where existing electrical services extend through or are in an area to serve items which are to remain, maintain the services in operation. Include for rerouting existing services concealed behind existing finishes and which become exposed during the renovation work, so as to be concealed behind new or existing finishes.
- .6 Under all conditions and circumstances, existing electrical systems and services serving operating portions of the building must be maintained in service. Include for all work to comply with this requirement.
- .7 If and where new openings for doors, windows, etc., are to be cut in existing

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- building surfaces, be present when the work is done and should any damage occur to existing systems required to remain in operation, repair the damage immediately and report the incident to the Consultant.
- .8 Unless otherwise specified, remove from the site and dispose of all existing materials which have been removed and are not to be relocated or reused. Refer to waste management and disposal requirements specified in the Basic Electrical Materials and Methods Section.
- .9 Where existing panelboard breakers are removed, replaced, or otherwise revised, provide new typed panelboard circuit directories.
- .10 Before beginning Work and admittance of any workers on the site, furnish the Consultant with a report in the form of a deficiency list, covering all fittings, fitments, fixtures, surfaces, and any other building component in the existing buildings and exterior building surfaces or site work where Work is being done, whose proximity to alteration Work renders it vulnerable to damage.
- .11 Existing raceways shall not be used for new and/or relocated wiring unless otherwise noted and/or approved in writing by the Consultant.
- .12 Existing items to be relocated shall be cleaned and repaired or altered as required to suit new location. All damaged or ineffective parts shall be replaced and the item made "as new".
- .13 Make good all surfaces and finishes in areas from which items have been removed and in which items are relocated. Cap all existing services required to be severed to effect alterations and do all other work necessary to make good such areas to satisfaction of consultant.
- .14 Openings in existing floor assemblies and vertical fire separations necessitated by installation of equipment and systems or construction in general to be temporarily sealed with fire barrier materials such as mineral wool or other noncombustible insulation.
- .15 Existing equipment and systems that are shut down due to work of this project, shall be tested and proper operation verified when returned to service.
- .16 All existing dead wiring and conduit in renovated areas shall be removed in its entirety where accessible. Where not accessible, wiring only shall be removed and conduit shall remain.
- .17 Disconnect and remove any electrical equipment in ceiling space or walls that causes interferences during renovation work. All equipment shall be reinstalled and reconnected upon completion of renovation work.

3.2 HAZARDOUS MATERIALS AND/OR WASTE

- .1 Be advised that items such as oil filled transformers, capacitors and old lighting fixture ballasts may contain hazardous waste. Governing Codes and Regulations, and caution is to be taken when disconnecting and removing/storing these items.
- .2 If hazardous waste not listed in the Specification is found, notify the Owner and Consultant immediately and await directions.
- .3 Asbestos, Mould, Lead Paint, Etc.: If at any time during the course of the work asbestos containing materials, black mould, lead paint, or any other such materials are encountered or suspected, immediately report the discovery to the Consultant and cease all work in the area in question. Do not resume work in

affected areas until the situation has been properly corrected and without written approval from the Owner.

3.3 INTERRUPTION TO AND SHUT-DOWN OF ELECTRICAL SERVICES AND SYSTEMS

- .1 Co-ordinate all shut-down and interruption to existing electrical systems with the Owner. Generally, shut-downs may be performed only between the hours of 12:00 midnight until 6:00 a.m.
- .2 Upon award of contract, submit a list of anticipated shut-down times and their maximum duration.
- .3 Prior to each shut-down or interruption, inform the Owner in writing [3] [5] working days in advance of the proposed shut-down or interruption and obtain written approval to proceed. Do not shut down or interrupt any system or service without such written approval.
- .4 Perform work associated with shut-downs and interruptions as continuous operations to minimize the shut-down time and to reinstate the systems as soon as possible, and, prior to any shut-down, ensure that all materials and labour required to complete the work for which the shut-down is required are available at the site.
- .5 Coordinate all start-up of existing electrical systems which have been shut down with the Owner.
- .6 Include in Bid Price for all overtime or premium time hours necessary to minimize duration of service interruptions.

3.4 ROOFING WORK

- .1 Where roof revisions and/or replacements are part of the project, include for disconnecting, lifting, or temporarily removing/relocating electrical equipment on the roof as required to permit completion of the roofing work, and for re-installing the equipment when the roofing work is complete.
- .2 Where existing motorized mechanical equipment on the roof is to be removed/relocated/reinstalled to permit new roofing work, include for electrical disconnection and reconnection of the equipment.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- .1 Test Reports: Submit signed test reports for all testing work specified.
- .2 Approval Certificates: Submit Certificates of Approval as issued by governing authorities.
- .3 Electrical Distribution System Coordination Study: Submit copies of the electrical distribution system protective device coordination study specified in Part 3 of this Section, prior to energizing the electrical distribution equipment.
- .4 Allow for testing any cabling and equipment that is to be re-used.

2 PRODUCTS

Not applicable.

3 EXECUTION

3.1 GENERAL ELECTRICAL WORK TESTING REQUIREMENTS

- .1 Satisfactorily perform all testing required by governing authorities, Codes, Regulation, and the Specification, including general testing specified below. Prepare and sign test reports to confirm satisfactory completion of testing and submit as specified in Part 1 of this Section.
- .2 Perform testing to suit phasing of the work, as applicable.
- .3 Leaks, Grounds, and Crosses: After luminaires, switches, receptacles, motors, signals, and similar equipment has been installed, whether or not the work has been installed as part of the work of this Division of the Specification or by other Divisions (telephone system excepted), test the work to ensure that there are no leaks, grounds, or crosses.
- .4 Motor Operation: Test and establish proper motor rotation, measure full load running currents, and check overload elements. Report to the Consultant any discrepancies that are found. Existing motors that have been disconnected and reconnected as part of the electrical work must be checked with a rotation meter, and be responsible for any damage caused by reverse rotation.
- .5 Branch Circuit Voltage Drop: Demonstrate to the Consultant that branch circuit voltage drop is within specified limits.

3.2 GROUNDING AND BONDING SYSTEM

- .1 Provide visual and mechanical inspection of the grounding and bonding system and verify that the system is in compliance with all requirements.

3.3 DISTRIBUTION SYSTEM TESTING AND COORDINATION STUDY

- .1 Appoint and pay for independent inspection and testing consultant specializing in this work to carry out a complete coordination study of primary and secondary power distribution and to perform on-site pre-service inspection, testing of electrical equipment, and any other witness tests as required by governing authorities. Prior to appointment of testing consultant obtain approval of Consultant as to the coordination study format. The study shall be limited to the new areas considered in this project and not the entire facility. This will include confirmation of the new panels short circuit ratings for the new panel boards replacing the existing

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- panelboards.
- .2 Coordinate electrical work and inspection and testing company work and provide adequate advance notice as to when the work of this section will be ready for inspection and testing. Allow sufficient time to carry out inspection and testing as specified herein.
 - .3 Submit initial short circuit/coordination study with equipment shop drawings for Consultants review and prior to release of equipment for manufacture. If formal completion of the study may cause delay in equipment manufacturer approval from the Consultant may be obtained for a preliminary submittal of sufficient study data to ensure that the selection of device ratings and characteristics will be satisfactory.
 - .4 The electrical distribution system protective devices have been selected such that protection is adequate and proper coordination is possible, however, since differences do exist between manufacturers of equipment, some changes in trip ratings or relay settings may be necessary and are to be performed as part of the work, prior to energizing the electrical distribution system and these changes shall be included at no extra cost to the Owner. To determine the above, a testing and coordination study of the electrical distribution system equipment is to be performed by one of the following companies:
 - .1 G. T. Wood Co. Ltd.
 - .2 Brosz and Associates Ltd.
 - .3 Rondar Inc.
 - .4 Siemens Westinghouse Technical Services
 - .5 Schneider Canada
 - .6 Cutler-Hammer Engineering Services
 - .5 Short Circuit and Coordination Study: Immediately upon notification of award of Contract, arrange for the testing company to perform the following:
 - .1 cooperate with and obtain from manufacturers of the distribution system equipment a list of equipment requiring protective devices to be used, and, along with the manufacturers, ensure that proper control and protective devices are selected such that they can be properly coordinated.
 - .2 prepare, as soon as possible, a set of coordination curves on proper time current characteristic graph paper and submit to the Consultant, accompanied by supporting symmetrical as well as asymmetrical fault current calculation data with tabulations to verify protection of the various distribution system elements under maximum and minimum fault conditions at the various points in the system.
 - .6 The graph shall include:
 - .1 Up-to-date system single line diagrams for high voltage and low voltage systems
 - .2 Composite time-current characteristic curves of all pertinent relays, breakers, fuses and the like including the thermal damage curves for cables, transformers, motors and the like.
 - .3 Summation chart showing all ratings and settings referenced to the appropriate time-current characteristic curve.
 - .4 Three phase bolted fault current, symmetrical and asymmetrical, and minimal arcing ground fault values.
 - .7 Plot the time current characteristic curves for the following:
 - .1 main and feeder protective devices at all voltage levels used in the distribution system.
 - .2 protective devices associated with the largest motor in each motor control center, the refrigeration machine compressors (as applicable), and the largest load fed from each distribution panelboard.
 - .3 emergency power engine generator set protective devices, damage curves, and

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- current decrement curves.
- .8 Where relays, breakers, etc., do not perform to approved coordination curves they are to be revised at no cost as part of the work.
 - .9 Complete system shall be coordinated as follows:
 - .1 Coordinate all protective devices in all switchgear, switchboards, distribution panels and branch circuit panels so that smaller low voltage branch feeder breaker will, in the event of fault, interrupt before main breaker. Main secondary breakers shall interrupt before high voltage breaker of fuse supplying Supply Authority transformer, and the like. Coordinate with Supply Authority.
 - .2 Coordinate main breakers in all panelboards so that they will trip prior to the breaker in upstream distribution equipment supplying same.
 - .3 Coordination shall typically include at least one stage upstream to the last protective device.
 - .4 Set ground fault, short time, and long-time trip devices as directed by coordination study and/or Consultant.
 - .10 The on-site test and coordination study of distribution system protective devices is to include, as applicable:
 - .1 Primary and secondary voltage switchgear and transformers.
 - .2 Major interconnecting cables and busways.
 - .3 testing, cleaning when necessary, and calibrating relays and circuit breaker trip devices (calibration of protective devices is to conform to requirements of approved coordination curves)
 - .4 a function test of associated control devices
 - .5 replacement of any fuses destroyed during tests at no additional cost
 - .6 an acceptance test in the presence of and to the satisfaction of the Consultant
 - .7 the presence at the site, for the length of time required, of qualified equipment manufacturer's service representatives.
 - .8 an insulation resistance test of "load" side feeders with respect to ground
 - .9 a test of cables, distribution and branch circuit panelboards, distribution transformers, power receptacles and switches
 - .10 testing of motor control centers, motor starters, and, where supplied as part of the electrical work, variable speed drives.
 - .11 Necessary data required to complete this coordination study shall be obtained from the Supply Authority and manufacturers of protective devices in the system.
 - .12 Ensure that the suggested settings of the devices, as determined from the coordination study are acceptable to the Supply Authority.
 - .13 Short circuit and coordination study shall be prepared under the supervision and sealed by a Professional engineer licensed in the Province of Ontario.
 - .14 Inspection and testing shall be done prior to the system being energized and typically will include:
 - .1 Arrange with manufacturer to witness plant test of all low voltage breakers and associated control equipment and ensure proper functioning of all elements prior to shipment to site.
 - .2 Check all control devices in automatic transfer scheme and ascertain their proper connection prior to energizing the system.
 - .3 Check all bus connections, bus joints, and clearances in all equipment before energizing.
 - .4 Verification of potential and current transformers.
 - .5 All reports required from switchboard and switchgear manufacturers shall be sent to

manufacturers prior to commencing of manufacturing of switchgear.

END OF SECTION

1 GENERAL

1.1 GENERAL DESCRIPTION OF THE WORK OF THIS SECTION

- .1 This Section outlines, defines and describes the electrical work commissioning process and the responsibilities of the various parties involved.

1.2 DEFINITIONS

- .1 The following are definitions of words used in this Section:
 - .1 Commissioning: the process of the Contractor demonstrating to the Owner and Consultant, for the purpose of final acceptance, by means of successful and documented functional performance testing, that all systems and/or subsystems are capable of being operated and maintained to perform in accordance with requirements of the Contract Documents, all as further described below.
 - .2 Pre-Performance Testing: the process of the Contractor and his subcontractors, under supervision of equipment manufacturer's/supplier's technical personnel, starting and operating equipment and systems, making any required adjustments, documenting the process, and submitting reports to prove that the equipment and systems have been properly installed and are operational as intended.
 - .3 Operational Performance Testing: testing, adjusting and operating of components, equipment, systems and/or subsystems, by the Contractor, after pre-performance testing but before functional performance testing, to confirm that all components, equipment, systems and/or subsystems operate in accordance with requirements of the Contract Documents, including all modes and sequences of control and monitoring, interlocks, and responses to emergency conditions.
 - .4 Functional Performance Testing: a repeat of successful operational performance testing with documentation by the Contractor in the presence of the Consultant, Owner, and Commissioning Agent to validate and verify that the equipment, systems and subsystems are complete in all respects, function correctly, and are ready for acceptance.
 - .5 Validate: to witness and record results of successful equipment/system tests and demonstrations performed by the Contractor.
 - .6 Certify: to review and verify the accuracy of project close-out documentation provided by the Contractor.
 - .7 Commissioning documentation sheets: prepared sheets for each piece of equipment/system to be commissioned, each sheet or set of sheets complete with the Project name and number, date of commissioning, equipment/system involved, equipment/system name and model number, equipment tag as per the drawings, and, for each commissioning procedure listed, a column giving the expected data as per the Contract Documents, a column to fill in the observed data during commissioning, and space for signatures of the Contractor.
 - .8 Systems Operating Manual: a manual prepared by the Commissioning Agent to present an overview of the building electrical systems and equipment to be used by building maintenance personnel to assist them in daily operation of the systems.

1.3 COMMISSIONING OBJECTIVES

- .1 Objectives of the commissioning process are as follows:
 - .1 To support quality management by means of monitoring and checking the installation.
 - .2 To verify equipment/system performance by means of testing and commissioning of the completed installation.
 - .3 To move the completed equipment/systems from the "static" Completion state to the "dynamic" Operating state so to transfer a complete and properly operating installation from

- the Contractor to the Owner
- .4 To optimise equipment/system operating and maintenance by the Owner's personnel by means of comprehensive training and instruction to the Owner's personnel, and delivery to the Owner of complete and accurate Operating and Maintenance Manuals
- .5 To deliver accurate historical records such as as-built drawings, test certificates, warranties, and other such data to the Owner to aid in operation and maintenance of the equipment/systems, as well as future renovations, repairs, etc.

1.4 SUBMITTALS

- .1 Commissioning Plan, Procedures, Schedule and Forms: Submit for review, a Commissioning Plan with schedule, commissioning procedures for all commissioning events, and functional performance testing (commissioning) forms for all procedures.
- .2 List of Commissioning Instruments: Submit a list of commissioning instruments, and for each instrument, indicate the purpose of the instrument and include a recent calibration certificate.
- .3 Pre-Performance Test Reports: Submit equipment and system pre-performance test reports prior to operational performance testing.
- .4 Letters To Certify Readiness for Functional Performance Testing: After successful operational performance testing, submit, for each system or subsystem, a letter to confirm that operational performance testing has been successfully completed and the system or subsystem is ready for functional performance testing.
- .5 As-Built Record Drawings: Submit red-line site white print as-built drawings for review, with written certification that the as-built drawings have been reviewed by the Commissioning Agent and are complete and accurate, and, when the red line as-built drawings have been reviewed by the Consultant, submit final CADD record drawings.
- .6 Operation and Maintenance Manuals: Submit an operation and maintenance manual for review, with written certification that the manuals have been reviewed by the Commissioning Agent and are complete and accurate as per the Contract Documents, and, when the manuals have been reviewed by the Consultant, submit the required number of final O & M Manuals.
- .7 Systems Operating Manual: Submit a system operating manual for review, with written certification that the manual has been prepared by the Commissioning Agent and is complete and accurate.
- .8 Extended Warranties: Submit copies of all extended warranties. Ensure that all extended warranties are in accordance with requirements of the Contract Documents.

1.5 COMMISSIONING AGENT

- .1 The commissioning agent (CA) has been contracted directly by the Owner for this project. The CA has overall responsibility for planning and coordinating the commissioning process. Commissioning involves all parties to the design and construction process, including the Contractor and his sub-contractors and suppliers.

1.6 RESPONSIBILITIES OF THE CONTRACTOR

- .1 Construction Phase: Responsibilities of the Contractor during the construction phase are as follows:
 - .1 Prepare and submit an installation mission statement which generally includes the method of equipment delivery to the installation location on site, and the prerequisite preparation for delivery such as completion of factory testing and the completion of site work to accept the equipment.
 - .2 Prepare and submit an installation schedule which is to include the time schedule for each activity with lead and lag time allowed and indicated, shop drawing and working detail drawing submissions, and major equipment factory testing and delivery dates.
 - .3 Prepare and submit a commissioning schedule which is to include a time schedule coordinated with the installation schedule referred to above, and allowances for additional

- time for re-tests as may be required, and update the schedule on a monthly basis as required
- .4 Chair progress meetings and attend commissioning meetings.
- .5 Promptly correct all reported deficient work
- .6 Where required by Codes and/or the Specification, retain equipment manufacturers/suppliers or independent third parties to certify correct installation of equipment/systems, and training of the Owner's operating personnel.
- .7 Under the supervision of equipment manufacturers/suppliers, complete pre-performance testing and adjust all equipment and systems to design requirements, and submit pre-performance test reports which include all equipment data such as manufacturer and model number, serial number where applicable, and performance parameters, all signed by the equipment manufacturer/supplier and the Contractor.
- .8 In accordance with the updated commissioning schedule and actual progress at the site, certify in writing to the Consultant that equipment and/or systems are complete, have been checked, started and adjusted, and are ready to be commissioned, and schedule the commissioning procedures giving the Consultant a minimum of five working days notice
- .9 Test and commission all required equipment and systems, and complete and submit all testing and commissioning forms to the satisfaction of the Consultant and Commissioning Agent
- .10 Submit for review by the Consultant, updated, red-line site white-print, as-built record drawings, then, when the review by the Consultant is complete, prepare and submit the final CAD set of record drawings as per the Specification
- .11 Submit for review by the Consultant, preliminary copies of Operating and Maintenance Manuals, then, when the review by the Consultant and is complete, submit final copies of the Manuals with all comments incorporated as well as all testing and commissioning results and reports.
- .12 Obtain, issue and assign to the Owner, all extended warranties for equipment and systems.
- .2 Post Construction Phase: Responsibilities of the Contractor during the post construction phase are as follows:
 - .1 Optimize equipment and system operation in accordance with the building's occupant's needs and comments.
 - .2 Complete all commissioning procedures, activities, and performance verification procedures that were delayed or not concluded during the construction phase
 - .3 Correct all deficiencies revealed by the system checks described above, and, where required, involve equipment manufacturers/suppliers during corrective actions
 - .4 Schedule for four (4) months after Substantial Completion and conduct question and answer session(s) at the building with the Owner's operating and maintenance personnel, with the duration of the session(s) dictated by the number of questions and concerns that have to be addressed.

1.7 TESTING EQUIPMENT

- .1 The Contractor is to supply all instruments and test equipment required to conduct start-up, testing and commissioning procedures.
- .2 Instruments and test equipment to be supplied are to include, but not be limited to the following:
 - .1 1000-volt megger tester
 - .2 Polarity tester
 - .3 Multi-meter
 - .4 Grounding tester
 - .5 Low resistance tester for testing contact resistance
 - .6 Clamp-on ammeter
 - .7 Phase sequence meter
 - .8 Receptacle testers
 - .9 High potential dielectric tester

- .10 Automatic voltage/load recorder
- .11 Infrared temperature scanner
- .12 Light meter
- .13 Any other test equipment required to perform site testing.
- .3 The Contractor is to submit to the Consultant and the Commissioning Agent, a list of the instruments and equipment to be used, as well as a copy of the latest calibration certificate for each.

2 PRODUCTS

Not applicable

3 EXECUTION

3.1 COMMISSIONING

- .1 Commission the electrical work in accordance with requirements of this Section of the Specification.
- .2 Prerequisites to Commissioning: Prerequisites to successful completion of commissioning by the Contractor are as follows:
 - .1 submittal of start-up and test reports
 - .2 successful completion of operational performance testing
 - .3 submittal of letters to the Consultant certifying that the equipment, systems and subsystems have been tested, adjusted, operational performance tested, and are in accordance with requirements of the Contract Documents

3.2 PHASING OF COMMISSIONING

- .1 Commissioning may be phased to suit the progress of the work. For example, if the electric service and distribution systems are complete, (but not BAS connections), the commissioning process may commence. Pre-performance testing can be performed and documented, operational performance testing may be completed and when successful, functional performance testing may be scheduled and performed in accordance with requirements specified in this Section.

3.3 DEFICIENCIES LISTED DURING COMMISSIONING

- .1 Deficiencies listed by the Consultant during the commissioning process are to be corrected within fifteen calendar days unless agreed otherwise with the Consultant.

3.4 OPERATIONAL PERFORMANCE TESTS AND FUNCTIONAL TESTS

- .1 When pre-performance inspection and testing has been completed and reports have been submitted to confirm that the equipment and systems are properly installed and operational as intended, operational performance testing and functional testing may begin. For all tests, test result records are to be kept for submittal. Tests are to include but not be limited to the following:

Table 1: Insulation Testing Table

NOMINAL CABLE/EQUIPMENT RATING	JM TEST VOLTAGE, MANUFACTURER'S RECOMMENDED	RECOMMENDED MINIMUM INSULATION RESISTANCE IN MΩ VALUES.
USE IF NOT AVAILABLE, USE THE VALUES BELOW		
300 V		25
600 V		100

1000 V		100
15000 V		5000
25000 V		20000
345000 V & ABOVE		100000

- .1 Low Voltage Switchboards:
 - .1 Check the mechanical operation of the switches or circuit breakers.
 - .2 Check to ensure that all connecting bolts are tightened to the correct torque values
 - .3 Disconnect any devices that would be damaged by test voltage, and megger test with a 1000-volt tester between all phase to phase, phase to ground, phase to neutral, and neutral to ground, if applicable, for insulation resistance which is not to be less than 100 megaohms
 - .4 Test all circuit breakers with integral protection devices for proper trip operation, and record the magnitude of the test currents and the corresponding tripping times.
 - .5 Check all the indication lights and control switches for correct functions.
 - .6 Prior to energizing the switchboard, set all protection devices to the correct values according to results of the distribution system testing and coordination study and as instructed by the Consultant.
 - .7 After energization, check and test phase sequence and the observed voltages.
- .2 Distribution and branch circuit panelboards:
 - .1 Verify that the panelboard circuit directory is correct and indicates the size of each circuit breaker or switch, equipment served, cable type and size, and include a copy of each the directory in the test records.
 - .2 Test to ensure that the voltage drop is within specified limits from the switchboard to the panelboards, and test to ensure that branch circuit voltage drops are within specified limits.
 - .3 Test to ensure panelboards are properly grounded.
 - .4 500-volt megger test for branch circuits, and the minimum value is to be:
 - .1 Phase to phase: 50 megaohms
 - .2 Phase to ground: 50 megaohms
 - .3 Neutral to ground: 50 megaohms measured with incoming neutral
 - .4 Phase to neutral: 50 megaohms
- .3 Lightning protection system: the certified system installer is to verify that the system is installed in accordance with the Ontario lightning rods act and is to issue a certificate which is to be included in the o & m manuals.
- .4 Lighting and lighting control systems: verify that all automatic controls properly are connected and functioning properly, and:
 - .1 Verify that the emergency lighting system are connected, and functioning properly.
 - .2 Perform lighting level tests as required and directed by the commissioning agent.
- .5 Security system and CCTV system: provide a line diagram showing the location and number of each station and device, then:
 - .1 Test and document each type of alarm from each station, noting the station number(s) at which the signal is received.
 - .2 Re-run the test for each mode of operation, such as call-forward mode, and emergency power mode.
 - .3 Check CCTV cameras for proper operation, such as:
 - .1 Proper focusing of the cameras.
 - .2 Proper movement of the cameras.
 - .3 Light level sensitivity
 - .4 Check the calibration of the devices.
 - .5 Check for proper door release operation.

-
- .6 Test for proper interface to other systems as specified.
 - .6 Fire alarm system: Perform system verifications and tests according to CAN/ULC S536, Inspection and Testing of Fire Alarm Systems, and CAN/ULC S537, Verification of Fire Alarm Systems.
 - .7 Other systems: Perform operational performance testing and functional testing on the following systems, as applicable:
 - .1 public address system
 - .2 network cabling system

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- .1 Product Data: Submit product data sheets for all products specified in this Section. Indicate compatibilities and limitations, and application instructions and include data to confirm that the product proposed meets all requirements of the Specification.
- .2 Samples: If requested, submit identified conductor samples.
- .3 MSDS Sheets: Submit Material Safety Data Sheets for conductor pulling lubricants.

2 PRODUCTS

2.1 DISTRIBUTION AND BRANCH CIRCUIT CONDUCTORS

- .1 Minimum gauge: #12 AWG, unless specifically noted otherwise. Conductors #12 and #10 AWG are to be solid. Conductors #8 AWG and larger are to be stranded. Use #14 AWG for control wiring unless noted otherwise. All conductors are to be constructed from 98% conductive copper and are to be approved for 600 volts. Conductors are to be colour coded, factory identified on the insulation with the manufacturer's name, conductor size and metal, voltage rating, and CSA type and designation. Conductors are to be as follows:
 - .1 "T-90 Nylon" single copper conductor in accordance with CSA C22.2 No. 75, Thermoplastic-Insulated Wires and Cables, 90° C (194° F) rated, PVC insulated and nylon covered for #10 AWG and smaller.
 - .2 "RW-90" single copper conductor in accordance with CAN/CSA C22.2 No 38, Thermoset-Insulated Wires and Cables, 90°C (194° F) rated, X-link polyethylene insulated for #8 AWG and larger.
 - .3 "TWU" single copper conductor in accordance with CSA C22.2 No. 75, 60° C (140° F) rated, PVC insulated.
 - .4 "AC90" flexible cable to CSA C22.2 No. 51, Armoured Cable, with 90° C (194° F) rated, X-linked polyethylene insulated copper conductors, a concentric ground conductor, and an interlocking aluminum armor jacket
 - .5 Equal to Tyco/Raychem "CI" cable in accordance with requirements of CSA C22.2 No. 208, Fire Alarm and Signal Cable, FAS90 shielded or un-shielded as required, 90°C (194°F) rated, consisting of a copper conductor, silicone rubber insulation, and a polyolefin outer jacket.
 - .6 Equal to Nexans Canada "Corflex II" RA90 flexible cable in accordance with requirements of CSA C22.2 No. 123, Aluminum Sheathed Cable, consisting of single or multiple copper conductors with X-link polyethylene insulation enclosed in a liquid and vapour-tight solid corrugated aluminum sheath and, an overall PVC jacket
 - .7 Equal to Nexans Canada "Firex II" TECK 90 cable in accordance with requirements of CSA C22.2 No. 131, Type TECK 90 Cable, consisting of single or multiple copper conductors with X-link polyethylene insulation enclosed in a liquid and vapour-tight solid corrugated aluminum sheath and, an overall PVC jacket

2.2 LOW VOLTAGE (24 VOLT) CONDUCTORS

- .1 "T-90" or "RW90" stranded copper conductors as specified above
- .2 Equal to Nexans Canada "Securex II" FAS/LVT/FT1300 volt wire to CSA C22.2 No. 208, Fire Alarm and Signal Wire, 105° C (220° F) rated, consisting of solid copper conductors (stranded for control wiring), flame retardant PVC insulation, an aluminum/Mylar optional shield with a #22 AWG tinned copper drain wire, if required for the application, an outer PVC jacket, and, if required for the application, interlocking aluminum armour with or without an overall jacket.

2.3 CONNECTORS

- .1 Conductors In Conduit: Except as noted, equal to Ideal Industries Inc. "Wing Nut" CSA certified, 600 volt rated pressure type twist connectors.
- .2 Conductors 3/0 AWG and Larger: Long barrel, double-crimp, compression type lug connectors, unless otherwise specified.
- .3 Armoured Cable: Except as noted, proper squeeze type connectors and plastic anti-short bushings at terminations in accordance with requirements of CSA C22.2 No. 18.3, Conduit, Tubing and Cable Fittings.
- .4 Corflex/Teck Cable: Connector and termination hardware supplied by the cable manufacturer to suit the application.

2.4 CONDUCTOR PULLING LUBRICANT

- .1 Equal to Ideal Industries Inc. "Yellow 77" or ClearGlide", as required.
- .2 French Chalk or Talcum Powder conductor pulling lubricant.

3 EXECUTION

3.1 GENERAL RE: CONDUCTOR INSTALLATIONS

- .1 Conform to the following conductor installation requirements:
 - .1 Conductor Routing: Conductor routing indicated on the drawings is schematic and approximate. Determine exact routing and conductor lengths at the site. Route conductors to avoid interference with other work. Unless otherwise specified or shown install conductors parallel to building lines.
 - .2 Conductor Pulling: When pulling conductors into conduit use lubricant and ensure that the conductors are kept straight and are not twisted.
 - .3 Securing/Supporting Conductors: Conform to the following requirements:
 - .1 Neatly secure exposed conductors in equipment enclosures with proper supports and/or ties
 - .2 Support flexible armoured cable in ceiling spaces and stud walls with steel two-hole cable straps to Code requirements.
 - .4 Conductor Splicing: Generally conductor splicing is not permitted unless otherwise approved by the Consultant, and if approved, splicing is subject to the following conditions:
 - .1 Splicing is permitted to extend existing conductors.
 - .2 For thermoplastic insulated conductors, splices are to be made

within an approved electrical box with mechanical compression connectors to suit the type and size of conductors, and the box(es) are to be properly identified and locations are to be indicated on "as-built" drawings

- .3 Do not splice "Corflex" cable unless justified by cable pulling tension calculations and when approved by the Consultant, and, if approved, locate splices where directed by the Consultant
- .4 Do not splice "Teck" cable unless justified by cable pulling tension calculations and when approved by the Consultant, and, if approved, locate splices where directed by the Consultant

3.2 INSTALLATION OF DISTRIBUTION AND BRANCH CIRCUIT CONDUCTORS

- .1 Provide all required conductors.
- .2 Non-Fire Rated Conductors: Unless otherwise specified herein or on the drawings, non-fire rated conductors are to be as follows:
 - .1 Conductors underground inside or outside the building, and in non-climate-controlled areas – TWU
 - .2 Flexible armoured cable AC90 (BX) may be used ONLY for short drops to lighting fixtures (not more than 1525 mm (5 ft.) per drop.)
- .3 "Corflex" Cable Installation Requirements: Install "Corflex" cable in accordance with the manufacturer's instructions, including the following requirements:
 - .1 Support and secure overhead suspended "Corflex" cable on a system of cable tray where indicated.
 - .2 Secure individual cables to cable tray or, where shown, directly to building surfaces by means of single screw non-ferrous clamps
 - .3 Ground and bond single conductor cable at both ends where the sheath currents do not affect the cable ampacity.
 - .4 for certain areas, where the sheath currents will reduce the cable ampacity, ground and bond the cable at the supply end and isolate the cable at the load end as recommended by the cable manufacturer, and provide a No. 3/0 AWG green TW ground conductor for each cable, all as per Section No. 10 of the Ontario Electrical Safety Code
- .4 "Teck" Cable Installation Requirements: Install "Teck" cable in accordance with the manufacturer's instructions, including the following requirements:
 - .1 support and secure overhead suspended "Teck" cable on a system of cable tray where indicated.
 - .2 secure individual cables to cable tray or, where shown, directly to building surfaces by means of single screw non-ferrous clamps.
 - .3 terminate cable with lugs and termination kits supplied with the cable.
- .5 Conductor Sizing: Generally, conductor sizes are indicated on the drawings. Unless otherwise specified, do not use conductors smaller than No. 12 AWG in systems over 30 volts. Unless otherwise specified, do not use conductors smaller than No. 6 AWG for exterior luminaire wiring. Conductor sizes indicated on the drawings are minimum sizes and must be increased, where required, to suit length of run and voltage drop in accordance with the voltage drop schedule found at the end of this Section.
- .6 Conductor Colour Coding: Unless otherwise specified, colour code conductors to

identify phases, neutral, and ground by means of self-laminating coloured vinyl tape, coloured conductor insulation, or properly secured coloured plastic discs. Colours are to be as follows:

- .1 phase A – red
- .2 phase B – black
- .3 phase C – blue
- .4 neutral – white
- .5 control – orange

3.3 MAXIMUM BRANCH WIRING DISTANCE FOR 120 VOLT SYSTEM AT 3% VOLTAGE DROP

Wire Size	Breaker Size (Amperes)	15	20	30	40	50	60	70	80	100
	Max. Load At 80% (Amperes)	12	16	24	32	40	48	56	68	80
No.12	---	22.0	16.0	---	---	---	---	---	---	---
No.10	---	36.0	27.0	18.0	---	---	---	---	---	---
No.8	---	59.0	44.0	30.0	22.0	---	---	---	---	---
No.6	---	91.0	70.0	47.0	35.0	28.0	23.0	---	---	---
No.4	---	---	109.0	73.0	54.0	42.0	35.0	30.0	25.0	---
No.2	---	---	---	114.0	85.0	68.0	57.0	50.0	41.0	35.0
No.1	---	---	---	---	103.0	85.0	73.0	61.0	50.0	43.0
No.1/0	---	---	---	---	128.0	102.0	85.0	73.0	60.0	48.0
No.2/0	---	---	---	---	---	121.0	100.0	86.0	74.0	60.0
No.3/0	---	---	---	---	---	---	118.0	102.0	88.0	70.0
No.4/0	---	---	---	---	---	---	---	120.0	102.0	83.0
250 MCM	---	---	---	---	---	---	---	---	114.0	91.0
300 MCM	---	---	---	---	---	---	---	---	---	103.0

NOTE: DISTANCES INDICATED IN METERS FROM PANEL TO LOAD FOR SINGLE PHASE.

END OF SECTION

1.01 RECOMMENDATIONS INCLUDED

- .1 Conform to the General Electrical Provisions, Section 26 05 01 as applicable.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- .1 Thermal and Moisture Protection Division 7
- .2 Submittals Section 26 05 02
- .3 Basic Materials and Methods Section 26 05

1.03 QUALITY ASSURANCE

- .1 Conform to the 2012 Ontario Building Code (OBC) Compendium containing the Building Code Act and including all amendments.
- .2 Conform to CAN4-S115-M "Standard Method of Fire Tests of Fire Stop Systems".

1.04 SUBMITTALS

- .1 Submit shop drawings in accordance with Section 26 05 02, paragraph 1.4 for the following items:
 - .1 Fire stopping materials.
 - .2 Manufacturers literature and installation instructions.
 - .3 Manufacturers Letter of Certification that project meets or exceeds specified requirements.
- .1 Additional manufacturers wishing to bid products other than the product specified herein, are to submit to Consultant prior to tender close a list of three past installations of products similar to those listed. Complete catalogue data along with deviations from the product specified are to be noted in the submittal to the Consultant. The manufacturer guarantees the proposed substitute product to comply with the product specified and as detailed on the drawings, unless the deviations are so noted in the submittal for approval.

2.01 FIRE STOP MATERIAL FOR SERVICE PENETRATIONS

- .1 Provide materials and systems capable of maintaining effective barrier against flame, smoke and gases.

- .2 Comply with the requirements of CAN4-S115-M35, and do not exceed opening sized for which they have been tested.
- .3 Systems to have an For FT rating (as applicable) not less than the fire protection rating required for closures in a fire separation.
- .4 The fire stopping materials are not to shrink, slump or sag and to be free of asbestos, halogens and volatile solvents.
- .5 Fire stopping materials are to consist of a component sealant applied with a conventional caulking gun and trowel.
- .6 Fire stop materials are to be capable of receiving finish materials in those areas which are exposed and scheduled to receive finishes.
- .7 Acceptable Manufacturers:
 - Fyresleeve
 - Industries Inc.
 - General Electric Pensil Firestop
 - Systems International Protective
 - Coatings Corp. Rectorseal
 - Corporation (Metacaulk) Prose
 - Systems
 - Minnesota Mining and
 - Manufacturing (3M). Tremco.
 - Hilti

3.01 INSTALLATION

- .1 Confirm location and extent of fire separations from architectural drawings.
- .2 Inspect surface to be fire stopped. Report unsatisfactory conditions to the Consultant in writing prior to commencement. Initiation of work to be deemed as acceptance of conditions and surfaces.
- .3 Store all materials in accordance with manufacturer's recommendations as to acceptable ambient temperatures. Damaged or deteriorated materials are not to be used and are to be removed from the site.
- .4 Install fire stopping and smoke seal material and components in accordance with ULC certification and manufacturers instructions in all conduit, cable, duct etc. penetrations in new or existing fire separation to provide temperature, flame and smoke rated seals not less than the fire resistance rating of the assembly, or separation.

-
- .5 Seal all holes made by through-penetrations and un-penetrated openings to ensure continuity and integrating of fire separation, including where existing component or device has been removed.
 - .6 Notify Consultant and/or Authority having jurisdiction for inspection prior to concealing or enclosing fire stopping materials and service penetrations.
 - .7 Remove excess material and debris and clean adjacent surfaces immediately after application. Leave in a tidy condition.

**END OF
SECTION**

1.01 REQUIREMENTS INCLUDED

- .1 Conform to Division 01, General Conditions and Section 260501, General Electrical Provisions as applicable.
- .2 Related Work
 - .1 Submittals Section 260502

1.02 DESCRIPTION

- .1 Changes and alterations to existing facilities and equipment caused by the work of this division.

1.03 EXISTING EQUIPMENT

- .1 All existing equipment and associated wiring and conduit specifically marked, shall be removed from the renovated area unless noted otherwise on drawings.
- .2 All existing equipment removed shall be handed over to the Owners and/or discarded at their discretion.

1.04 FAMILIARIZATION

- .1 It is this contractor's responsibility to visit the site and become thoroughly familiar with the existing building, equipment and systems prior to submitting tender price.

3.01 GENERAL

- .1 Provide under this Section for the relocation or re-routing of existing conduits and other electrical equipment remaining which are exposed during the work.
- .2 Where existing wall or ceiling is being removed and/or replaced or where new drywall is being installed on existing studs, remove and reinstall all electrical equipment and wiring. Use information from the site and from architectural drawings to determine this division's scope of work.
- .3 It is the responsibility of this division to patch and repair all surfaces affected by work of this trade. All patching and repairs must be done by an approved means acceptable to the Architect.

-
- .4 Refer to the asbestos audit for the building, prior to proceeding with work.
 - .5 Where asbestos will be disturbed in the execution of this contract, comply with the regulation respecting asbestos on construction projects and in buildings and repair operations made under the Occupational Health and Safety Act, Ontario Regulation 645/85 and local requirements pertaining to asbestos. Asbestos inspection reports have been bound into this specification for use by this Contractor. Employ only licensed asbestos removal Contractors to execute abatement of all asbestos.
 - .6 This Contractor shall visit the site and examine the existing conditions and make necessary allowances in his tender price for removal, rerouting, relocation and reconnecting of equipment as may be necessary for the execution and completion of this project.
 - .7 Wiring, conduits, etc., located in areas being altered or demolished, but feeding outlets or equipment required to remain in service shall be rerouted as required to maintain the continuity of these services to the satisfaction of the Engineer.
 - .8 Include for strapping existing conduits and cables that are not properly supported and are required to remain above the ceilings. Determine exact extent of work on site.
 - .9 This Contractor shall provide adequate protection to existing equipment throughout the project and particularly where wiring, piping, equipment, etc. have become exposed to mechanical injury or moisture in the course of the alternations.
 - .10 Existing distribution equipment in areas designated to be demolished shall be permitted to be reused only as indicated on the drawings.
 - .11 Existing equipment being reused shall be checked for proper operation. Reused equipment shall not have any sign of physical abuse or corrosion. Any knockouts removed in existing equipment being reused shall be plugged.
 - .12 All wiring made redundant due to demolition/renovation work shall be disconnected and removed to the nearest distribution point upstream that is not affected by demolition/renovation work. All concealed conduit made redundant due to demolition/renovation work may remain provided it does not adversely affect any new installations, unless it is noted to be removed on the drawings. All exposed conduit in finished areas made redundant due to demolition/renovation work shall be removed and the wall patched.

.13 Existing wiring devices shall be permitted to be reused as indicated on the drawings.

Existing outlet boxes may be reused if "as new" condition. Existing branch circuit wiring will only be permitted to be reused in existing non accessible walls/ceilings where the existing wiring is of adequate size, has acceptable bonding conductor and is as new condition.

.14 All existing panel schedules, zone legends and distribution equipment identification shall be reworked to reflect any changes made by any demolition/renovation work.

3.02 CHANGE OVER SERVICES

.1 To obtain permission for an interruption, submit a request at least two weeks before, stating the time the interruption is to begin, expected duration and the services and area affected. Where in the opinion of the Consultant it is advisable or desirable to maintain service in the area or any part of the area involved during the interruption, provide such temporary wiring, equipment, etc., as required or as may be deemed necessary by the Consultant to maintain services. No additional payments will be made for any additional

cost or inconveniences which may incur. Under NO circumstances will the Contractor's operation be allowed to interfere with or interrupt the tenants or the owners of the building

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- .1 Shop Drawings/Product Data: Submit shop drawings and product data sheets for products specified in this Section.
- .2 Test Reports: Submit signed test reports for all testing work specified.

2 PRODUCTS

2.1 GROUNDING AND BONDING CONDUCTORS

- .1 Equipment Grounding Conductors: Unless otherwise specified, insulated (green colour) stranded copper conductors, except that conductor #10 gauge and smaller may be solid copper.
- .2 Bonding Conductors: As for equipment ground conductors but bare copper.

2.2 GROUNDING AND BONDING CONNECTIONS

- .1 Below Grade: Equal to Erico International Corp. "Cadweld" exothermic welded connections.
- .2 Above Grade: Compression type connectors with zinc-plated fasteners and external tooth lock washers, or, if approved by the Consultant, exothermic connections as for below grade connections

3 EXECUTION

3.1 GENERAL ELECTRICAL WORK GROUNDING REQUIREMENTS

- .1 Perform all required electrical work grounding and bonding. Unless otherwise specified, grounding and bonding work is to be in accordance with requirements of CAN/CSA-C22.2 No. 0.4-04. Bonding of Electrical Equipment, and the requirements of all other governing authorities.
- .2 Bond metallic conduits, boxes, cable trays, ducts, and non-current carrying metal parts of equipment together to form a continuous ground system. In electrical equipment rooms, solidly bond circuits, switchgear, switchboards, panelboards, transformers, conduits, equipment enclosures, and other equipment to perimeter ground bus using bronze connectors and hardware.
- .3 Install connectors in accordance with the manufacturer's instructions.
- .4 Protect exposed grounding conductors from mechanical injury. Install underground conductors a minimum of 450 mm (18") below grade.
- .5 Use tinned copper conductors for aluminum structures.
- .6 Do not use bare copper conductors near un-jacketed lead sheath cables.

3.2 EQUIPMENT GROUNDING

- .1 Provide grounding connections to mechanical and electrical equipment as shown and/or specified on the drawings and in accordance with CAN/CSA C22.2 No. 0.4 and requirements of governing authorities.
- .2 Ground hinged doors of electrical equipment to the equipment enclosure main

frame using flexible jumpers.

3.3 NEUTRAL GROUNDING

- .1 Connect transformer neutral and distribution neutral together using 1000 volt insulated conductor to one side of ground test link, the other side of the test link being connected directly to the main station ground. Ensure that distribution neutral and neutrals of potential transformers and service banks are bonded directly to the transformer neutral and not to the main station ground.
- .2 Interconnect electrodes and neutrals at each grounding installation.
- .3 Connect the neutral of the station transformer to main neutral bus with a tap of the same size as the secondary neutral.
- .4 Ground the transformer tank with a continuous conductor from the tank ground lug through the connector on the ground bus to the primary neutral. Connect neutral bushing at the transformer to the primary neutral in the same manner.

END OF SECTION

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.3 SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

1.4 QUALITY ASSURANCE

- A. Listing and Labeling: Provide raceways and boxes specified in this Section that are listed and labeled.
 - 1. The Terms "Listed" and "Labeled": As defined in ESA.
- B. Comply with ESA.

1.5 COORDINATION

- A. Coordinate layout and installation of raceways and boxes with other construction elements to ensure adequate headroom, working clearance, and access.
- B. Provide a layout and installation of raceways and boxes to coordinate the work requirements for this and other Divisions:
 - 1. Coordinate installation with other trades.
 - 2. Route upward, and then horizontally in ceiling space to maximize space for other services.
 - 3. Avoid flanges of members that support hangers of other systems.

1.6 MANUFACTURERS

- A. Manufacturers: Unless otherwise directed by the Owner, provide products by one of the following:
 - 1. Metal Conduit and Tubing
 - a. Anamet, Inc.; Anaconda Metal Hose.
 - b. Grinnell Co.; Allied Tube and Conduit Div.
 - c. Triangle PWC, Inc.
 - 2. Nonmetallic Conduit and Tubing

- a. George-Ingraham Corp.
- b. Lamson & Sessions; Carlon Electrical Products.
- 3. Conduit Bodies and Fittings
 - a. Crouse-Hinds; Div. of Cooper Industries.
 - b. Emerson Electric Co.; Appleton Electric Co.
 - c. Hubbell, Inc.; Killark Electric Manufacturing Co.
 - d. O-Z/Gedney; Unit of General Signal.
- 4. Metal Wireways
 - a. Hoffman Engineering Co.
 - b. Square D Co.
- 5. Surface Metal Raceways
 - a. Wiremold Co. (The); Electrical Sales Division.
- 6. Boxes, Enclosures, and Cabinets
 - a. Appleton Electric Co.
 - b. Crouse-Hinds; Div. of Cooper Industries.
 - c. Hubbell Inc.; Killark Electric Manufacturing Co.
 - d. Hubbell Inc.; Racor, Inc.
 - e. O-Z/Gedney; Unit of General Signal.

1.7 METAL CONDUIT AND TUBING

- A. Rigid Steel Conduit: ANSI C80.1.
- B. IMC (Intermediate Metal Conduit): ANSI C80.6.
- C. EMT (Electrical Metallic Tubing) and Fittings: ANSI C80.3.
 - 1. Fittings: Compression type. Setscrew type not acceptable.
- D. FMC (Flexible Metal Conduit): Zinc-coated steel.
- E. LFMC (Liquidtight Flexible Metal Conduit): Flexible steel conduit with PVC jacket.
- F. Fittings: NEMA FB 1; compatible with conduit/tubing materials.

1.8 NONMETALLIC CONDUIT AND TUBING

- A. ENT (Electrical Nonmetallic Tubing): NEMA TC 13.
- B. RNC (Rigid Nonmetallic Conduit): NEMA TC 2, Schedule 40 or 80 PVC.
- C. ENT and RNC Fittings: NEMA TC 3; match to conduit or conduit/tubing type and material.
- D. LFNC (Liquidtight Flexible Nonmetallic Conduit): UL 1660.

1.9 METAL WIREWAYS

- A. Material: Sheet metal sized and shaped as indicated.

- B. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- C. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.
- D. Wireway Covers: Hinged type.
- E. Finish: Manufacturer's standard enamel finish.

1.10 OUTLET AND DEVICE BOXES

- A. Sheet Metal Boxes: NEMA OS 1.
- B. Cast-Metal Boxes: NEMA FB 1, Type FD, cast box with gasketed cover.

1.11 PULL AND JUNCTION BOXES

- A. Small Sheet Metal Boxes: NEMA OS 1.
- B. Cast-Metal Boxes: NEMA FB 1, cast aluminum with gasketed cover.

1.12 ENCLOSURES AND CABINETS

- A. Hinged-Cover Enclosures:
 - 1. NEMA 250, Type (1, 3R, 4, 7, 12, etc.) as specified
 - 2. Galvanized steel box
 - 3. Continuous hinged cover with flush latch.
 - 4. Finished inside and out with manufacturer's standard enamel. .
- B. Examine surfaces to receive raceways, boxes, enclosures, and cabinets for compliance with installation tolerances and other conditions affecting performance of raceway installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

1.13 WIRING METHODS

- A. Outdoors: Use the following wiring methods:
 - 1. Exposed: Rigid steel or IMC.
 - 2. Concealed: Rigid steel or IMC.
 - 3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 - 4. Boxes and Enclosures: NEMA 250, Type 3R or Type 4.

B. Communications

1. Provide raceways for telephone, data, audio-visual and other communication systems as noted.
 2. Provide a floor box raceway system in the conference room, for media system, as indicated.
- C. Indoors: Use the following wiring methods:
1. Exposed: Rigid steel conduit to 10 feet above floor and EMT above that point.
 2. Concealed: EMT.
 3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC; except in wet or damp locations, use LFMC.
 4. Underfloor, Damp or Wet Locations: Rigid steel conduit.
 5. Boxes and Enclosures: NEMA 250, Type 1, except as follows:
 - a. Production facilities: NEMA 250, Type 12.
 - b. Damp or Wet Locations: NEMA 250, Type 4, stainless steel, or Type 4X, fiberglass-reinforced polyester.

1.14 INSTALLATION

- A. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions and the following:
1. Provide minimum 1/2-inch trade size.
 2. Conceal raceway in finished walls, ceilings, and floors, unless otherwise indicated.
 3. Maintain at least 6 inches clearance from parallel flues, steam or hot-water pipes.
 4. Install level and square and at proper elevations.
 5. Provide adequate headroom.
 6. Complete installation before starting conductor installation.
 7. Use temporary closures to prevent foreign matter from entering.
 8. Protect stub-ups through floor slabs from damage.
 9. Make bends and offsets so as not to reduce the ID.
 10. Keep bends in the same plane and straight legs of offsets parallel.
 11. Provide fittings compatible with raceways and suitable for use and location.
 12. Provide threaded rigid steel conduit fittings for intermediate steel conduit.
 13. Route with a minimum of bends, in the shortest practical distance, considering the type of building construction and obstructions.
 14. Tighten setscrew fittings with suitable tools.
- B. Install exposed raceways parallel to or at right angles to nearby surfaces or structural members and follow the surface contours as much as practical.
1. Run parallel or banked raceways together, on common supports where practical.
 2. Make bends in parallel or banked runs from same centerline to make bends parallel. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.
- C. Join raceways with fittings designed and approved for the purpose and make joints tight.

1. Make raceway terminations tight.
2. Provide bonding bushings or wedges at connections subject to vibration.
3. Provide bonding jumpers where joints cannot be made tight.
4. Provide insulating bushings to protect conductors.

D. Terminations:

1. Align raceways to enter boxes squarely and install locknuts.
2. Provide one locknut inside and one outside a box where one locknut is not secure.
3. Screw raceways or fittings tightly into the hub so the end bears against the wire protection shoulder at threaded hubs,
4. Align raceways so the coupling is square to the box.
5. Tighten so that no threads remain exposed where chase nipples are used.

E. Install pull wires in empty raceways.

1. Provide #14 AWG zinc-coated steel or monofilament plastic line with not less than 200-lb tensile strength.
2. Provide at least 12 inches of slack at each end of the pull wire.

F. Telephone and Signal System Raceways, 2-Inch Trade Size and Smaller:

1. Install raceways in continuous lengths not to exceed 250 feet.
2. Install raceways with a maximum of four 90-degree bends or equivalent.
3. Provide pull or junction boxes where necessary to comply with these requirements.
4. Provide an insulating bushing for each conduit not terminated in a box or fitting.

G. Flexible Connections:

1. Use maximum of 6 feet of conduit for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and motors.
2. Provide liquid tight flexible conduit in wet or damp locations.
3. Provide separate equipment grounding conductor.

- H. Install hinged-cover enclosures and cabinets plumb. Support at each corner.

1.15 PROTECTION

- A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer that ensures coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

1.16 CLEANING

- A. After completion of installation, including outlets, fittings and devices:
1. Inspect exposed finishes.
 2. Remove burrs, dirt, and construction debris.

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3. Repair finishes that have damage such as chips, scratches, and abrasions.

END OF SECTION

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes identification of electrical materials, equipment, and installations.

1.3 QUALITY ASSURANCE

- A. Comply with ESA.

1.4 SEQUENCING AND SCHEDULING

- A. Coordinate and install electrical identification after completion of finishing where identification is applied to field-finished surfaces.
- B. Coordinate and install electrical identifying devices and markings prior to installing acoustical ceilings and similar finishes that conceal such items.

1.5 MANUFACTURERS

- A. Manufacturers: Unless otherwise directed by the Owner, provide products by one of the following:
 - 1. Almetek
 - 2. Brady USA, Inc.; Industrial Products Div.
 - 3. Carlton Industries, Inc.
 - 4. Ideal Industries, Inc.
 - 5. Panduit Corp.
 - 6. Seton Name Plate Co.

1.6 RACEWAY AND CABLE LABELS

- A. Underground Line Warning Tape: Permanent, bright-colored, continuous-printed vinyl tape with the following features:
 - 1. Size: Not less than 6 inches wide by 4 mils thick.
 - 2. Compounded for permanent direct-burial service.
 - 3. Embedded continuous metallic strip or core.
 - 4. Printed Legend: Indicates type of underground line.

1.7 ENGRAVED NAMEPLATES AND SIGNS

- A. Products: Refer to Detail Drawings.
- B. Engraving Stock, Laminate, and Legends: Refer to Detail Drawings.

- C. Fasteners for Plastic-Laminated and Metal Signs: Self-tapping stainless steel screws or No. 10/32 stainless steel machine screws with nuts and flat and lock washers.

1.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties with the following features:
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength: 50 lb minimum.
 - 3. Temperature Range: Minus 40 to 185 deg F.
 - 4. Color: As indicated where used for color coding.

1.9 INSTALLATION

- A. Install labels where indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.
- B. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations used for electrical identification with corresponding designations used in the Contract Documents or required by codes and standards. Use consistent designations throughout the Project.
- C. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.
- D. Self-Adhesive Identification Products: Clean surfaces of dust, loose material, and oily films before applying.
- E. Install Warning Labels on Enclosures containing voltages over 120 Volts: Use pressure-sensitive, self-adhesive label indicating highest voltage present. Letters to be black, preprinted on orange field. Install warning label on exterior of enclosure where plainly visible even when the enclosure door(s) are open or removed.
- F. Install Identification and Voltage Warning labels on electrical busway, including cable tab boxes, expansion sections, and bus plugs. Locate voltage warning labels every 50 feet on busway. Lettering of label to be a minimum of 3 inches tall and visible from plant floor.
- G. Install a warning label on the disconnecting device of a panel if the panel is interconnected to other equipment and remains energized from a source other than its disconnecting device. The sign shall be legible and shall read "Warning – Parts of the Control Panel are NOT de-energized by this Switch".
- H. Install Circuit Identification Labels on Boxes: Label externally as follows:
 - 1. Exposed Boxes: Pressure-sensitive, self-adhesive plastic label on cover.
 - 2. Concealed Boxes: Plasticized card-stock tags.
 - 3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.

- I. Install identification as follows:
 1. Apply equipment identification labels on each major unit of equipment, including central or master unit of each system. This includes communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Except as otherwise indicated, provide a single line of text with 1/2-inch-high lettering on 1-1/2-inch-high label; where 2-lines of text are required, use label 2 inches high. Use black lettering on white field. Apply labels for each unit of the following categories of equipment.
 - a. Panelboards, electrical cabinets, and enclosures.
 - b. Motor starters.
 - c. Contactors.
 2. Apply designation labels for disconnect switches, breakers, push buttons, pilot lights, motor control centers, and similar items for power distribution and control components above, except panelboards and alarm/signal components where labeling is specified elsewhere. For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- .1 Shop Drawings and Product Data: Submit shop drawings and product data sheets for disconnect switches and accessories. Ensure that the shop drawings and product data sheets indicate all features of the disconnects to confirm that the equipment is in accordance with the requirements of this Section.

2 PRODUCTS

2.1 DISCONNECT SWITCHES

- .1 Heavy-duty, CSA certified, quick-make/quick break action switches complete with a handle suitable for padlocking in the "off" position and arranged so that the door cannot be opened with the handle in the "on" position and an EEMAC enclosure. Fusible units are to be complete with fuse clips to suit fuse types specified below, without adaptors.
- .2 Fuses: Unless otherwise scheduled or specified fuses are to be equal to English Electric Ltd. HRC fuses, Form I Class "J" for constant running equipment and Form II Class "C" for equipment that cycles on and off.
- .3 Enclosures: Unless otherwise specified, enclosures are to be in accordance with the following NEMA/EEMAC ratings:
 - .1 all enclosures located in sprinklered areas – Type 2
 - .2 all enclosures exposed to the elements – Type 3R, constructed of stainless-steel.
 - .3 all enclosures inside the building in wet areas – Type 3R, constructed of stainless-steel.
 - .4 all enclosures in explosion rated area – Type 7 with exact requirements to suit the area and application.
 - .5 all enclosures except as noted above – Type 1
 - .6 all enclosures located in finished areas – as above but recessed type with brushed stainless steel faceplate.
- .4 Acceptable Manufacturers: Acceptable manufacturers are:
 - .1 Rockwell Automation (Allen-Bradley)
 - .2 Eaton Corp. (Cutler-Hammer)
 - .3 Siemens Canada
 - .4 Schneider Electric Ltd. (Square D)

3 EXECUTION

3.1 INSTALLATION OF DISCONNECT SWITCHES

- .1 Provide all required disconnect switches in accordance with drawing plans, schedules, details, and requirements of the Specification.
- .2 Provide fuses for fusible disconnects.
- .3 Refer to the Section titled, Wiring Requirements for Mechanical Equipment.

END OF SECTION

1 GENERAL

1.1 PRODUCT DATA COORDINATION

- .1 Shop Drawings and Product Data: If required, review shop drawings and product data sheets for mechanical equipment requiring wiring connections as part of the electrical work to ensure that all connection requirements are performed.

2 PRODUCTS

2.1 WIRING PRODUCTS

- .1 Wiring products such as conduit, conductors, boxes, etc., are to be as specified in appropriate Sections of this Division of the Specification.

3 EXECUTION

3.1 WIRING CONNECTIONS FOR MECHANICAL WORK

- .1 Unless otherwise specified or indicated, perform the following electrical wiring work:
 - .1 "line" side power wiring to motor starters or disconnect switches in motor control centres and "load" side wiring from the starters or disconnects to the equipment.
 - .2 "line" side power wiring to motor starters or disconnect switches on motor starter panels and "load" side wiring from the starters or disconnects to the equipment.
 - .3 "line" side power wiring to individual wall mounted starters, and "load" side wiring from the starters to the equipment
 - .4 "line" side power wiring to pre-wired power and control panels and "load" side power wiring from the panels to the motors
 - .5 "line" side power wiring to variable frequency drives and "load" side power wiring from the VFD's to the motors
 - .6 provision of receptacles for plug-in equipment
 - .7 provision of disconnect switches for all motors that are in excess of 10 m (30') from the power supply/starter location, or that cannot be seen from the power supply/starter location, and all associated power wiring.
 - .8 all motor starter interlocking in excess of 24 Volts.
 - .9 wiring from motor winding thermistors in motors 30 HP and larger to motor starter contacts
 - .10 provision of dedicated 120 volt, 15A-1P circuits terminated in junction boxes in mechanical equipment rooms for automatic control and building automation system wiring connections to be made as part of the automatic controls work.
 - .11 120-volt power connections to electrical receptacles integral with small ceiling exhaust fans, including wiring through light switches or speed controllers
 - .12 120-volt wiring connections to lighting fixture/switch combinations integral

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- with air handling units
 - .13 120-volt wiring connections to duplex receptacles integral with air handling unit control panels
 - .14 120- and 208-volt wiring connections to electric space heating units integral with air handling units.
 - .2 Mechanical wiring work not listed above or specified herein or on the drawings to be done as part of the electrical work will be done as part of the mechanical work.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- .1 Shop Drawings and Product Data: Submit shop drawings and product data sheets for wiring devices. Ensure that the sheets indicate all features of the devices to confirm that the devices are in accordance with requirements of this Section, including colours and faceplate finishes.

1.2 QUALITY ASSURANCE

- .1 All wiring devices are to be CSA certified as a minimum, in accordance with the following standards, as applicable:
 - .1 CAN/CSA C22.2 No 42, General Use Receptacles, Attachment Plugs and Similar Wiring Devices
 - .2 CAN/CSA C22.2 No 42.1, Cover Plates for Flush Mounted Devices
 - .3 CSA C22.2 No. 111, General Use Snap Switches
- .2 Wherever possible, all wiring devices are to be supplied by the same manufacturer.
- .3 Acceptable Manufacturers: Unless otherwise specified in this Section or on the drawings, acceptable manufacturers are:
 - .1 Hubbell Canada
 - .2 Cooper Industries (Arrow Hart)
 - .3 Legrand/Pass & Seymour
 - .4 Leviton Canada

1.3 WIRING DEVICE AND PLATE COLOURS

- .1 Unless otherwise specified, wiring device colours will be as specified in Part 3 of this Section.

2 PRODUCTS

2.1 SWITCHES

- .1 Unless otherwise specified, Specification Grade, Premium Quality, back and side wired, 20 ampere, 120 or 347 volt A.C. quiet action toggle switches, single pole, 2-pole, 3-way, 4-way or key type as indicated on the drawings, each complete with a nickel plated steel ground terminal, brass power wiring terminals and screws, silver cadmium oxide contacts with a moveable brass contact arm, and nylon toggle with colour as specified below. Switch types are as follows:
 - .1 Standard Wall Toggle Switches: As above.
 - .2 Decorative Wall Rocker Switch: Generally as specified above for standard toggle switches but rectangular decorative rocker type with rocker handles.
 - .3 Motor Control Snap Action Switch: Illuminated handle snap action horsepower rated switch CSA certified for motor control and sized to suit the application.

2.2 OCCUPANCY SENSOR SWITCHES

- .1 Combination passive infrared and ultrasonic sensor/switch assemblies with a rating to suit the connected load, wall (180° coverage) and/or ceiling mounted (360° coverage) as indicated on the drawings, white, almond or ivory colour as directed, each complete with time, range and light adjustments, adjustable blinders to block peripheral signals, a photocell to detect light to enable ambient light override, Fresnel lens, LED indicator which flashes when the sensor detects motion, and a manual on-off push button.

2.3 SPECIFICATION GRADE STANDARD RECEPTACLES

- .1 Back or side wired, U-ground, 2-pole receptacles as follows:
 - .1 15 Amp. 125 Volt Duplex Receptacle: 3-wire receptacles, NEMA configuration 5-15R
 - .2 15 Amp. 250 Volt Duplex Receptacle: 3-wire receptacles, NEMA configuration 6-15R
 - .3 20 Amp. 125 Volt Duplex Receptacle: 3-wire receptacles, NEMA configuration 5-20R
 - .4 20 Amp. 250 Volt Duplex Receptacle: 3-wire receptacles, NEMA configuration 6-20R

2.4 SPECIFICATION GRADE GROUND FAULT RECEPTACLES

- .1 Heavy-duty, 15/20 ampere, 125 volt, ULC Class "A", Group 1. automatic ground fault circuit interrupting duplex receptacles with a 10 kA short circuit current rating, automatic self-test diagnostics, green power on LED, and red ground fault LED. Ground fault receptacles for indoor climate controlled and outdoor or non-climate controlled areas are to be as follows:
 - .1 indoor climate controlled areas: equal to Hubbell Canada No. GFST20 "AUTOGUARD"
 - .2 outdoor areas and indoor non-climate controlled area: equal to Hubbell Canada No. GFR 5362 "AUTOGUARD"

2.5 DEVICE FACEPLATES

- .1 Device faceplates are to be ULC listed and CSA certified and, unless otherwise specified, supplied by the device manufacturer. Where two or more devices are installed in a common box, a common one-piece faceplate is to be used. Faceplate colours are specified in Part 3. Faceplates, unless otherwise specified, are to be as follows:
 - .1 Phenolic switch and receptacle faceplates, complete with color matching screws
 - .2 "Decorator" type Phenolic switch and receptacle faceplates
 - .3 type 302/304 stainless steel switch and receptacle faceplates, satin finish as directed, with stainless steel screws
 - .4 high impact smooth finish nylon switch and receptacle faceplates
 - .5 hot dipped galvanized steel switch and receptacle faceplates
 - .6 NEMA 3 rated, single gang, horizontal/vertical mounting, weather-proof in

- use, gasketed cast aluminum receptacle faceplates to suit the type of receptacle used
- .7 weather-proof, gasketed, water-tight single gang type 302 stainless steel switch plate with clear silicone rubber bubble over the switch toggle

3 EXECUTION

3.1 GENERAL RE: INSTALLATION OF WIRING DEVICES

- .1 Provide all required wiring devices and faceplates.
- .2 Confirm exact locations, including mounting heights, prior to roughing-in.
- .3 For barrier-free mounting heights for devices, conform to requirements of the governing code or regulation.
- .4 Ensure that switches located adjacent to doors are located at the strike side of the door. Confirm door swings prior to roughing-in.
- .5 Install single throw switches with the handle in the up position when the switch is closed.
- .6 Confirm all switch, receptacle and faceplate types, colours and finishes prior to ordering.
- .7 Faceplates for computer equipment receptacles are to be permanently identified with "Computer Equipment Only" wording.
- .8 Faceplates for housekeeping receptacles are to be permanently identified with "Housekeeping Only" wording.
- .9 Do not install faceplates for flush devices until wall, etc., finishing work is complete.

3.2 WIRING DEVICE AND FACEPLATE TYPES & COLOURS

- .1 Standard switches and receptacles in finished areas, non-essential circuits: white with stainless steel faceplates
- .2 'Decorator' switches and receptacles in finished areas, non-essential circuits: white
- .3 Switches and receptacles in unfinished areas, non-essential circuits: white with galvanized steel faceplates
- .4 Isolated power receptacles: orange.
- .5 Weather-proof receptacles: cast aluminum gasketed weather-proof faceplates to suit the type of receptacle installed.
- .6 Weather-proof switches and weather-proof gray neoprene press-switch plate and press switch.
- .7 Faceplates materials: stainless steel 302/304 satin finish

3.3 TESTING

- .1 When installation is complete, test operation of all devices.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- .1 Shop Drawings / Product Data: Submit shop drawings and product data sheets for lighting fixtures and lamps. Ensure that the drawings and sheets indicate all features of the fixtures to confirm that the equipment is in accordance with requirements of this Section. Include:
 - .1 certified fixture photometric data which includes total input watts, candlepower summary, candela distribution zonal lumen summary, luminaire efficiency, CIE type, coefficient of utilization, and lamp type and lumen rating in accordance with CSA IESNA testing procedures
 - .2 ballast and driver data such as maximum THD, power factor, and noise rating

1.2 QUALITY ASSURANCE

- .1 All lighting fixtures and lamps are to be ULC listed and/or CSA certified and labeled.

2 PRODUCTS

2.1 GENERAL RE: LUMINAIRES AND LAMPS

- .1 Luminaires and lamps are scheduled on the drawings.
- .2 All luminaires (lighting fixtures) are to be suitable in all respects for the mounting locations indicated on the drawings and are to be complete with all required mounting hardware.
- .3 Unless otherwise specified, any fixture operated by means of a driver must be equipped with its own driver.
- .4 Confirm exact colour and finish of luminaires at the submittals stage and prior to ordering.
- .5 Lamps and drivers for luminaires connected to dimmers are to be suitable in all respects for the application.
- .6 "GC and EC to provide itemized price for the lighting fixtures only".(This itemized price excludes controls)

2.2 LAMPS AND CONTROLS

- .1 Acceptable Lamp Manufacturers: Unless otherwise specified, acceptable lamp manufacturers are:
 - .1 LITHONIA
 - .2 SIGNIFY
 - .3 HUBBELL
 - .4 PHILIPS

Any deviations from specifications provided must be approved by Architect prior to tender close. Detailed fixture specifications and photometric calculations will be required to review or accept any proposed 'equals'.

- .2 Light Emitting Diodes (LED's): Current technology LED's with a minimum colour temperature of from [3500K] to [4100K], a minimum CRI of 80, a rated life of from 50,000 to 70,000 hours based on 70% lumen depreciation level, and heat sinks to remove heat from the bottom of the semiconductors. Acceptable manufacturers are Philips Color Kinetics, OSRAM Opto Semiconductors, Cree Inc., Nitchia Corp., and Philips Lumileds Lighting Co.
- .3 Compatible control systems as listed below; system functionality is described on the drawings.

LEGRAND/WATT STOPPER, LEVITON, ACCUITY, LUTRON, EATON, PHILIPS

LIGHTING FIXTURE SCHEDULE				
TYPE	DESCRIPTION	LAMPS	MTG	MANUFACTURER
L1	1'X4' LED FIXTURE, 3300LM, 3500K. CAT No.: CPANL 1X4 33LM 35K M4	LED, 31W	CEILING	LITHONIA LIGHTING
L2	2'X4' LED FIXTURE, 5000LM, 3500K. CAT No.: CPANL 2X4 50LM 35K M2	LED, 45W	CEILING	LITHONIA LIGHTING
L3	2'X4' LED FIXTURE, 4000LM, 3500K. CAT No.: CPANL 2X4 40LM 35K M2	LED, 36W	CEILING	LITHONIA LIGHTING
L4	2'X4' LED FIXTURE, 6000LM, 3500K. CAT No.: CPANL 2X4 60LM 35K M2	LED, 55W	CEILING	LITHONIA LIGHTING
D1	HIGH BAY LIGHT, 12000LM, 4000K. CAT No.: JEBL 12L 12000LM 40K 80CRI WH	LED, 95W	CEILING	LITHONIA LIGHTING
L5	2' LED FIXTURE, 3000LM, 3500K. CAT No.: DMW2 L24 3000LM MD MVOLT GZ10 35K 90CRI	LED, 27W	CEILING	LITHONIA LIGHTING

3 EXECUTION

3.1 INSTALLATION OF LUMINAIRES AND LAMPS

- .1 General Installation Requirements:
 - .1 Provide luminaires and lamps where shown. Include for all required site assembly, and provide all required installation and support hardware.
 - .2 Confirm exact luminaires locations prior to roughing-in.
 - .3 In finished areas, refer to architectural reflected ceiling plans and/or wall elevations.
 - .4 In equipment rooms, shafts, and similar unfinished areas install luminaires after the equipment is roughed-in, and shelving and similar items are installed.
 - .5 Prior to roughing-in for luminaire installations, examine drawings and site conditions to determine that suitable space is available for luminaire installations as shown. If sufficient space is not available, notify the Consultant immediately and, if required, relocate luminaires within reasonable distances without additional cost.
 - .6 Locate recessed downlights, troffers, and surface mounted luminaires in or on suspended tile ceilings in or on full tiles. Where ceiling tile openings are cut for fixtures cut to exact sizes so that there are no gaps and fixture trim completely covers the perimeter of the opening.
 - .7 Provide plaster frames for luminaires in suspended plaster or drywall ceilings.
 - .8 Use clean gloves when handling reflector cones, louvers, halogen lamps, glass, sconces, and all exposed surfaces of fixtures.

3.2 SUSPENDED LUMINAIRES

- .1 Support luminaires in suspended ceilings from the slab or building construction above independent of the suspended ceiling construction, with a minimum of two aircraft type cable supports and in accordance with requirements of governing Codes and Regulations.
- .2 Support continuous rows of luminaires at minimum 1.2 m (48") centres.
- .3 Fixture support hardware in high humidity areas is to be corrosion resistant.

3.3 LUMINAIRE ALIGNMENT

- .1 Align luminaires mounted in continuous rows to form straight uninterrupted lines. Alignment variation is not to exceed 6 mm (1/4") in any 5 m (16') run.
- .2 Align luminaires mounted individually parallel and/or perpendicular to building lines.
- .3 Aim accent and spot lighting as indicated and/or as directed by the Consultant, and secure the fixture positions after the Consultant's approval.

3.4 LAMPS

- .1 Provide new lamps for each luminaire.
- .2 Include a full listing of lamps in O & M Manuals.
- .3 At Substantial Performance, replace all lamps used for construction lighting.

3.5 LUMINAIRE CIRCUIT WIRING

-
- .1 Connect luminaires to circuits indicated with wiring as specified.

3.6 EXISTING LUMINAIRES

- .1 Where existing luminaires are to be reused, examine the luminaires during the bidding period and include for replacing faulty ballasts, broken lenses, and any other obvious damage, include for replacing all lamps at Substantial Performance, and conform to the following requirements:
- .1 Relocated Luminaires: Disconnect, safely store where directed, relocate and reinstall.
 - .2 Obsolete Luminaires: Unless otherwise directed, disconnect and remove, identify and make wiring safe, and dispose of the luminaires off-site in an approved manner.
 - .3 Existing Luminaires With PCB Ballasts: If existing luminaires to be removed are equipped with ballasts that contain PCB's, engage the services of a disposal company licensed by the MOE to remove and destroy PCB ballast to remove the ballasts and destroy them off-site at an approved facility. The disposal company is to be fully insured, registered and in good standing with the WSIB, and is to issue a Certificate of Destruction upon completion of the work.

3.7 CLEANING

- .1 When all luminaire installation work is complete, clean all luminaries and lamps, and any ceiling, wall, etc., surfaces soiled as a result of the luminaire installation work.
- .2 If wall and ceiling surfaces are damaged as a result of the luminaire installation, replace the wall or ceiling surface to the Consultant's approval.

3.8 OWNER TRAINING AND COMMISSIONING

- .1 Provide material such as vendor information and present to the client's team for a two-hour period in a classroom. Allow for an additional two hours of practical demonstration of the commissioning of the system.

3.9 LIGHTING AND CONTROLS WARRANTY

- .1 Provide a full warranty for the systems for all components in the system. This shall include for all costs for any required site visits, trouble shooting and replacement of defective components.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- .1 Shop Drawings/Product Data: Submit shop drawings and product data sheets for exit lighting fixtures and lamps. Ensure that the drawings and sheets indicate all features of the fixtures to confirm that the equipment is in accordance with requirements of this Section.

1.2 QUALITY ASSURANCE

- .1 All exit lighting fixtures are to be CSA certified in accordance with:
 - .1 CSA C22.2 No. 141, Unit Equipment for Emergency Lighting
 - .2 CSA C860, Performance of Internally-Lighted Exit Signs

2 PRODUCTS

2.1 EXIT LIGHTS

- .1 Recessed, wall, end to wall, or ceiling mounted, single or double face exit lights as indicated, complete with directional arrows as shown, 120 volt, LED's maximum 5 watt consumption, designed for a minimum of 50,000 hours of continuous operation without re-lamping, mounting accessories, and the following:
 - .1 Housing constructed of one-piece extruded aluminum with baked white enamel finish.
 - .2 Faceplates constructed of extruded aluminum with knock-out directional chevrons and baked white enamel finish.
 - .3 Pictogram "Running Man" legend.
 - .4 LED sensitive diffuser mounted behind the legend to provide the exit letters with even illumination.
 - .5 An average exit legend illumination level of 79 cd/m2 (7.34 cd/ft2)
 - .6 wireguard where indicated
 - .7 An emergency power source
- .2 Acceptable manufacturers are:
 - .1 Canlyte Inc. "Uniglo"
 - .2 Lumacell Inc.
 - .3 Emergi-Lite Ltd.
 - .4 Hubbell Inc. "Dual-Lite"
 - .5 Luxnet Corp.
 - .6 Beghelli
 - .7 Philips "Lightguard"
 - .8 Stanpro

3 EXECUTION

3.1 INSTALLATION OF EXIT LIGHTS

- .1 Provide exit lights where shown. Include for all required site assembly and

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- provide all required installation and support hardware.
 - .2 Confirm exact exit light locations prior to roughing-in.
 - .3 Connect exit lights to circuits indicated with wiring as specified. Install wiring in conduit. Ensure that panelboard breakers serving exit lights are equipped with lock-on devices.
 - .4 Provide all required lamps.
 - .5 When all exit light installation work is complete, clean all fixtures and lamps, and any ceiling, wall, etc., surfaces soiled as a result of the installation work.
 - .6 If wall and ceiling surfaces are damaged as a result of the installation, replace the wall or ceiling surface to the Consultant's approval.

END OF SECTION

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes installation of Owner furnished service and distribution switchboard rated 600 V and less.
- B. Related Sections include the following:
 - 1. Division 26 Section "Identification for Electrical Systems" for identification requirements of electrical components.

1.3 QUALITY ASSURANCE

- A. Comply with OESC and OBC.

1.4 COORDINATION

- A. Coordinate layout and installation of switchboard and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.5 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

1.6 EXAMINATION

- A. Examine elements and surfaces to receive switchboard for compliance with installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

1.7 INSTALLATION

- A. Install switchboards and accessories according to NEMA PB 2.1 and OESC.

- B. Install and anchor switchboards level on concrete bases, 4-inch nominal thickness. Concrete base is specified in Division 26 Section "Common Work Results for Electrical," and concrete materials and installation requirements are specified in Division 3.
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
 - 2. For switchboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to switchboards.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
- D. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
- E. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
 - 1. Set field-adjustable circuit-breaker trip ranges.

1.8 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."
- B. Switchboard Nameplates: Label each switchboard compartment with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

1.9 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Sections 7.1, 7.5, 7.6, 7.9, 7.10, 7.11, and 7.14 as appropriate. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

1.10 CLEANING

- A. On completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

1.11 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories.

END OF SECTION

1.1 RELATED DOCUMENTS

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

This Section includes installation of lighting, receptacle, splitter box, and power distribution panelboards and associated auxiliary equipment rated 600 V and less.

1.3 SUBMITTALS

Copies of circuit directory for each panelboard.

1.4 QUALITY ASSURANCE

Comply with ESA.

Comply with NEMA PB 1.

1.5 MANUFACTURERS

Manufacturers: Unless otherwise directed by the Owner, provide products by one of the following:

Panelboards, Overcurrent Protective Devices, Controllers, Contactors, and Accessories:

- a. Eaton Corp.; Cutler-Hammer Products.
- b. General Electric Co.; Electrical Distribution & Control Div.
- c. Siemens Energy & Automation, Inc.
- d. Square D Co.

1.6 FABRICATION AND FEATURES

Enclosures: Column-width or standard-width cabinets. NEMA PB 1, Type 1, to meet environmental conditions at installed location.

Fabricate cabinets from code-gauge galvanized or phosphatized sheet steel having primed and finish paint surfaces with manufacturer's standard finish.

Provide gutter space to accommodate size of cable used in accordance with NEC.

Multiple-section panels shall have full capacity main bus in each section.

Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.

Directory Card: With transparent protective cover, mounted inside metal frame, inside panelboard door.

Bus: Hard-drawn copper, 98 percent conductivity.
All buses shall be un-tapered with full rated capacity throughout.

Main, Neutral and Ground Lugs: Suitable for use with conductor material.
Under 200A: Copper mechanical type lugs.
200A and Greater: Copper compression/crimp type lugs.

Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.

1.7 SPLITTER RACEWAYS

Splitter raceways shall be steel enclosure, hinged cover, with lock hasp, minimum 36" in length for NEMA type 1 environment, with 225A terminal blocks for phases and ground conductor terminations.

1.8 OVERCURRENT PROTECTIVE DEVICES

Branch Overcurrent Protective Devices:

Bolt-on circuit breakers: replaceable without disturbing adjacent units.
Fully rated to interrupt symmetrical short-circuit current available at terminals

Molded-Case Circuit Breaker:

NEMA AB 1, with interrupting capacity to meet available fault currents.
Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

Fusible Switches: Quick-make, quick-break type, horsepower rated up to 200 amperes.
Equip the switch with external operating handle and interlock with the cover door to prevent opening in the "ON" position.
Incorporate means for padlocking the operating handle in the "OFF" position with a minimum of three 5/16 inch shackle padlocks.
Equip the switches with Class J rejection type fuse clips and Class J fuses as specified to obtain a short circuit rating of 100,000 A.I.C., minimum.

1.9 INSTALLATION

Install panelboards, splitter raceways, and accessory items according to NEMA PB 1.1.

Mounting Heights: Top of trim 74 inches above finished floor, unless otherwise indicated.

Mounting: Plumb and rigid without distortion of box. Mount flush panelboards uniformly flush with wall finish.

Circuit Directory: Type directory to indicate installed circuit loads after balancing panelboard loads. Obtain approval through submittal prior to installing.

Install filler plates in unused spaces.

Wiring in Panelboard Gutters: Arrange conductors into groups, and bundle and wrap with wire ties after completing load balancing.

1.10 IDENTIFICATION

Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

Panelboard Nameplates: Label each panelboard with engraved laminated-plastic or metal nameplates mounted with corrosion-resistant screws.

1.11 CONNECTIONS

Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

1.12 FIELD QUALITY CONTROL

Operate main and branch devices to insure proper mechanical operation.

Verify proper connection of wire terminations.

1.13 CLEANING

On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and marks of finish to match original finish.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- .1 Shop Drawings/Product Data: Submit shop drawings and product data sheets for the fire alarm system. Ensure that the shop drawings and product data sheets indicate all features of the system and its components to confirm that the system is in accordance with requirements of this Section. Include the following:
 - .1 identified wiring schematics with component identification and product/catalogue numbers for the central control facility and all associated components
 - .2 Complete documentation of system(s) testing.
 - .3 Certification that the system has been inspected and tested, is/are installed entirely in accordance with the applicable codes, standards, manufacturer's recommendations and ULC listings, and is/are in proper working order.
- .2 Submittals To Fire Authority: Submit to the local fire authority at the same time as submittal to the Consultant, all items required by subparagraphs of paragraph .1 above.
- .3 System Review and Confirmation: As specified in Part 3 of this Section, submit a letter from the system manufacturer/supplier which confirms that the system has been properly installed in accordance with issued installation instructions, and an inspection and test report in accordance with CAN/ULC-S536.
- .4 Manufacturer's Support of System Components: Submit, on the system manufacturer's letterhead and signed by a signing officer of the company, a written declaration that manufacturer will supply system replacement parts for a minimum of ten years from Substantial Performance of the work.
- .5 As-Built Record Drawing Requirements: In addition to all other "as-built" conditions, indicate on as-built record drawings the locations of all end-of-line resistors and all line isolation modules.
- .6 Independent Third Party Testing and Verification Agency: Submit the name, qualifications, and certification of the independent third party testing and verification agency proposed for the project.
- .7 Certificate of Insurance: As specified in Part 3, submit a Certificate of Insurance covering testing and verification of the fire alarm system.
- .8 Extended Warranty: Submit a signed extended warranty in the name of the Owner covering the entire fire alarm system for a period of two years after the Contract warranty expires. The terms of the extended warranty are to be full parts and on-site labour as for the Contract warranty.

1.2 QUALITY ASSURANCE

- .1 The fire alarm system and its installation is, as applicable, to be in accordance with requirements of the following:
 - .1 CSA B222, Installation Code for Local Fire Alarm Systems
 - .2 CSA C22.2 No. 208, Fire Alarm and Signal Cable
 - .3 CAN/ULC-S524, Standard for the Installation of Fire Alarm Systems
 - .4 CAN/ULC-S525, Audible Signal Devices for Fire Alarm Systems,

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- .5 Including Accessories
 - .5 CAN/ULC-S526, Visual Signal Devices for Fire Alarm Systems, Including Accessories
 - .6 CAN/ULC-S527, Control Units for Fire Alarm Systems
 - .7 CAN/ULC-S528, Manual Pull Stations for Fire Alarm Systems, Including Accessories
 - .8 CAN/ULC-S529, Smoke Detectors for Fire Alarm Systems
 - .9 CAN/ULC-S530, Heat Detectors
 - .10 CAN/ULC-S531, Smoke Alarms
 - .11 CAN/ULC-S533, Egress Door Securing and Release Devices
 - .12 CAN/ULC-S536, Inspection and Testing of Fire Alarm Systems
 - .13 CAN/ULC S537, Standard for the Verification of Fire Alarm Systems
 - .14 CAN/ULC-S552, Maintenance and Testing of Smoke Alarms
 - .15 CAN/ULC-S553, Installation of Smoke Alarms
 - .16 CAN/ULC-S559, Equipment for Fire Signal Receiving Centres and Systems
 - .17 CAN/ULC-S561, Installation and Services for Fire Signal Receiving Centres and Systems
 - .18 ULC/ORD 693, Central Station Fire Protective Signalling
 - .19 ULC-S548, Alarm Initiating and Supervisory Devices for Water Type Extinguishing Systems
 - .20 National, Provincial and Local Building Codes
 - .21 Ontario Electrical Safety Code
 - .2 System Components: All system components are to be ULC listed and labelled in accordance with standards listed above, and, unless otherwise specified, are to be supplied by a single manufacturer. All components must be suitable in all respects for conditions of the installation location. Any equipment not bearing a ULC label shall be removed and replaced with compatible ULC labelled equipment at the Contractors expense.

1.3 WARRANTY PERIOD REQUIREMENTS

- .1 The system manufacturer/supplier must have a local repair and maintenance facility and must respond to any system operational problem during the warranty period (including the extended warranty) within four hours of notification by the Owner, twenty-four hours a day, seven days a week.
- .2 The system manufacturer/supplier is to maintain accurate record of each warranty call to the site and document the date and time of the call, the reason for the call, and the duration and type of the corrective action taken.
- .3 During the warranty period, any spare parts in the Owner's possession are to be replaced if used for corrective actions.
- .4 Include for a one year no cost (to the Owner) maintenance period to commence at notification of Substantial Performance and which is to include two site inspections of the system with reports. Inspections are to be scheduled with the Owner and Consultant.

1.4 SOFTWARE REVISIONS

- .1 After successful testing, verification and commissioning of the system, but prior to turn over to the Owner, obtain a list of final room, area, and , if applicable, building names and revise system software to incorporate all required revisions.
- .2 Include for an additional software update to suit any requirements of governing authorities.
- .3 In addition to programming revisions specified above, include for, after system turn over to the Owner, another site visit to make any supplementary software revisions requested by the Owner.
- .4 Where the work is phased and completed phases will be accepted and occupied by the Owner, include for requirements of paragraphs .1 to .3 above for each such phase.

1.5 WASTE MANAGEMENT AND DISPOSAL

- .1 Separate and recycle waste materials in accordance with requirements specified in the Section entitled Basic Electrical Materials and Requirements.

1.6 ACCEPTABLE MANUFACTURERS

- .1 To match existing.

1.7 GENERAL

- .1 Provide all labour, services and materials necessary to provide and install a complete, functional life safety fire system. The System shall comply in respects with all pertinent codes, rules, regulations and laws of the local Authority Having Jurisdiction. The System shall comply in all respects with the requirements of these specifications, manufacturer's recommendations and Underwriters' Laboratories of Canada (ULC) listings.
- .2 This Fire Alarm / Life Safety System Specification must be conformed to, in its entirety to ensure that the installed and programmed Life Safety System will function as designed, and will accommodate the future requirements and operations required by the building owner. All specified operational features must be met without exception.
- .3 Upon completion of this work, Provide the Owner with: Complete information and drawings describing and depicting the entire system(s) as installed, including all information necessary for maintaining, troubleshooting, and/or expanding the system at a future date.
- .4 The system shall include, but not be limited to:
 - .1 Fire alarm control panel and remote annunciator(s).
 - .2 Automatic and manually activated alarm initiating and monitoring devices
 - .3 Audible and Visual Notification appliances and peripherals
 - .4 Standby power supplies
 - .5 System programming and commissioning.
 - .6 Training of operators
 - .7 Conduit, wire, and accessories required to provide a complete and operational life safety system

1.8 DEFINITIONS / ABBREVIATIONS

- .1 AFF: Above Finished Floor.
- .2 AHJ: Authority Having Jurisdiction.
- .3 Approved: Unless otherwise stated, materials, equipment or submittals approved by the Authority or AHJ.
- .4 Circuit: Wire path from a group of devices or appliances to a control panel or transponder.
- .5 Class A Circuit: (Return Loop Circuit) – A circuit having one continuous path connecting all components on the circuit and terminating through an alternate connection path in the source enclosure.
- .6 Class B Circuit: (Terminated Circuit) – A circuit having one continuous path connecting all devices on the circuit and terminating at an end-of-line device.
- .7 CPU: The central computer of a multiplex fire alarm or voice command control system.
- .8 Data communications Link (DCL): the data channel between the control units, annunciators, active field devices and supporting field devices of a distributed type system.
- .9 FACP: Fire Alarm Control Panel.
- .10 HVAC: Heating Ventilating and Air Conditioning.
- .11 IDC: Initiating Device Circuit.
- .12 LED: Light Emitting Diode.
- .13 LCD: Liquid Crystal Display.
- .14 NAC: Notification Appliance (Signal) Circuit.
- .15 ULC: Underwriters Laboratories of Canada
- .16 ULC Listed: Materials or equipment listed and included in the most recent edition of the ULC Fire Protection Equipment Directory.
- .17 Zone: Combination of one or more circuits or devices in a defined building area, i.e. 3 circuits on a floor combined to form a single zone.

1.9 SYSTEM DESCRIPTION

1.10 EXISTING SYSTEMS

- .1 Before construction begins on any phase as outlined in architectural contract documents, the fire alarm system verification and certification contractor shall verify the existing fire alarm system.
- .2 At the beginning of each construction phase, existing initiating devices, in the area of construction, shall be disconnected and removed. Provide in area of construction, during the construction period, temporary life safety devices and/or fire watch personnel as required by applicable codes.
- .3 At the completion of construction, at completion of each phase of construction, and after attaining Substantial Performance, and after verification and certification of the total system the verification and certification contractor shall insert on Autocad CD floor plans supplied by the Consultant, the address of each intelligent/addressable initiating and signal device and each intelligent/addressable module for non-addressable fire alarm zones and each non-addressable initiating and signal device. The Autocad version shall match that of the contract drawings. Submit a copy of the record CD to the Contractor and to the Consultant. Include a verification statement as per CAN/ULC-S537.

2 PRODUCTS

2.1 MANUFACTURER

- .1 The manufacturer of the system equipment shall be regularly involved in the design, manufacture, and distribution of all products specified in this document. These processes shall be monitored under a quality assurance program that meets the ISO 9001:2008 requirements.
All System components shall be the catalogued products of a single supplier. All products shall be listed by the manufacturer for their intended purpose.
All control panel assemblies and connected field appliances shall be both designed and manufactured by the same company, and shall be tested and cross-listed as to ensure that a fully functioning is designed and installed. The system supplied under this specification shall be a microprocessor-based, direct wired, multi-priority peer-to-peer networked system. The system shall utilize electronically addressed, microprocessor-based smoke detectors, heat detectors, and modules as described in this specification.
- .2 Notification Appliance Circuits:
 - .1 Provide as indicated on the plans, supervised hard-wired Notification Appliance (Signal) Circuits (NAC) for the control of 24Vdc notification appliances.
 - .2 NAC's shall be capable of providing steady, 20bps, 120bps or temporal rate outputs.

2.2 FIELD MOUNTED SYSTEM COMPONENTS

- .1 Analytical Microprocessor-based Addressable Detectors - General:
 - .1 Early warning analog addressable detectors shall use state-of-the-art multi-sensor or technology. Each detector shall incorporate a microprocessor capable of making alarm decisions based on fire parameter algorithms stored in the detectors head. The microprocessor shall evaluate all sensing elements simultaneously and take into account real-time environmental conditions and the duration of an event, resulting in reliable and accurate decisions that distinguish real fire conditions from unwanted deceptive nuisance alarms. Digital filters shall eliminate signal patterns that are not typical of fires. Detectors that use the control panel processor to make alarm decisions are not acceptable.
 - .2 Addressable detectors shall be capable of full digital communications using both broadcast and polling protocols. The maximum total analog loop response time for detectors shall be 750 ms.. The maximum alarm response time for the system to sound an alarm shall not be more than 3-seconds regardless of the detector location or the number of detectors on the addressable loop. The analog loop controller shall support up to 250 devices including 125 modules, 125 detectors and 125 isolator bases. The analog loop must not require shielded wire and shall be capable of a total distance of 1219 m (4000 feet) minimum using #18AWG twisted pair when 100 addressable detectors and 100 addressable modules are

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- connected. The analog loop shall support up to 124 wiring T-taps.
- .3 Each detector shall have the ability to learn its environment and automatically adjust its reference value for changes in its environment. Detectors that require adjustments to their sensitivity settings months after they are installed are not acceptable. Environmental compensation shall allow each sensing element to adapt to short and long term changes caused by dirt, dust, humidity, temperature and ageing. The detector shall adjust and update its sensitivity (% obscuration) and ambient temperature baselines for each sensing element approximately six times per hour. The detector shall utilise a 4-hour rolling average of the environmental information and for verification purposes also maintain a 24-hour average of the analog values, both of which may be taken into account in the alarm decision making process.
- .4 The detectors on-board micro-processor shall monitor the environmental effects on its baseline and generate a "maintenance alert" message at the control panel when the detectors environmental compensation is 80% used up indicating it should be cleaned. This event shall be programmable to initiate any type of system response such as send a pocket pager message to maintenance. When the environmental compensation head room is 100% used up, a trouble condition shall latch on the system to advise that the detector requires cleaning immediately. Up to this point the detectors sensitivity shall not have been compromised. Dirty detectors that continue to be ignored will eventually post an internal device fault and will not false alarm as a result of the accumulation of dirt. Dirty detectors that false alarm if not cleaned are not acceptable.
- .5 The detector shall be capable of identifying up to 32 self-diagnostic codes including verification that the detectors reference value is within its prescribed factory and ULC limits. Sensitivity reports shall include the percent obscuration that the detectors alarm level is set at and the percentage of compensation used as a result of environmental factors (dirt, dust, humidity, etc). This information shall be available for system maintenance and may be requested per device or generate reports based on only the detectors that require cleaning.
- .6 The early warning analog addressable detectors and the analog loop controller shall provide increased reliability and inherent survivability through intelligent analog conventional operation. Detectors shall automatically change to stand alone, conventional device operation in the event of a loop controller polling communications failure. In the analog conventional detector mode, each detector shall continue to operate using its programmed sensitivity and "learned" environmental information stored in the detector's memory at the time of communication failure. The analog loop controller shall be capable of monitoring the loop and activating a loop alarm, without communicating to the devices, if any detector reaches its alarm sensitivity threshold.
- .7 Each Signature Series device shall be capable of automatic electronic addressing and/or custom addressing without the use of DIP or rotary

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- switches. Devices using DIP or rotary switches for addressing, either in the base or on the detector shall not be acceptable.
- .8 Each detector shall have a separate means of displaying communication and alarm status. A green LED shall flash to confirm normal status communication with the analog loop controller. A red LED shall flash to display alarm status. Both LED's on steady shall indicate an alarm in the conventional stand-alone mode status. The LEDs shall be visible through a full 360 degree viewing angle.
- .9 It shall be possible to matrix program Signature analog detectors. Responses shall be programmable based on activated detectors within the physical location to one another and/or the number of activated detectors in a programmable group or groups.
- .10 All detectors shall be compatible with all Signature Series mounting bases.
- .2 Detectors – 3D Multi-Sensor Detectors (Photoelectric, Thermal & Time)
- .1 Provide intelligent Signature Series 3D multi-sensor smoke detectors. The multi-sensor analog detector shall gather analog information from each of its two sensors: a light scattering type photoelectric sensor and an ambient temperature sensor. The integral microprocessor shall employ time-based algorithms to dynamically examine values from each sensor simultaneously and make an alarm decision based on that data. Separately mounted photoelectric and heat detectors in the same location are not acceptable alternatives.
- .2 Each detector shall be capable of adapting to ambient environmental conditions and the integral heat sensor shall be capable of causing an alarm when it reaches its fixed temperature alarm set point of 57°C (135°F) nominal.
- .3 The detector shall have a ULC Smoke Sensitivity Range of 0.67-3.7% obscuration/ft 305mm (foot). The alarm smoke obscuration per foot setting shall be field selectable to any one of five sensitivity settings ranging from 1.0% to 3.5%. The pre-alarm smoke obscuration per foot setting shall be field selectable in .05% increments for a total of 19 selections per sensitivity setting starting at 0.05% smoke obscuration per foot. Multi-sensor analog detectors shall be capable of an automatic day/night alternate sensitivity adjustment for both alarm and pre-alarm thresholds. Alarm and pre-alarm events shall have independent programmable responses. The pre-alarm message shall display in the monitor queue and the alarm message in the alarm queue.
- .4 The multi-sensor detectors shall be suitable for area protection and for direct insertion into air ducts up to 0.91m (3 ft) high and 0.91m (3 ft) wide and air velocities up to 25.4 m/sec (5000 ft/min.) without requiring specific duct detector housings or supply tubes. The multi-sensor detector shall be rated for ceiling installation with maximum 9.1m (30-foot) centers. For clean room applications requiring very early warning pre-alarm sensitivities, recommended area coverage is 18.6m² (200 square feet).
- .5 The detector shall be protected by a ULC listed protective guard in areas where subjected to mechanical damage or abuse. The design must be

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- 100% compatible with the detector and must not affect the detector sensitivity or reduce detector spacing. The guard shall be low profile and suitable for flush or surface mounted detectors.
 - .6 The multi-sensor detector shall be suitable for operation in the following environment:
 - .1 Temperature: 0°C to 38°C (32°F to 100°F)
 - .2 Humidity: 0-93% RH, non-condensing
 - .3 Elevation: no limit
 - .3 Detectors - Photoelectric Smoke Detector, (Duct Detector Use)
 - .1 Photoelectric detector shall utilize a light scattering type photoelectric smoke sensor to detect visible particulates produced by combustion. The integral microprocessor shall dynamically examine values from the sensor and initiate a system alarm based on the analysis of data.
 - .2 The alarm set point shall be field selectable to any of five sensitivity settings ranging from 1.0% to 3.5% smoke obscuration per foot. The photo detector shall be suitable for operation in the following environment:
 - .1 Temperature: 0°C to 49°C (32°F to 120°F)
 - .2 Humidity: 0-93% RH, non-condensing
 - .3 Elevation: no limit
 - .4 Duct Detector Housing:
 - .1 The Analytical Microprocessor-based photoelectric smoke detector shall be readily adaptable for use in air duct smoke detection applications, using a housing that mounts to the outside of the duct. When used for duct smoke detection, the smoke detectors will not forfeit any of the system functionality that they have when used as area smoke detectors.
 - .2 The duct smoke detection housing shall allow the detector to sample and compensate for, variations in duct air velocity between 91 and 1219 m (300 and 4,000 feet) per minute.
 - .3 Remote alarm LEDs and Remote Test Stations shall be supported by the duct smoke detector and provided where indicated.
 - .5 Detectors – Combination Fixed Temperature/Rate of Rise Heat Detector
 - .1 Heat Detector shall have a solid state heat sensor, and shall transmit an alarm at a fixed temperature of 57°C (135°F) or due to a temperature Rate of Rise of 9°C/minute (15°F/minute). The detector shall continually monitor the temperature of the air in its surroundings to minimize thermal lag to the time required to process an alarm.
 - .2 The heat detector shall be rated for ceiling installation at 21.3m (70 ft) centers and be suitable for wall mount applications.
 - .6 Detectors - Fixed Temperature Heat Detector,
 - .1 Heat detector shall have a solid-state heat sensor, and shall transmit an alarm at a fixed temperature of 57°C (135°F). Detector shall continually monitor the temperature of the air in its surroundings to minimize thermal lag to the time required to process an alarm.
 - .2 Heat detector shall be rated for ceiling installation at 21.3m (70 ft) centers and be suitable for wall mount applications.
 - .7 Detectors - Mounting Bases
 - .1 Mounting bases shall support all microprocessor-based detector types

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- detailed in this specification
- .2 Removal of the respective detector shall not affect communications with other addressable devices.
 - .3 Field wiring connections shall be made to the room side of the base, so that wiring connections can be made or disconnected by the contractor without the need for remove the mounting base from the electrical box.
 - .4 Bases will have the option of external LED operation, Relay Base or Data Line Isolator Base.
 - .5 The relay base shall support all Addressable Detector types and have the following requirements:
 - .1 Form "C" contacts rated at 1 amp @ 30VDC and listed for "pilot duty".
 - .2 The position of the contact shall be supervised
 - .3 Separate power shall not be required to the relay base.
 - .4 The relay shall automatically de-energize when a detector is removed
 - .5 The relay operation shall be exercised by the detector processor on power up.
 - .6 The relay shall be a bi-stable type and selectable for normally open or normally closed operation.
 - .7 For added survivability, relay operation shall be controlled by the detectors microprocessor. The relay shall be capable of operation in the conventional stand-alone mode in the event communication is lost with the loop controller. Relay bases not controlled by the detector's microprocessor shall not be acceptable.
 - .6 The isolator base shall support all Addressable Detector types and have the following requirements:
 - .1 The isolator shall operate within a minimum of 23msec of a short circuit condition on the analog communication wiring.
 - .2 An analog addressable detector mounted with an isolator base shall only use 1 address on the loop. It shall be possible to provide one isolator for every detector to achieve the highest level of survivability possible. The analog loop controller shall support up to 250 devices including 125 modules and 125 detectors with 125 isolator bases.
 - .3 In a Class A configuration, the analog loop controller shall identify an isolated circuit condition and provide communications to all non-isolated analog devices.
 - .4 Isolators are required between all Floor Areas as defined in the NBC.

2.3 MICROPROCESSOR-BASED ADDRESSABLE MANUAL PULL STATIONS

- .1 Fire Alarm / Life Safety System shall incorporate single stage microprocessor-based addressable Manual Pull Stations connected over a 2 wire electronic communications loop, using both broadcast and serial polling protocols. All Manual Pull Stations shall display communications and alarm status via LED's mounted on their integral, factory assembled module.

- .2 All addressing of the Manual Pull Stations shall be done electronically, and the electrical location of each station shall be automatically reported to the Fire Alarm Control Panel, where it may be downloaded into a PC, or printed out. The addressing of the Manual Pull Station will not be dependent on their electrical location on the circuit.
- .3 Provide intelligent single action single-stage fire alarm stations where shown on plans. The fire alarm station shall be of metal construction with an integral toggle switch to activate alarm signals. Stations shall be finished in red with silver "PULL IN CASE OF FIRE" lettering in [English] [English-French]. The manual station shall be suitable for mounting on a North American 64 mm (2-½") deep, single-gang electrical box.
- .4 All Manual Fire Alarm station shall be suitable for operation in the following environment:
 - .1 Temperature: 0°C to 49°C (32°F to 120°F)
 - .2 Humidity: 0-93% RH, non-condensing

2.4 FIRE ALARM NOTIFICATION APPLIANCES - GENERAL REQUIREMENTS

- .1 All appliances which are supplied for the requirements of this specification shall be ULC Listed.
- .2 All appliances shall be of the same manufacturer as the Fire Alarm Control Panel specified to insure absolute compatibility between the appliances and the control panels, and to insure that the application of the appliances are done in accordance with the single manufacturer's instructions.
- .3 Any appliances that do not meet the above requirements, and are submitted for use must show written proof of their compatibility for the purpose intended. Such proof shall be in the form of documentation from all manufacturers that clearly states that their equipment (as submitted) is 100% compatible with each other for the purpose intended.
- .4 Self-Synchronized Horns and Strobes
 - .1 Provide electronic horn/strobes to match existing. Horn and strobe power shall be provided on one pair of wires. It shall be possible to control the horn (on, off and coded) independently from the strobe. The horn shall be selectable for continuous or synchronized temporal operation. The strobe shall be selectable for a continuous or temporal synchronized flash rate to match the horn and meet the intent of the National Building Code, Appendix Clause 3.2.4.20 (1).
 - .2 The horn shall provide an output of 94 dB peak using a low frequency tone for superior wall penetration. The strobe output shall be synchronized and available in 15, 30, 60, 75 & 110 candela (cd) as listed on the plans. The light output shall be an even "Full Light" pattern throughout the strobes protected area. Strobes utilizing a traditional specular reflector with uneven light distribution are not acceptable.
 - .3 The horn/strobe shall be an ultra low profile single gang design, finished in UV stable textured red and shall not protrude more than 25.4 mm (1") from the wall. All mounting hardware shall be captive and there shall be no mounting screws visible after the device is installed.
 - .4 The devices shall mount to a standard single gang electrical box and

have an optional trim ring for 2-gang, octagonal or 102 mm (4") square boxes. The signalling device series shall share a common appearance and be available in a horn, strobe or combination horn/strobe unit as listed on the plans.

2.5 WIRING

- .1 In accordance with CSA C22.2 No. 208, CAN/ULC-S524, and governing Codes and Regulations, all electrically supervised, and as follows:
 - .1 All other wiring unless otherwise specified: minimum 105°C (220°F) rated with copper conductors and colour coded insulation, and, unless otherwise shown or specified, sized in accordance with the fire alarm system manufacturer's instruction but in any case minimum No. 16 AWG.
 - .2 Install all wiring in conduit, except M.I. cables, conduit sized to code. Minimum conduit size 19 mm (3/4").
 - .3 Install alarm indicating circuits and alarm receiving circuits in separate conduits.
 - .4 Provide end-of-line resistors to electrically supervise all wiring.
 - .5 Ground and bond all system cabinets and other work to the building grounding system.

3 EXECUTION

3.1 INSTALLATION:

- .1 The entire system shall be installed in accordance with the latest edition of CAN/ULC-S524 and the approved manufacturer's manuals and wiring diagrams. The contractor shall provide all labour, conduit, wiring, outlet boxes, junction boxes, cabinets and similar devices necessary for a complete, functional life safety fire alarm system. Provide all necessary power supply, interconnecting and remote signal wire in dedicated conduit throughout and installed in accordance with the manufacturer's wiring diagrams and the requirements of the Ontario Electrical Safety Code and the Inspection Authority. All penetration of floor slabs and fire walls shall be fire stopped in accordance with all local fire codes. End-of-line resistors shall be provided as required for mounting as directed by the manufacturer.

3.2 TESTING AND INSPECTION:

- .1 The manufacturer's representative shall make an inspection of the fire alarm equipment, including those components necessary to the direct operation of the system such as manual stations, thermal and smoke actuated detectors and controls, whether or not manufactured by the manufacturer. The inspection shall comprise an examination and test of such equipment for the following:
 - .1 That the type of equipment installed is that designated by the specifications.
 - .2 That the wiring connections to all equipment components show that the installer undertook to have observed ULC requirements.
 - .3 That all products of combustion (smoke) detectors have been properly

- calibrated and adjustments set correctly.
- .4 That the representative equipment has been installed in accordance with the manufacturer's recommendations.
- .5 That the supervisory wiring of all devices connected to a supervised circuit is operating and that the wiring having been met to the satisfaction of the inspecting officials.
- .6 Testing to be done in the presence of the local building inspector and the local Fire Marshall.
- .7 Fire alarm System shall be verified as per the latest issue of CAN/ULC-S537, Verification of Fire Alarm Systems standard.

3.3 SYSTEM PROGRAMMING

- .1 Arrange for all required system programming to be done by the system manufacturer's technical representatives.

3.4 SYSTEM TESTING, CERTIFICATION, AND VERIFICATION

- .1 The system manufacturer and an independent third party testing company are to test and verify the completed system. The independent third party testing company is to have primary responsibility for testing and verification.
- .2 Commissioning, System Manufacturer's Testing and Verification: Accompanied by qualified personnel of the system manufacturer, the Commissioning Agent is to visually inspect the system for completeness, then test system operation, including all alarm initiating devices, signal devices, and all other system operations and functions. When the Commissioning Agent and system manufacturer confirm that the system is operating as intended, obtain from the Commissioning Agent and manufacturer and submit copies of signed test, inspection, and commissioning sheets, and a signed letter from the system manufacturer certifying that the system has been checked, tested, operated, adjusted, and is operating as intended, all as per CAN/ULC-S536. Qualified personnel system manufacturer's personnel are also to be available on-site to accompany independent third party personnel testing and verification.
- .3 Independent Third Party System Testing and Verification: Retain and pay all costs for independent third party testing and verification of the system in accordance with CAN/ULC S537. The independent third party is to be a qualified and experienced testing agency with personnel trained in accordance with the Fire Alarm Technology Program of the Canadian Fire Protection Association, or Certified Fire Alarm Electricians certified by the Electrical Contractors Association of Ontario. All such personnel are to carry identification cards at all times while on-site. Third party independent testing and verification is to be responsible for:
 - .1 coordinating attendance at the site of all required fire inspection personnel so as to obtain their approval of testing and verifying work
 - .2 coordinating attendance at the site of system manufacturer's technical personnel to advise as required
 - .3 written confirmation that all alarm initiating devices, signals, paging, telephone, and all other components have been tested and operate properly

- .4 written confirmation that all supervised wiring is properly installed and operating and is in accordance with all applicable requirements
- .5 written confirmation that the overall system and sequences of operation, including operation of communication equipment, mechanical equipment, elevators, similar equipment as specified, battery power and charging have been tested and are in accordance with all requirements and meet with the approval of local governing authorities
- .6 submittal of signed test report sheets and a signed Verification Certificate and approval documentation issued by the local Fire Authorities

3.5 LIABILITY INSURANCE POLICY

- .1 Within fifteen days of written notification of award of contract, submit a Certificate of Insurance for a Commercial General Liability Insurance Policy from an insurer licensed to do business in the Province of the work and signed by an officer of the insurer covering public liability and property damage in a minimum amount of two millions dollars inclusive in Canadian funds and insuring all services, operations, products, and fire alarm system work. The policy is to be extended to include bodily injury, property damage, personal and advertising injury, products and completed operations, contractual liability, Owners and Contractors protective liability and to a limit of not less than two million dollars Canadian per occurrence.
- .2 The policy is to:
 - .1 include a cross liability clause and be endorsed to include the Owner
 - .2 include non-owned automobile insurance to a limit of not less than two million dollars Canadian
 - .3 include automobile insurance (OAP1) for both owned and leased vehicles with inclusive limits of two million dollars Canadian
 - .4 be non-contributing with and will apply only as primary and not excess to any other insurance or self-insurance available to the Owner
 - .5 contain an undertaking by the insurers to notify the Owner in writing not less than thirty days before any material change in coverage or cancellation of coverage

END OF SECTION

1.1 DESCRIPTION OF WORK

- .1 This section covers the provision of power for door locks and conduit for 24 VDC hardware wiring.
- .2 Door lock equipment and card access equipment provided by the door hardware supplier.
- .3 Low voltage (24VDC) wiring supplied & installed by the door hardware supplier.

1.2 RELATED SECTIONS

- .1 Section 08 71 – Door Hardware.
- .2 Section 26 05 34 – Conduits, Conduit Fastenings and Conduit Fittings.

1.3 EQUIPMENT SUPPLIED BY DIVISION 26

- .1 Provide all 120 VAC wiring in conduit system for power supply as indicated...
- .2 Provide an empty conduit system with pull cords for installation of 24VDC wiring by door hardware supplier, as indicated.

1.4 COORDINATION

- .1 Co-ordinate with door hardware supplier to ensure that equipment, boxes, wiring and conduit are located correctly.

1.5 CONNECTION TO FIRE ALARM PANEL

- .1 Where scheduled, door power supplies shall be wired to normally closed contacts in the fire alarm panel to release door locks on activation of fire alarm.

1.6 CERTIFICATE OF COMPLIANCE

- .1 Provide a letter of verification stating that the system has been checked out and is operational in advance of the Substantial Completion inspection.

1.7 EXECUTION

- .1 Install 120 VAC power to door power supplies.
- .2 Install empty conduit system c/w pull cords for 24 VDC wiring.

END OF SECTION