

Project Manual

Cyclic Materials Hub Center
Q/A Lab

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Project Manual
Cyclic Materials Hub Center
Q/A Lab

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PART - 1 GENERAL

1.1 SUMMARY

.1 Section Includes:

- .1 Labour, Products, equipment, and services necessary for demolishing, salvaging, relocating, and removing wholly or in part the various items designated on the drawings or required to be removed or partially removed for the receipt of the Work of this Contract.
- .2 Selective demolition includes, but is not necessarily limited to:
 - .1 Alteration and renovations to existing building.
 - .2 Cutting and removing of walls, ceilings, floor, and wall finishes, fitments, and fixtures, in the existing buildings as indicated on drawings.
 - .3 Patching, making good walls, floors, and ceilings, including painting, as required.
 - .4 Removal of rubbish, debris, demolished fixtures, fitments, and items not scheduled to remain Owner's property, resulting from the demolition and preparatory work.
 - .5 Dust control during the operations of the work of this section.

.2 Related Requirements:

- .1 Comply with Conditions of the Contract and Division 01 - General Requirements.

1.2 QUALITY ASSURANCE

- .1 Comply with pertinent codes, regulations and insurance carriers providing coverage for this Work.
- .2 Execute the work in strict accordance with 'The Occupational Health and Safety Act and Regulations for Construction Projects' latest addition. Keep copy of the Act at the place of the Work at all times.
- .3 Carry out demolition work in accordance with CSA S350-M.
- .4 Submit fire safety plan in accordance with requirements of Owner.

1.3 SUBMITTALS

- .1 Submit demolition and cutting schedule to Consultant for review. Schedule to show timing and phasing of the Work in the various areas of the existing building. Deviation from schedule will not be permitted without approval.
- .2 Submit drawings for demolition of structural elements bearing stamp of a professional engineer registered in the Place of Work.

1.4 STORAGE AND HANDLING

.1 Storage and Protection.

- .1 Remove and store materials to be salvaged, in manner to prevent damage.
- .2 Store and protect in accordance with requirements for maximum preservation of material.
- .3 Handle salvaged materials as new materials.

- .2 Waste Management and Disposal.
 - .1 Separate waste materials for recycling.
 - .2 Place materials defined as hazardous or toxic in designated containers.
 - .3 Remove materials that cannot be salvaged for reuse or recycling and dispose of in accordance with applicable codes at licensed facilities.

1.5 **PROTECTION**

- .1 Use all means necessary to protect existing objects designated to remain and in the event of damage, immediately make all repairs and replacements necessary to the approval of the Consultant and at no additional cost to Owner.
- .2 Provide protection required to enable existing building and equipment to remain in continuous and normal operations and maintain construction schedule.
- .3 Erect barricades, covered ways, barriers, scaffolding, screens, notice and warning boards and maintain all lights, signals, and protection of all kinds for the protection of workers on the Work, for the protection of adjoining property and for the protection of public.
- .4 Maintain fences free of advertising.

PART - 2 PRODUCTS

2.1 **TEMPORARY PARTITIONS**

- .1 Prior to demolition Work proceeding in existing structures, temporarily enclose Work areas. Provide dustproof and weatherproof partitions. Design partitions to prevent dust and dirt infiltration into adjoining areas, prevent ingress of water, and to resist loads due to weather.
- .2 Prevent dust, dirt and water from demolition operations entering operational areas.
- .3 Adjust and relocate partitions as required for various operations of Work.
- .4 Upon completion of Work, remove and dispose of partitions from Site.

PART - 3 EXECUTION

3.1 **GENERAL**

- .1 Coordination: The Contract Documents, including the demolition scope and the scope for new construction and modification of existing facilities, shall be read as a whole and the Work shall be coordinated with each discipline and with the various trades, prior to proceeding with the Work, and confirmation of the extent of demolition work shall be reviewed for accuracy by the Consultants and the Owner's Representatives.
- .2 Existing Conditions: Prior to beginning work, survey and record the condition of existing conditions to remain in place that might be affected by the demolition operations. After demolition operations are completed, survey the conditions again and restore existing facilities to their pre-demolition condition.
 - .1 All information relative to existing conditions is offered to assist the Contractor in evaluation of the Work, but with no specific representation, either expressed or implied, as to completeness or accuracy. Be responsible for any deductions or conclusions made on the basis of this information and that of any additional site inspections, if made.

- .3 Take inventory and record the condition of items being removed and salvaged.
- .4 Demolished materials become Contractor's property. Remove materials from site daily, unless such materials are specified or shown on Contract Documents to be reused or turned over to Owner.
- .5 Reused materials: Provide protection for materials to be re-used. Cover stockpiles of materials with tarpaulins.
- .6 Remove contaminated or dangerous materials defined by authorities having jurisdiction, relating to environmental protection, from site and dispose of in safe manner to minimize danger at site or during disposal.

3.2 **PREPARATION**

- .1 Notify the Consultant at least two full working days prior to commencing of the Work.
- .2 The Drawings do not purport to show all objects existing on the site.
- .3 Before commencing the Work, carefully check drawings and verify with the Consultant regarding all objects to be removed and all objects to be preserved.
- .4 Schedule all Work in a careful manner with all necessary consideration for the requirements of Owner, Owner's employees, and the public.
- .5 Avoid interference with the use of, and passage to and from, adjacent buildings and facilities.
- .6 Before starting the operations, arrange with the appropriate trade concerned for the disconnection of all utility services, affecting the work.
- .7 Preserve in operating condition all active utilities to remain.

3.3 **DEMOLITION AND PREPARATORY WORK**

- .1 In order to afford the least interference with the efficient operations of the existing building and to keep the risk of fire to a minimum at all times, ensure that demolished materials are continuously removed from the buildings and grounds as they accumulate, that no hazard condition is left during non-working hours and that full measures are taken by sprinkling and other means to keep dust to a minimum and to confine what dust there is within the working area.
- .2 Maintain proper and safe means of fire exit from all zones of the existing building to the approval of the authorities having jurisdiction.
- .3 Confine operation to those parts of the buildings which are to be altered or renovated. Do not damage existing construction beyond that necessary for performance of new work and repair such damage as required.
- .4 Carefully remove in re-usable condition, transport and store on site where directed by Consultant, and protect against damage all materials and equipment to be salvaged or relocated for reuse in the new Work.
- .5 Take possession of all other materials arising from the demolition work and remove from the site.

- .6 Cut openings through existing walls, partitions, and floors. Establish exact location of steel reinforcing in existing concrete slabs or walls before holes are made. Be responsible for damage to existing steel reinforcing and be liable for structural failure. Make good surfaces disturbed with materials to match existing.
- .7 The use of pneumatic or electrical jack hammers is not permitted.
- .8 Where items are to be removed from existing structure or surfaces that are to remain in place, remove those items complete with hangers, brackets and other readily removable supports and fastenings:
 - .1 Remove bolts, but not inserts embedded in concrete or masonry.
 - .2 Remove bolt and rivet fastenings from steel structure.
- .9 Demolish work into sections of practical size for removal without alteration or damage to the existing building remaining in place.
- .10 Upon completion of demolition, leave interior surfaces broom clean.
- .11 New openings required in existing walls and partitions shall be carefully cut and formed to blend into existing work.
- .12 Join and make good new work to existing in such a manner that the joint is structurally sound and inconspicuous.
- .13 Cuts, breaks and other temporary openings into existing surfaces, which are required for installation or application of new fixtures, fitments, materials, or services shall be, at completion of work, patched and/or made good and finished to blend with surrounding finishes. Openings to allow passage of ducts shall be closed tight to perimeters of duct at all locations where fire dampers are required.
- .14 In areas where work is required to be performed over acoustic ceilings composed of lay-in panels in a supporting grid, carefully remove panels to avoid damage and replace when work is completed. If existing lay-in panels in a room are damaged and cannot be matched with new panels, then replace all the panels in that room with new units to the Consultant's approval at no additional expense to Owner.
- .15 Where fireproofing membranes or coverings to existing structural steel members and open web steel joists are disturbed, restore the fire protection with materials and methods acceptable by the authorities having jurisdiction.
- .16 Materials and other equipment not required for re-use shall not be stored or sold from the site.
- .17 Burning of materials on site is prohibited.
- .18 Always maintain the existing building in a weather and watertight condition.
- .19 Maintain security of existing building.

3.1 **SALVAGE**

- .1 Remove and store items indicated or directed for salvage. Remove, handle and transport such items to storage area designated in the Contract Documents, to an area within the Place of the Work designated by Consultant, or to an area away from the Place of the Work as directed by the Consultant. Perform such work to prevent damage to the items during removal and in storage.

- .2 The Owner will review Place of the Work prior to commencement of demolition and instruct the Contractor the items to be retained for re-use or be turned over to the Owner.
- .3 Remove and store indicated items for future use by Owner. Remove, handle and transport such items to storage area indicated in the Contract Documents or to an area within the Place of the Work designated by Consultant. Perform such work carefully and with diligence to prevent any damage to the items during removal and in storage.
- .4 Make an inventory of all items indicated for salvage or future use. Replace, at no cost to the Owner, any damaged or lost items indicated for salvage or future use.

3.2 **CUTTING AND PATCHING**

- .1 Perform cutting, fitting, and patching to complete the Work. Do not cut, drill, or sleeve load-bearing members without obtaining written approval for each condition.
- .2 Remove and replace defective and non-conforming work.
- .3 Perform work to avoid damage to other work.
- .4 Prepare proper surfaces to receive patching and finishing.
- .5 Cut rigid materials using power saw or core drill. Pneumatic or impact tools not allowed.
- .6 Restore work with new products to match existing in accordance with Contract Documents.
- .7 Fit work airtight to pipes, sleeves, ducts, conduit, and other penetrations through surfaces.
- .8 At penetration of fire rated wall, ceiling, or floor construction, completely seal voids with fire rated material, full thickness of construction element.
- .9 Refinish surfaces to match adjacent finishes; for continuous surfaces refinish to nearest intersection; for an assembly, refinish entire unit.

3.3 **MAKING GOOD**

- .1 Make good materials and finishes which are damaged or disturbed during the process of additions and reconstruction under the Contract.
- .2 Where existing work is to be made good, match new work exactly with the old work in material, form, construction, and finish unless otherwise noted or specified.
- .3 Protect work in the existing building, such as floors, finishes, trim, etc., as completely as possible to hold the replacing of damaged work to a minimum.
- .4 Preparation for new finishes:
 - .1 Remove existing finishes, including paint.
 - .2 Fill cracks and depressions with suitable filler and finish smooth, as recommended by the manufacturer of the new finishes.
 - .3 Grind protrusions level with substrates and finish smooth.
 - .4 Remove all evidence of existing adhesive, grease, oil, soil, and other encrustations of foreign material by washing, scraping and grinding if necessary.
 - .5 Clean and prepare substrates to receive new work.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

.1 Section Includes:

- .1 Labour, Products, equipment and services necessary to complete the work of this Section.

1.2 REFERENCES

.1 Reference Standards:

- .2 The latest edition of the following reference standards shall govern work of this Section, except where they are in conflict with requirements imposed by this specification, in which case the latter shall govern. Standards referenced in CAN/CSA-A23.1 apply but are not repeated in following list:

- .1 CSA Standard CAN/CSA-A23.1, Concrete Materials and Methods of Concrete Construction.
- .2 CSA Standard CAN3-A23.3, Design of Concrete Structures for Buildings.
- .3 CSA Standard G30.5, Welded Steel Wire Fabric for Concrete Reinforcement.
- .4 CSA Standard CAN/CSA G30.18, Billet-Steel Bars for Concrete Reinforcement.
- .5 CSA Standard W186, Welding of Reinforcing Bars in Reinforced Concrete Construction.
- .6 CSA Standard CAN/CSA-S413, Parking Structures.
- .7 ASTM D3963/D3963M, Standard Specification for Epoxy-Coated Reinforcing Steel.

1.3 SUBMITTALS

.1 Refer to Submittals Section 01 33 00.

.2 Shop Drawings:

- .1 Prepare shop drawings showing the size, spacing, location, quantities and details of reinforcing steel in accordance with the drawings and specifications. Use the "Manual of Standard Practice" by the Reinforcing Steel Institute of Ontario as a guide only.
- .2 Submit drawings showing the location and size of all sleeves, pipes and openings required for all trades which are not already shown on the structural drawings. Submit these drawings for Architect's review well in advance of construction. Drawings shall show the total openings required by all trades involved in the area covered by the drawing.
- .3 Consultant will review and return shop drawings in accordance with an agreed schedule. Consultant's review will be for conformity to design concept and for general arrangement only, and shall not relieve Contractor of responsibility for errors or omissions in shop drawings or of responsibility for meeting all requirements of Contract Documents.
- .4 Do not commence fabrication of reinforcement before drawings have been reviewed and Consultant's comments incorporated on drawings issued to fabricating shop.

1.4 **DELIVERY, STORAGE AND HANDLING**

- .1 Store materials in accordance with CSA A23.1.

PART - 2 PRODUCTS

2.1 **MATERIALS**

- .1 Bar Reinforcing Steel
 - .1 CSA G30.18, with 400 MPa minimum yield strength.
 - .2 Welded Wire Fabric: to CSA G30.5, and in flat sheets, not rolls.

2.2 **FABRICATION**

- .1 Fabrication of Reinforcing Steel
 - .1 Fabricate reinforcing bars in accordance with CSA A23.1.
 - .2 Fabricate welded wire fabric in accordance with CSA G30.5 or CSA G30.15.

PART - 3 EXECUTION

3.1 **PLACING OF REINFORCING STEEL**

- .1 Place reinforcing bars and mesh as shown on Drawings and in accordance with CSA A23.1.
- .2 Clean steel before placing concrete in accordance with CSA A23.1.
- .3 Support reinforcing steel in such a manner as to ensure that the spacing and cover of the reinforcement is accurately maintained, taking into account the proposed methods of placing and consolidating the concrete, and the weight of the reinforcement supported.
- .4 For concrete toppings, use mesh in flat sheets.
- .5 In concrete toppings, terminate floor mesh at edge of electrical in-floor duct. Add 51 x 51 MW9.1 x MW9.1 mesh over duct and lap 300 mm () with floor mesh.
- .6 Tie, do not weld, reinforcement in place. Tie the intersections of all reinforcing bars. Maintain supports in position by wiring to the reinforcement or by other positive means.
- .7 Unless otherwise detailed on the structural drawings, reinforcement shall be continuous through construction joints.
- .8 Unless otherwise shown, reinforce platforms and sidewalks with 152 x 152 MW 13.3 x MW 13.3 welded wire mesh.

3.2 **ADJUSTING AND CLEANING**

- .1 Adjust and secure reinforcement in correct position immediately before concrete is placed.
- .2 Provide a rodman during the entire duration of concrete placement to make last minute adjustments.
- .3 Remove contaminants which lessen bond between concrete and reinforcement.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section Includes:
 - .1 Labour, Products, equipment and services necessary to complete the work of this Section.
- .2 Co-operation with Consultant:
 - .1 Before commencing work, review with Consultant, work performed under this Section.
 - .2 Schedule work to allow sufficient time and access for Consultant to carry out periodic field review.

1.2 REFERENCE

- .1 The following reference standards govern work of this Section, except where they are in conflict with requirements imposed by this Specification in which case the latter governs. Standards referenced in CAN/CSA-A23.1 are not repeated in following list.
 - .1 CSA Standard CAN/CSA-A23.1/A23.2 Concrete Materials and Methods of Concrete Construction/Methods of Tests for Concrete.
 - .2 CSA A283-06 Qualification Code for Concrete Testing Laboratories.
 - .3 CAN/CSA-A3000 Cementitious Materials Compendium
 - .4 ACI 117 Standard Specifications for Tolerances for Concrete Construction and Materials, American Concrete Institute.
 - .5 Ontario Provincial Standard Specification OPSS 1010 Material Specification for Aggregates - Granular A, B, M and Select Subgrade Materials.
 - .6 ASTM C260/C260M Standard Specification for Chemical Admixtures for Concrete.
 - .7 ASTM C309 Standard Specification for Liquid Membrane Forming Compounds for Curing Concrete.
 - .8 ASTM C494/C494M Standard Specification for Chemical Admixtures for Concrete.
 - .9 The Contractor shall keep a copy of CSA A23.1 on the site for reference.
- .2 Definitions
 - .1 Environmental Product Declaration (EPD): Third-party verified documentation with the supporting Product Category Rule (PCR) and Life cycle assessment information. Prepared in accordance with ISO 14025, 14040, 14044, and EN 15804 or ISO 21930 and have at least a cradle to gate scope.
 - .2 Supplementary Cementitious Materials (SCM)s: Materials added to concrete which contribute to the properties of hardened concrete through hydraulic or pozzolanic activity.

1.3 SUBMITTALS

- .1 Provide testing, inspection results and reports for review by Consultant and do not proceed without written approval when deviations from mix design or parameters are found.
- .2 Concrete hauling time: Provide for review by Consultant deviations exceeding maximum allowable time of 120 minutes for concrete to be delivered to site of work and discharged after batching.

- .3 Minimum four (4) weeks prior to starting concrete work, provide proposed quality control procedures for review by Consultant on the following items:
 - .1 Hot weather concrete protection.
 - .2 Cold weather concrete protection.
 - .3 Concrete curing.
 - .4 Uniform and consistent concrete finishing
 - .5 Concrete placing schedule
- .4 Concrete Mix Designs:
 - .1 Minimum four (4) weeks prior to starting concrete work submit concrete mix design for review including:
 - .1 CSA class of concrete exposure
 - .2 Maximum water/cementing materials ratio (W/CM)
 - .3 Minimum concrete strength
 - .4 Maximum aggregate size
 - .5 Specific replacement limits on any materials (ie. fly ash, additives or ggbs)
 - .6 Air content and range
 - .7 Architectural requirements
 - .8 Durability requirements (ie. AVS or RCP)
 - .9 Slump at time of discharge
 - .10 Contractor placement requirements
 - .2 When optimum bulk density of aggregates is specified, provide supporting evidence of compliance with requirements.
 - .3 Review of mix design does not relieve Contractor from responsibility for compliance with Contract Documents.
- .5 Sustainable Design Submittals:
 - .1 LEED Submittals: in accordance with Section 01 35 21 - LEED Requirements.
 - .2 Environmental Product Declaration (EPD): Submit an Industry-wide EPD, and identify which mixes outlined in the EPD align with proposed project mix designs. Provide EPD with at least a cradle to gate scope, identifying the following impact categories:
 - .1 Global Warming Potential (GWP): All GWP information submitted in the form of kg CO₂ eq/kg.
 - .2 Ozone Depletion Potential (ODP): All ODP information submitted in the form of kg CFC-11/kg.
 - .3 Acidification Potential (AP): All AP information submitted in the form of kg SO₂ /kg.
 - .4 Eutrophication Potential (EP): All EP information submitted in the form of kg N/kg.
 - .5 Photochemical Ozone Creation/Smog Formation Potential (SFP): All SFP information submitted in the form of kg O₃ /kg.

- .3 Environmental Product Declaration (EPD): Submit both an Industry-wide EPD and Product specific EPD for 90% by volume for all the specified concrete mixes with at least a cradle to gate scope, identifying the following impact categories:
 - .1 Global Warming Potential (GWP): All GWP information submitted in the form of kg CO₂ eq/kg.
 - .2 Ozone Depletion Potential (ODP): All ODP information submitted in the form of kg CFC-11/kg.
 - .3 Acidification Potential (AP): All AP information submitted in the form of kg SO₂ /kg.
 - .4 Eutrophication Potential (EP): All EP information submitted in the form of kg N/kg.
 - .5 Photochemical Ozone Creation/Smog Formation Potential (SFP): All SFP information submitted in the form of kg O₃ /kg.
- .4 Environmental Product Declaration (EPD): Submit both an Industry-wide EPD and Product specific EPD for 90% by volume for all the specified concrete mixes for a 20 % reduction in GWP against industry average EPD with at least a cradle to gate scope, identifying the following impact categories:
 - .1 Global Warming Potential (GWP): All GWP information submitted in the form of kg CO₂ eq/kg.
 - .2 Ozone Depletion Potential (ODP): All ODP information submitted in the form of kg CFC-11/kg.
 - .3 Acidification Potential (AP): All AP information submitted in the form of kg SO₂ /kg.
 - .4 Eutrophication Potential (EP): All EP information submitted in the form of kg N/kg.
 - .5 Photochemical Ozone Creation/Smog Formation Potential (SFP): All SFP information submitted in the form of kg O₃ /kg.

1.4 **QUALITY ASSURANCE**

- .1 Manufacturer's qualifications:
 - .1 The ready mix concrete supplier shall be a member in good standing of Ready Mix Concrete Association of Ontario (RMCAO).

1.5 **PROJECT RECORDS**

- .1 Concrete Pour Records: Maintain accurate records of concrete pours including the following information:
 - .1 Date and time of concrete pour
 - .2 Location in building of each concrete pour
 - .3 Specified strength of concrete
 - .4 Air temperature when concrete was placed
 - .5 Test samples taken and results of tests as described in PART 3
 - .6 Keep these records on site until the project is completed.

- .2 Delivery Records: Before unloading concrete at site, file duplicate copies of the delivery ticket with each batch of concrete on which the following information shall be recorded:
 - .1 Name of concrete supplier
 - .2 Location of batch plant
 - .3 Date and serial number of slip
 - .4 Truck number, cumulative total, and/or load number
 - .5 Name of contractor
 - .6 Project name and location
 - .7 Approved mix code, specified strength, air content, and exposure class
 - .8 Volume of concrete in load
 - .9 Time loaded or time of first mixing of aggregate, cementing materials and water.
- .3 Record the following information after discharge of concrete has been completed:
 - .1 Time that load arrived at site
 - .2 Time that discharge of load was started
 - .3 Time that discharge of load was completed
 - .4 Type and amount of admixtures, if added at site
 - .5 Amount of water, if added at site
- .4 Record Drawings:
 - .1 Record on a set of Drawings:
 - .1 Time and date of each pour
 - .2 High and low ambient air temperature during each pour
 - .3 Date of removal of forms in each area
 - .4 Founding elevations of all footings
 - .5 Variations of foundation work from that shown on drawings
 - .2 Make record drawings available for Consultant's inspection at all times.

1.6 **DELIVERY, STORAGE, AND HANDLING**

- .1 Deliver and store materials on site in accordance with CAN/CSA A23.1/A23.2
- .2 No water shall be added after the initial introduction of the mixing water for the batch. This requirement may be waived at the start of discharge, when the measured slump of the concrete is less than that specified and when not more than 60 minutes have elapsed from the time of batching to the start of discharge. In this case, water may be added once and only with the authority of the Contractor and in an amount not exceeding 12 L/m³. The drum or blades shall then be turned an additional 30 revolutions or more if necessary at mixing speed, until the uniformity of concrete is consistent with A23.1. Water shall not be added to the batch at any later time.
- .3 In no case shall time between batching and complete discharge exceed 120 minutes.
- .4 At no time shall water be added to the concrete after it has left the mixer.

PART - 2 PRODUCTS

2.1 MATERIALS

- .1 Cement and Supplementary Cementing Materials shall conform to CAN/CSA A3000
- .2 Water shall conform to CSA A23.1/A23.2
- .3 Aggregates shall conform to CSA A23.1/A23.2
- .4 Fine Aggregate:
 - .1 For slabs on grade, fineness modulus of fine aggregate to be between 2.7 and 3.1.
- .5 Coarse Aggregate:
 - .1 20 mm to 5 mm (No.4 sieve) except as specified below.
 - .2 For slabs on grade 125 mm and thicker, 40 mm to 5 mm (No.4 sieve); combine at least two of the single sizes specified in table 11 (eleven) Group II of A23.1, one of which is to be 40 mm ; to obtain maximum bulk density (unit weight) and optimum grading, in accordance with an approved procedure.
 - .3 For slabs on grade:
 - .1 Abrasion loss not to exceed 35%.
 - .2 Petrographic number of aggregate not to exceed 125 when tested in accordance with CSA test method A23.2-15A, as conducted by Ministry of Transport of Ontario.
 - .4 For columns less 300 mm in least dimension, or less than 95,000 mm² in cross-sectional area: 10 mm to 5 mm (No.4 sieve).
 - .5 For all other concrete: 20 mm to 5 mm (No.4 sieve).
- .6 Admixtures:
 - .1 Air entraining admixture shall conform to CSA A23.1/A23.2 and ASTM C260/C260M
 - .2 Chemical admixture shall conform to ASTM C494/C494M
 - .3 Provide only admixtures that are free of chlorides.
 - .4 Consultant to approve accelerating or set retarding admixtures during cold and hot weather placing.
 - .5 When requested, provide evidence acceptable to Consultant that superplasticizer does not increase shrinkage of concrete.
 - .6 Superplasticizers to be compatible with finishes and other admixtures.
- .7 Synthetic Fibres:
 - .1 Sika® Fibre HP, Sika Group, Canada.
 - .2 Sika® Fibre MS, Sika Group, Canada.
- .8 Granular Underbed:
 - .1 For slabs on grade: 20mm clear limestone, proof rolled for compaction, compacted thickness 150 mm under slabs 125 mm or less, 200 mm under thicker slabs.

- .9 Curing-Sealing Compound:
 - .1 Membrane curing-sealing compound formulated from chlorinated rubber resins or acrylic emulsion or solvent free for use in occupied buildings, to ASTM C309, type 1.
- .10 Floor Hardener:
 - .1 Metallic Hardener: Ferrous aggregate premixed with Portland cement and plasticizers.
 - .2 Non-metallic Hardener: Natural and synthetic materials with Mohs hardness 7 minimum, premixed with Portland cement.
- .11 Premixed Grout:
 - .1 Non-shrink Metallic:
 - .1 Embeco 636 Grout by Master Builders Ltd., or equal
 - .2 Non-shrink Non-metallic:
 - .1 V-3 grout by W.R. Meadows of Canada Limited.
 - .2 Masterflow 713 grout by Master Builders Ltd. or equal.
 - .3 Flowable grout:
 - .1 Non-metallic shrinkage compensating:
 - .2 Masterflow 713 by Master Builders Ltd., or equal
- .12 Vapour Barrier - 0.15 mm (6 mil) polyethylene.

2.2

CONCRETE MIXES

- .1 Concrete:
 - .1 Ready mix, with 28 day compressive strength as indicated on Drawings, and in specifications.
 - .2 Air dry unit weight: minimum 2320 kg/m³ adjusted proportionally for maximum air content listed in CAN/CSA-A23.1.
 - .3 Design concrete mix in conformance with CAN/CSA-A23.1, Alternative 1 and as follows:
 - .1 Exposure Classification C-1 with 25% Portland cement replaced with cementitious hydraulic slag, for parking garage floors, and walls, balustrades and columns adjacent thereto. Conform to the additional requirements of CAN/CSA-S413, Parking Structures.
 - .2 Exposure Classification C-2 with 25% Portland cement replaced with cementitious hydraulic slag, for pavements, sidewalks, curbs and gutters.
 - .3 Exposure Classification F-1 with 25% Portland cement replaced with cementitious hydraulic slag, for exposed exterior beams, columns, walls and slabs not exposed to chlorides.
 - .4 Slabs-on-grade: Use Portland cement. When mean daily temperature exceeds 18°C at time of placement, replace 25% of cement with cementitious hydraulic slag.
 - .1 Water/cement ratio 0.45 maximum.
 - .2 Modulus of rupture 3.5 MPa average, 3.0 MPa minimum.

- .5 Interior Concrete, other than specified above, and not exposed to freezing and thawing or the application of deicing chemicals:
 - .1 Select water/cement ratio or cement content on basis of strength, workability and finishing requirements.
- .6 Columns:
 - .1 Incorporate superplasticizer to provide 200 mm slump concrete for columns.
- .4 Admixtures:
 - .1 Chemical Admixture
 - .1 Incorporate water-reducing admixture, type WN, in all concrete.
 - .2 Air Entraining Agent
 - .1 Incorporate air-entraining agent in addition to chemical admixture in concrete of exposure classification F-1, F-2, C-1, C-2, C-3 and C-4 in accordance with CAN/CSA-A23.1.
 - .3 Calcium Chloride
 - .1 Do not use calcium chloride or admixtures containing chloride in concrete.
- .2 Concrete Toppings:
 - .1 Provide topping with minimum 28 day compressive strength of 30 MPa.
 - .2 For floors left exposed: noted as traprock finish, provide topping with traprock aggregate and with minimum 28 day compressive strength of 35 MPa.
 - .3 Architectural Concrete: For concrete designated as architectural concrete:
 - .1 Obtain aggregate and cement from same source at same time, for entire project.
 - .2 Use tools and handling equipment that are absolutely clear of rust, salts, hardened concrete, and other harmful and foreign material.
 - .4 Grout:
 - .1 Dry pack grout under steel plates and where grout thickness does not exceed 75 mm:
 - .2 Premixed grout mixed in accordance with manufacturer's instruction.
 - .3 Dry pack grout for underpinning and where grout thickness equals or exceeds 75 mm :
 - .4 Mix one part Portland Cement, one and one-half (1.5) parts concrete sand and two parts of 10 mm pea gravel, with only sufficient water that mix will retain its shape when made into ball by hand.
- .3 Sustainable Concrete Performance Criteria
 - .1 Quality Control Plan: ensure concrete supplier meets performance criteria of concrete as established by Departmental Representative DCC Representative Consultant and provide verification of compliance as described in PART 1 - QUALITY ASSURANCE.
 - .2 Provide supplementary cementitious materials and products that contribute to a 10 15 20 % reduction in the Global Warming Potential (GWP) against the listed GWP

identified in the industry-wide EPD and a reduction in the environmental impact categories as measured through a cradle to gate scope.

- .3 Provide supplementary cementitious materials and products that contribute to a maximum Global Warming Potential (GWP) of 200 250 300 kg CO₂ per m³ against the listed GWP identified in the industry-wide EPD and a reduction in the environmental impact categories as measured through a cradle to gate scope.
- .4 Use of supplementary cementitious materials that contribute to a 10 20 30 40 % reduction in the quantity of Portland cement and provide a corresponding GWP reduction value.
- .5 Recycled Content: Where practical, use recycled content of concrete mix as part of the GWP reduction to meet the above target.
- .6 Provide Supplementary Cementitious Materials (SCM) and products that contain or are sourced from processes that use post-consumer and pre-consumer recycled content.

PART - 3 EXECUTION

3.1 PREPARATION FOR PLACING CONCRETE

- .1 Notify Consultant at least 24 hours before commencing to place concrete, and 24 hours before wall forms are closed in.
- .2 Ensure that footing excavations and skim slabs are free of frost or water before placing concrete. If a sump is required for pumping water from the excavation, excavate it outside the area of the footing. Remove any wet or disturbed soil just prior to placing concrete.
- .3 Before placing concrete, check that all forms are rigid and structurally safe, and that all reinforcing steel, formwork, sleeves, anchor bolts and other items are installed in accordance with the drawings and specifications. Ensure that all trades have checked the security and location of all components required in the concrete by those trades.
- .4 Ensure that the electrical conduits have been properly set in the mid-height of the slab, beam, or other concrete. Avoid concentrations and crossing of conduit. Any such concentrations which are required shall be approved by the Consultant before concrete is placed. The Contractor shall co-ordinate the placing of reinforcement with the Electrical Subcontractor to ensure that both conduit and reinforcement are properly placed.
- .5 Obtain geotechnical Consultant's written confirmation that prepared subgrade is acceptable for placement of granular underbed.
- .6 Place granular underbed over entire area of scheduled pour and proof roll.
- .7 Obtain geotechnical Consultant's confirmation that thickness, elevation and proof rolling of granular underbed are acceptable.
- .8 Prior to placing interior concrete slabs on grade, cover granular base with one layer of polyethylene in areas shown on drawings. Lap joints 150 mm and ensure that sheet is not perforated.
- .9 Immediately prior to placing concrete slabs on granular base, where a vapour barrier is not required, moisten the base material to reduce absorption of moisture from the concrete.

3.2 COOPERATION WITH OTHER TRADES

- .1 Set all bolts, inserts, anchors, hangers and other means of fasteners required to be installed for other trades. Consult "Work by Other Sections" Article of other sections to determine scope of this work.
- .2 No continuous slotted inserts are to be used in beams or slab.

- .3 No continuous slotted inserts are to be used in slabs except within the following limitations:
 - .1 Parallel to main reinforcing - any length.
 - .2 Perpendicular to main reinforcing - only in the middle half of the span and in lengths not exceeding 1 m and spaced so that at least 65% of the main reinforcing is not affected.
- .4 Provide holes through concrete work required by other trades for pipes, ducts, conduits and other items of equipment. Obtain Consultant's approval for location of holes not shown on the structural drawings.
- .5 Ensure that all sleeves, inserts, anchors and other fasteners required to be installed by other trades are installed before placing concrete.
- .6 Set all frames in concrete.

3.3 **CONTROL JOINTS**

- .1 In slab on grade floors, form or sawcut control joints as detailed. Where 'diamonds' or other isolation joints are shown to be constructed around columns or piers, place after the floor has been concreted and sawcuts have been made as specified under Section 03 35 00.

3.4 **CONSTRUCTION JOINTS**

- .1 Where construction joints other than those indicated on drawings are required, locate in consultation with the Consultant.
- .2 Unless agreed otherwise for specific locations by the Consultant, provide shear keys in all construction joints. Normally, form keys from 50 x 100 mm material. Depth of keys shall total approximately 1/4 of the depth of the member. In deep members, use two or more keys.
- .3 Construction joints shall be straight and plumb unless otherwise agreed for specific conditions.
- .4 Unless otherwise detailed on the structural drawings, reinforcement shall be continuous through construction joints.
- .5 Maximum length of pour not to exceed 20 m, unless advance authorization is obtained from Consultant.

3.5 **EXPANSION JOINTS**

- .1 Provide expansion joints where shown and as detailed.
- .2 Take special care to prevent concrete 'bridging' over expansion joints. Carefully pack around bearing pads with expansion joint material to maintain freedom of movement of joint.
- .3 Expansion joints in floors and walls shall be continuous from one to the other.

3.6 **COLD WEATHER CONCRETE**

- .1 When the air temperature is below, or is likely to fall below 5°C (as forecast by the local meteorological office) carry out all concrete work in accordance with the recommendations of CSA A23.1. Have all equipment prepared and operational before commencing to place concrete.
- .2 When heated concrete is exposed to the drying effects of wind, provide adequate windbreaks to protect the surface.
- .3 Methods of heating shall be such as to prevent discharge of combustion products over, or drying of, the surface of the fresh concrete.

- .4 Keep a permanent temperature record conforming to the following requirements:
 - .1 Records to show date, time, outside temperature and the maximum and minimum temperature at several points within any enclosure, before the placing of concrete in or above the enclosure.
 - .2 Use maximum and minimum type thermometers for measuring temperature. If concrete is placed on forms heated from an enclosure below, place thermometers close to the underside of the forms. Temperature record to be kept available for Consultant's inspection at any time.
- .5 Temperature of air within enclosures shall not exceed 32°C. Maintain concrete temperatures at 21°C for five days. Removal of concrete protection shall conform to CSA A23.1.
- .6 If required by the Consultant, place tubes in the concrete to permit insertion of thermometers for direct reading of concrete temperature. Provide thermometers of suitable length and diameter.
- .7 Do not place concrete on frozen ground, on ground which contains frozen materials, nor on or against any surface which is at a temperature of less than 10°C .

3.7 **HOT WEATHER CONCRETE**

- .1 Carry out hot weather concreting, unless otherwise specified, in accordance with CSA A23.1.
- .2 Protect concrete from effect of hot or drying weather conditions. Protect forms and reinforcing from the direct rays of the sun, or cool by fogging and evaporation.
- .3 Refer to curing article for special curing precautions in hot weather.
- .4 At air temperature over 27°C, use a set retarding admixture meeting requirements of CSA A23.1 and this specification, in accordance with manufacturer's directions. Set retarding admixture shall be used in all slabs exceeding 200 mm thickness and in all walls, unless otherwise agreed by the Consultant.

3.8 **TEMPERATURE OF CONCRETE**

- .1 In cold weather, concrete shall be delivered to the work having a temperature of not less than 18°C and not more than 32°C .
- .2 In hot weather, concrete shall be delivered to the work having a temperature of not less than 10°C and not more than 27°C

3.9 **SYNTHETIC FIBER-REINFORCED CONCRETE**

- .1 Provide synthetic fibre entrained concrete where called for on the drawings.
- .2 Use 12 mm long rapid dispersing micro-element synthetic fibers at the rate of .91 kg/m³ of concrete, Fibrin 23 as supplied by Fibrin Inc.
- .3 Fibers may be introduced with the aggregates or after all ingredients have been blended or mixed.
- .4 Add fibers to the mix slowly to aid in dispersion and allow a few minutes additional mixing for proper distribution.
- .5 All work shall be as per manufacturer's instructions or recommendations.

3.10 **DEPOSITING**

- .1 Notify the Consultant at least 2 working days before each day's operation of placing concrete.

- .2 Convey concrete from the mixer to the place of final deposit by methods which will prevent:
 - .1 The separation or loss of ingredients. Chutes, if used, shall be rounded in cross-section and have a minimum diameter of 8 times the maximum aggregate size.
 - .2 Displacement of rebar and/or mesh from their specified location.
- .3 Do not deposit any concrete in the work which has partly hardened or which has been contaminated with foreign matter.
- .4 Cast footings, beams and slabs their full design depth in one operation. In upset beams, stepped footings and similar details cast the upper portion as soon as stiffening of the lower portion will permit. The consistency of the lower portion shall be of lower slump than generally specified for the class of work. Remove any free water or laitance from the lower portion before the subsequent layer of concrete is placed.
- .5 Immediately before placing concrete in walls, cover the bottom of the form with a layer of stiff grout. Proportions of cement and sand in the grout shall be similar to that in the concrete being used in the wall.
- .6 Place and consolidate concrete in floors (suspended and on grade) and screed to level ready for finishing under the concrete floor finish section.
- .7 Where pumps are to be used for placing concrete design the concrete mix accordingly. Maintain design slump at point of entry into pumps and add superplasticizer to take into account the slump lost during the pumping process.
- .8 Unless otherwise agreed by the Consultant, consolidate concrete including slabs on grade in place by means of internal vibrators. Use the largest vibrator consistent with the type and location of concrete being placed. Vibrators shall be in accordance with CSA-A23.1.
- .9 When concrete is being placed in deep members (such as walls and footings) vibrators shall be inserted and withdrawn vertically, and shall not be used to flow concrete into final position. They shall be lowered through the full lift of concrete into the lift below, so as to ensure blending of the concrete in the two lifts.
- .10 Apply vibrators systematically and at such spacing that the zones of influence over-lap. Do not over-vibrate.
- .11 Keep one spare vibrator for every three vibrators in use, in case of breakdown.
- .12 After completing concrete in walls or columns, allow at least two hours before placing slabs and beams supported thereon.

3.11 TOLERANCES

- .1 In accordance with ACI 117; definitions for tolerance terminology and tolerances for formed concrete surfaces are recapitulated in Section 03 11 00.
- .2 Difference between elevation of high point and low point in specified area not to exceed:
 - .1 In any bay up to 100 m²: 12 mm
 - .2 In any bay up to 400 m²: 25 mm
- EITHER
- .3 F-Number System:
 - .1 Finish floor slabs to meet following tolerance classification in accordance with CAN/CSA-A23.1.
 - .1 Class A $F_F = 20$ $F_L = 15$
 - .2 Class B $F_F = 25$ $F_L = 20$

.3 Class C $F_F = 35$ $F_L = 25$

.4 Class D $F_F = 45$ $F_L = 35$

- .4 Measure F levelness tolerance within 72 hours of concrete placement, on slabs on grade, and on formed slabs before removal of shores.

OR

- .5 Straight-edge Method:

.1 Finish floor slabs to meet following tolerances when measured within 72 hours after placement and before shores are removed from formed slabs, by placing a freestanding unlevelled straightedge anywhere on slab and allowing it to rest on two high spots. Gap between straightedge placed on two highspots and floor surface not to exceed: 3 m straightedge

.1 Class A 8 mm

.2 Class B 6 mm

3.12 CURING

- .1 Protect and cure concrete in such a manner as to prevent evaporation of moisture from the concrete and injury to the surface.
- .2 When the air temperature may exceed 27°C curing shall be by methods which keep the surface continually moist for at least 7 days after placing, commencing immediately the concrete has set sufficiently. Moisture shall be applied by fogging or by the application of wetted burlap, or by other acceptable methods which will not damage the surface. A curing membrane is not acceptable under these conditions.
- .3 Cure all slabs on grade using wet curing procedure in clause .2 above.
- .4 When the temperature will not exceed 27°C a curing membrane meeting requirements of CGSB 90-GP-1 type 1 may be used. Membrane must be compatible with finish to be applied. For sidewalks, curbs and similar exterior concrete, use a membrane conforming to CGSB 90-GP-1 type 2.
- .5 Do not use a curing membrane on architectural exposed concrete or where a topping is to be applied.
- .6 For vertical surfaces, forms shall be left in place for a minimum of seven curing days or alternatively forms may be stripped earlier, and the surfaces kept covered with wet burlap, subject to the Consultant's approval. Wood forms remaining in place shall be wetted down during periods of hot weather.
- .7 Except as noted in .3 above, curing of finished concrete floors and concrete toppings under Concrete Floor Finishes Section.

3.13 TREATMENT OF FORMED SURFACES

- .1 Sandblasted concrete:
- .1 For concrete surfaces shown to be sandblasted finish, treat with a light (medium, heavy) sandblasting to match the approved sample for colour and texture.
- .2 For sandblasted concrete seal forms at joints to minimize dark lines due to leakage of laitence. Forms shall be free of "boats" and other surface imperfections.
- .3 Contractor proposed to carry out sandblasting shall submit evidence of at least three years experience in this class of work, including examples of such work carried out by him.

- .4 Protect other surfaces and equipment which are not to be sandblasted during the course of the work and be responsible for the cost of correction due to the failure of such protection.
- .5 Schedule, provide sufficient equipment and carry out the work in such a manner as to obtain a uniform texture throughout the work. Complete sandblasting before caulking joints in the concrete.
- .2 Board Formed Finish:
 - .1 Construct forms for board form finish concrete from boards backed by 20 mm plywood. Longitudinal joints between boards shall not exceed 1.5 mm in width. Transverse joints shall be placed randomly and shall be tight.
 - .2 Carefully consolidate concrete in place to obtain a finish free of imperfections. Repair if and where minor honeycombing is accepted, in accordance with CSA A23.1. Carry out repairs in such a manner as to maintain the board pattern and surface texture.
 - .3 Do not remove fins and similar joint marks. Do not rub surface with stone or burlap.
- .3 Flat Finish
 - .1 Where the concrete is to be painted, finish the concrete with a "sack rubbed finish" (Type 6) in accordance with CSA A23.1.
 - .2 Where the concrete is not to be painted, finish the concrete with a "smooth rubbed finish" (type 5) in accordance with CSA A23.1. Do not fill small air or water pockets in the surface of the concrete.
 - .3 "As-formed" concrete - not exposed in the finished work. Repair honeycomb, no additional treatment required.
- .4 Tie-Hole Filling
 - .1 Unless tie holes are shown or specified to be plugged with plastic plugs, cut back and patch tie holes in accordance with CSA A23.1.

3.14 **NON-SHRINK GROUT**

- .1 Grout between column and base plates and bearing surface of concrete piers and foundations and/or masonry walls. Use a premix non-shrink grout in accordance with the manufacturer's directions, and with a minimum 28 day strength of 48 Mpa (7000 psi).
- .2 Base plates up to 380 mm square shall be dry-packed. Place a rigid form on two adjacent sides and pack grout against the form from the other sides.
- .3 Where accessibility is difficult and for bases in excess of 380 mm square use a flowable grout. Install the grout with a positive hydraulic head and ensure that provision is made for escape of air from below the baseplate.
- .4 In areas where the grout is exposed in the finished work, use a non-staining material.
- .5 When grout is being placed at air temperatures below 4°C, ensure that concrete, grout and steel is preheated to 21°C before grouting. Enclose grouted area (including nearest 1.5 m length of all steel connecting to the base) and maintain at 10°C for a minimum of 3 days. If required by the Consultant, submit a written proposal describing the heating methods to be adopted.

3.15 **FLOOR INSTALLATION**

- .1 Structural slabs to receive a separate topping at a later date to be stiff-broomed after screeding to provide a suitable bonding surface; except that where a membrane or slip sheet is to be installed, the surface shall be machine-trowelled.
- .2 Bonded Toppings
 - .1 Clean and roughen all existing surfaces as required to accept new concrete work.
 - .2 Drill holes and/or set all bolts, inserts, anchors, hangers and other means of fastening required to be installed for other trades and as noted.
 - .3 Prime the cleaned and roughened surface with a latex, Albitol or approved equivalent.
 - .4 Where topping is less than 25 mm in thickness, use 10 mm coarse aggregate.
 - .5 Where topping is less than 13 mm in thickness, use sand aggregate only and terminate topping at a straight chase 3 mm deep.
- .3 Slabs on Grade
 - .1 Locate control joints and construction joints in consultation with Consultant. See concrete finishing section for spacing of joints.
- .4 Provide concrete chairs under reinforcing bars and mesh at maximum 600 mm centres in both directions.
- .5 Saw cuts shall be made in the concrete at the appropriate time but within 24 hours after placing.

3.16 **EXTERIOR CONCRETE STEPS, PLATFORMS, WALKS**

- .1 Exterior concrete steps and stairs, where indicated on the drawings, shall be of reinforced concrete.
- .2 Construct concrete walks and platforms with sides straight and plumb, and edges slightly rounded.
 - .1 Lay concrete platforms with positive slope away from the building. This slope shall not be less than 20 mm in one metre unless indicated otherwise on drawings.
 - .2 Unless otherwise noted, lay walks with crown, except where they abut a wall, in which case slope walk away from wall.
 - .3 Unless otherwise shown, platforms and sidewalks shall be 125 mm thick and be reinforced with 6 x 6 x w2.1/w2.1 welded wire mesh.
 - .4 Provide control and expansion joints in sidewalks and platforms. Install premoulded expansion joint filler to expansion joints. Unless otherwise shown, provide expansion joints at maximum spacing of 4.5 m and control joints at maximum spacing of 1.5 m. Control joints shall be tooled with a 'V' section. Expansion joints shall be tooled with rounded section, approximately 6 mm radius.
 - .5 Finish top surface of steps, platform and walks by trowelling all tool marks from top surface of concrete and then brushing with a corn broom. Broom strokes shall be continuous across the surface. Direction of finish shall be across the narrow width of the concrete unless otherwise directed by Consultant.

3.17 **SKIM COATS AND CONCRETE BACKFILL**

- .1 If concrete for foundations cannot be placed on the same day that excavation is carried out, cover the bottom of the excavation with a skim coat of plain concrete, minimum thickness 75 mm.
- .2 Immediately after completing excavation for footings, and before placing any reinforcement, cover the bottom of the excavation with a 75 mm skim coat of plain concrete.
- .3 If foundation excavations are to be left open long enough for water to collect in the bottom, or if rain is forecast before the foundation concrete can be placed, cover the bottom of the excavation with 75 mm skim coat of concrete.
- .4 During the excavations, if soft areas are located and the depth of such excavation has to be increased, backfill the areas with plain concrete. The cost of the extra concrete will be paid for at the unit rate stated in the unit prices section. Obtain Consultant's instructions before undertaking this work.

3.18 **DISTRIBUTION PADS**

- .1 Provide concrete distribution pads in masonry walls under areas of concentrated loads in locations indicated on the drawings.
- .2 Dimensions of the pad, if not indicated on the drawings, shall have a length at least equal to three times the bearing width of the concentrated load, but in any case not less than 400 mm. Depth of the pad shall be equal to the bearing width of the concentrated load but in any case not less than 200 mm. Thickness shall be equal to the thickness of the wall.

3.19 **TRENCHES AND PITS**

- .1 Construct trenches and pits. Angle frames and covers to be supplied under the Metal Fabrication Section 05 50 00 but installed under this section.

3.20 **CONCRETE FILL FOR STAIRS**

- .1 Provide and install concrete fill for treads and landings of steel stairs where shown. Use concrete with 10 mm maximum aggregate in treads 20 mm in landings, and reinforced with 4 x 4 x w1.5/w1.5 welded wire mesh, tied to 6 mm studs welded to steel pans. Studs to be provided and installed under the Steel Stair and Railing Section 05 51 00.

3.21 **CONCRETE BASES AND CURBS**

- .1 Construct concrete bases housekeeping pads, including oil tank storage bases, as shown on the drawings and as required by other sections.
- .2 Construct concrete curbs as per typical details shown on the drawings.

3.22 **LINTELS, BOND BEAMS AND BEARING BLOCKS**

- .1 Provide and install concrete and reinforcing steel to all reinforced concrete, concrete block lintels, bond beams and bearing blocks. Concrete block lintel and bond beam units and bearing blocks will be supplied and installed under the Masonry Section 04 20 00.

3.23 **INSPECTION AND TESTING**

- .1 Refer to Inspection and Testing Section 01 45 00.
- .2 Tests will be carried out under the appropriate CSA Standard. Tests will be carried out as directed by the Consultant.

- .3 Tests may be required on any material being supplied under this section including the following:
 - .1 Aggregates.
 - .2 Concrete.
 - .3 Non-shrink grout.
 - .4 Supply necessary samples to the inspection company for test. Supply additional labour required to assist the inspection company in making such tests. Costs of this material and labour to be borne by this trade.
 - .5 Pay costs of delivery of samples and concrete cylinders to the testing company's laboratory.
 - .6 Submit samples of aggregate for analysis and if such samples fulfil the requirements of CSA A23.1, similar material shall be considered to be acceptable. Acceptance of samples not to be considered as a guarantee of acceptance of all material for same source.
 - .7 Inspection company will make slump tests and test cylinders in accordance with the requirements of CSA A23.2. Not less than three cylinders from each 76 m³ of concrete of the same class, and in any case not less than one set of test cylinders from each class of concrete placed on the same day will be tested. No tests are required for concrete for skim slabs or concrete backfill.
 - .8 If the inspector for the testing company reports to the Contractor's representative that the slump is excessive, the Contractor shall remove the balance of that concrete from the site without further instructions.
 - .9 Testing company will label cylinders with the sample number and record and report the following information:
 - .1 Project.
 - .2 Location in structure where concrete placed.
 - .3 Concrete Supplier.
 - .4 Name - cylinders cast by. slumps.
 - .5 Time mixer charged. Time of sampling.
 - .6 Concrete temperature. Air temperature.
 - .7 Specified air (from ticket), Measured air %.
 - .8 Admixtures.
 - .10 In addition to the above information, the inspection company shall also comment on the type of failure of the cylinder.
 - .11 When air entrainment is specified, it shall be measured in accordance with CSA A23.2.
 - .12 Provide a box or boxes of sufficient size for storage of concrete cylinders in a location adjacent to the area where tests are made. Box to be such as to maintain the temperature of the cylinders between 15°C and 32°C and to prevent loss of moisture from the concrete.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

.1 Section Includes:

- .1 Labour, Products, equipment and services necessary to complete the work of this Section.

1.2 REFERENCE

.1 Comply with the Ontario Building Code and the By-laws of the local municipality.

.2 Reference Standards: Perform work of this Section in conformance with requirements of the latest edition of the following standards (ASTM standards referenced in S16-09 are not repeated in the following list:

- .1 CAN/CSA-S16-09, Limit States Design of Steel Structures.
- .2 CAN/CSA-S136, Cold Formed Steel Structural Members.
- .3 CSA Standard W59, Welded Steel Construction (Metal Arc Welding).
- .4 CSA Standard G164, Hot Dip Galvanizing of Irregularly Shaped Articles.
- .5 CSA Standard W178.1, Qualification Code for Welding Inspection Organizations.
- .6 CSA Standard W178.2, Certification of Welding Inspectors.
- .7 SSPC-SP 6, Structural Steel Painting Council, Commercial Blast Cleaning.

.3 Materials, design, fabrication and erection shall conform to CSA S16-09 except as noted herein. Where specific requirements are noted herein, they are in addition to the requirements of CSA S16-09 and do not supersede them unless specifically stated.

1.3 QUALIFICATIONS

.1 The work of this section shall be fabricated and installed by a company who is a member in good standing of the Canadian Institute of Steel Construction.

.2 Information submitted involving engineering services including design, execution, operations procedures and shop drawings shall be prepared by or under the direct supervision of a Professional Engineer registered in the Province of Ontario. He shall check all drawings, and calculations before submission to the Consultant, and shall certify that he has made such checks by sealing and signing the information submitted.

.3 Undertake welding only by fabricators certified by Canadian Welding Bureau under Division 2.1.

1.4 SOURCE QUALITY CONTROL

.1 Inspection and testing of materials and shop fabrication of work of this Section, and field quality control specified elsewhere in this Section, will be performed by an Inspection and Testing Company appointed by the Owner.

.2 Inspection and Testing Company shall be qualified under CSA W178.

.3 Welding inspectors shall be certified by Canadian Welding Bureau in Category (a), Buildings, to CSA W178.2.

.4 Inspection and Testing Company shall carry out:

.1 Mill Inspection:

- .1 Check that materials conform to specified standards. Mill test reports, properly correlated to materials, will be accepted in lieu of physical tests.

- .2 Shop Inspection
 - .1 Verify that:
 - .1 Structural Steel is fabricated in accordance with shop drawings.
 - .2 Specified fabrication, welding, cleaning and painting procedures are followed.
 - .3 Surfaces inaccessible for cleaning and painting after assembly are treated before assembly.
 - .4 For surfaces painted with zinc-rich paint or zinc primer, specified surface preparation is followed, and specified paint thickness is applied.
 - .3 Non-destructive Testing of Welded Connections
 - .1 Carryout non-destructive testing of welded connections chosen at random as follows:
 - .1 10% of moment connections involving use of fillet welds, by Magnetic Particle Inspection.
 - .2 All moment connections and all connections in direct tension involving use of Full Penetration Groove welds, by ultrasonic testing.
 - .3 Where moments are transferred by either fillet welds or groove welds into end plates in "T" joint configurations, examine base metal for lamellar tearing or cracking, by ultrasonic testing.

1.5

SUBSTITUTIONS

- .1 Submit all proposals for substitutions to the Consultant in writing in advance of shop drawings. Each item shall be clearly identified. Do not proceed with a proposal unless it is accepted in writing.
- .2 Substitution of alternative sections will be allowed provided the new members have equal or greater capacity and stiffness and are of dimensions acceptable at that location. Clearly identify all substitutions on shop drawings.

1.6

SUBMITTALS

- .1 Refer to Submittals Section 01 33 00.
- .2 Shop Drawings:
 - .1 Submit erection diagrams and shop details, fully detailed and dimensioned, with complete information necessary for fabrication and erection without reference to structural drawings.
 - .2 Submit typical details of connections and any special connections for review before preparation of shop drawings.
 - .3 Prior to submission to Consultant, Contractor shall review all shop drawings. By this review, Contractor represents to have determined and verified all field measurements, site conditions, materials, catalogue number and similar data and to have checked and coordinated each shop drawing with the requirements of Contract Documents. Contractors review of each shop drawing shall be indicated by stamp, date and signature of a responsible person.
 - .4 At time of submission, Contractor shall notify Consultant in writing of any deviations in shop drawings from requirements of Contract Documents.

- .5 Consultant will review and return shop drawings in accordance with an agreed schedule. Consultant's review will be for conformity to design concept and for general arrangement only, and shall not relieve Contractor of responsibility for errors and omissions in shop drawings or of responsibility for meeting all requirements of Contract Documents.
- .6 Contractor shall make any changes in shop drawings which Consultant may require consistent with Contract Documents, and resubmit unless otherwise directed by Consultant.

1.7 **PRODUCT HANDLING**

- .1 Handle and store steel materials at the job site in such a manner as to cause no damage to other materials, to existing buildings, to property or to the new structure.
- .2 Handle structural steel so as to avoid distortion.
- .3 Handle architecturally exposed structural steel with care, having due regard for the surface finish.

PART - 2 PRODUCTS

2.1 **MATERIALS**

- .1 Provide new materials in accordance with reference standards, of strength and quality noted on the structural drawings:- Structural Steel - CAN/CSA G40.20/21 grade 350W.
- .2 Hollow structural sections - CAN/CSA G20/21, Grade 350 W, Class C.
- .3 Bolts, nuts and washers - ASTM A325 for heavy hexagonal structural bolts. Where in contact with galvanized structural steel, use galvanized bolts, nuts and washers.
- .4 Drilled-in concrete anchor bolts - Kwik bolts and/or HIT HY-150 by Hilti.
- .5 Primer Type 'A' - CISC/CPMA 1-73a.
- .6 Primer Type 'B' - CISC/CPMA standard 2-75.
- .7 Zinc - rich paint: CGSB 1-GP-181, minimum dry thickness of each coat - three mils.
- .8 Galvanizing - CSA G164 M92 - Minimum 5 mil thickness.
- .9 Coal tar protective coating - Koppers Bitumastic No. 50.

2.2 **FABRICATION**

- .1 Use shop and field connections as indicated on the structural drawings, or herein, or in the absence of any such indications in accordance with CSA S16 and the CISC Handbook of Steel Construction.
- .2 The minimum end connections of any beams shall be such as to resist 50% of the maximum allowable unstiffened web shear capacity of the beam. In all cases, beam connections shall be adequate to resist the reactions indicated or produced by the framing or load conditions.
- .3 For composite construction, the minimum end connection shall be such as to resist the greater of either Article 2.2.2 or the reaction resulting from the factored moment resistance as tabulated in the CISC Handbook, assuming a 100% shear connection and with the depth of steel deck and/or slab shown on the drawings.
- .4 Provide flexible beam connections for unrestrained members in accordance with CSA S16.1, unless shown otherwise on Drawings. Submit for review, in advance of preparation of shop drawings, sketches and, when requested, design calculations sealed by a

- Professional Engineer licensed in the Province of Ontario, of connections which do not meet these requirements.
- .5 In addition to the tolerance requirements of S16.1, connections on columns shall not have a variation from the detailed location of more than 10 mm.
 - .6 Provide double angle header connections where practical. Where not practical, provide seat connection and top or side clip angles for lateral support.
 - .7 One sided connections or fish plates are not acceptable for members subjected to bending.
 - .8 At anytime before detailed drawings are completed and reviewed, provide punched holes not more than 12 mm in diameter for the convenience of other sections, in attaching metal or other materials to the work of this section. Place such holes so as not to cause any appreciable reduction in the strength of the members.
 - .9 Cutting of steel beams in the field shall be done only when directed.
 - .10 Where steel is exposed in the finish work, provide neat details and connections. Avoid excessive gaps and protrusions in forming connections.
 - .11 Provide adjustable connections for all lintel angles and head supports attached to the structural frame to allow for frame deflections and tolerances.
 - .12 Where members act as hangers, increase their connection capacity by an additional one-third of the live load.
 - .13 Provide all eccentrically loaded spandrel beams with top and bottom flange connections for torsional restraint.
 - .14 Detail and erect vertical diagonal bracing to provide a minimum prestress of 30 MPa.
 - .15 Use friction type high strength bolts for connections of bracing members required to resist effects of lateral loads. Provide tension adjustment hardware at rod type bracing.
 - .16 Provide at least one stiffener plate each side of web of beams continuous over columns unless another arrangement of stiffeners is shown on the drawings.
 - .17 Note that roof areas have slopes in two directions. This involves sloping some members, special shoes and special camber on some joists. No deviation from indicated requirements can be considered.
 - .18 Do not permit connections to encroach on the clearance lines required for the installation work of other sections.
 - .19 Design connections for bracing members in frames at reduced loads and stresses to allow for fatigue, based on 500,000 cycles.
 - .20 Fabricate trusses and sway frames as shown with connections to withstand the forces shown. Lines of truss members shall intersect at panel points. All double members are to have welded spacers in accordance with the Code. Camber trusses 3 mm per 3000 mm of length unless otherwise indicated. All trusses and sway frames shall be welded construction.
 - .21 Minimum thickness of material for exterior exposures – 5 mm (3/16").
 - .22 Where galvanized steel members are exposed to weather, connections are to be bolted to ensure minimum damage to galvanizing. Contact faces of bolted connections are also to be galvanized and connection capacities designed accordingly.
 - .23 Provide effective drainage holes to prevent accumulation of water in tubular members.

2.3 **CLEANING, SURFACE PREPARATION AND PRIMING**

- .1 Surface cleaning and preparation shall be in conformance with the following specification(s) of the steel structures painting council. SSPC vis 1-67T, Pictorial Surface Preparation Standards For Painting Steel Structures is to apply.
 - .1 SSPC.SP 1, Solvent Cleaning
 - .2 SSPC.SP 2, Hand Tool Cleaning
 - .3 SSPC.SP 3, Power Tool Cleaning
 - .4 SSPC.SP 4, Flame Cleaning of New Steel (Specify Location)
 - .5 SSPC.SP 5, White Metal Blast Cleaning
 - .6 SSPC.SP 10, Near-white Blast Cleaning
 - .7 SSPC.SP 6, Commercial Blast Cleaning
 - .8 SSPC.SP 7, Brush-off Blast Cleaning
 - .9 SSPC.SP 8, Pickling
- .2 Apply one coat of primer in the shop with the exception of:
 - .1 Surfaces encased in or in contact with cast-in-place concrete including top flanges of beams supporting slabs.
 - .2 Surfaces and edges to be field welded for a distance of 50 mm from the joint.
 - .3 Contact surfaces of friction type shear connections assembled with high-strength bolts.
 - .4 Top flanges of composite beams with field welded shear connectors.
 - .5 Members for which zinc-rich paint or galvanizing is specified.
 - .6 Surfaces fireproofed by spraying. Clean to SSPC.SP6.
- .3 Hot dip galvanize angles, hangers and their connections which support exterior wythes of exterior masonry walls and exposed steel members exposed to weather. Use recommended practice for safeguarding against embrittlement and recommended principles of design and preparation of materials. Minimum preparation to SSPC.SP6.
- .4 Apply one shop coat of zinc-rich paint to steel members embedded in the interior wythes of exterior masonry walls. Minimum cleaning to SSPC.SP6.
- .5 Apply zinc-rich primer paint not more than 24 hours after blast cleaning but prior to any visible rust occurring on the surfaces. Do not apply when relative humidity exceeds 80%.
- .6 Apply one shop coat and one field coat of coal tar protective coating to columns, base plates and anchor bolts in contact with soil where indicated on drawings. Minimum cleaning to SSPC.SP7. Apply minimum 15 mil dry thickness each coat.
- .7 Apply Primer Type 'B' to all steel which is exposed in finished work. Cleaning as specified in CISC/CPMA 2-75.
- .8 Apply Primer Type 'A' to all steel not otherwise primed. Clean as specified in CISC/CPMA 1-73a.
- .9 Apply touch-up paint after erection to all areas which have been missed, scraped or chipped using the same paint as the shop coat or primer.

2.4 OPEN-WEB STEEL JOISTS

- .1 Design open-web steel joists for the dead load, live load and to the depths as shown on the drawings and in accordance with CSA S16 and S136.
- .2 All joists, members and joints, shall be designed by a Professional Engineer registered in the Province of Ontario. Joists supporting uniform loadings may be selected from standard loading tables prepared by the Professional Engineer but those supporting concentrated or other special loads shall be individually designed. On request, submit calculations and such further proof as is necessary to show that the joists conform to the requirements of the specifications. All documents shall carry the seal of the Professional Engineer. The Professional Engineer responsible for joist design, or another Professional Engineer acceptable to him shall inspect all joists after fabrication. The Professional Engineer shall confirm that the joists have been fabricated in accordance with the design requirements. He shall approve any modifications made in the field because of site conditions. Submit the Engineer's report to the Consultant.
- .3 Minimum thickness of material for interior use only:
 - .1 Hot Rolled Sections - 3 mm
 - .2 Rods - 9 mm
 - .3 Cold Formed Sections - 2 mm
 - .4 Flats - 6 mm
- .4 Make all joist shoes with solid webs unless it can be shown by a fully documented analysis or test program that an alternative shoe arrangement is satisfactory.
- .5 Where requested, substantiate, by a documented test program, the load carrying capacity of joists fabricated from cold formed sections, double angle chords excepted. Tests to be witnessed by an independent inspection agency. Testing and inspection at no cost to the Owner.
- .6 Total load deflection shall not exceed $1/240$ the of the span and live load deflection $1/360$ the of the span.
- .7 Camber shall not exceed $1.5 \times$ dead load deflection.
- .8 Where point loads are shown but not specifically located, for purposes of design, place the loads to give maximum stress combination under dead and live loads.
- .9 Design bottom chords of open-web steel joists for an additional concentrated force of 0.4 kN placed in any location on the bottom chord between panel points. This load is to be used to check local axial force and bending conditions without contributing to the global bending moment.
- .10 For all joists design top chord for eccentricity between intersection of axis of chord and end diagonal and the centre of bearing of joist. For joists framing from one side only of a beam, centre the reaction point of the joist over the centre of the supporting beam.
- .11 For joists framing from both sides of a beam design the top chord of the end panel for additional eccentricity between the centre of bearing of joist and centroid of beam as shown on drawings.
- .12 Arrange joists and bridging to accommodate recessed fixtures, and mechanical and electrical services.
- .13 Locate bridging at panel points wherever possible.
- .14 Use crossed diagonal type bridging for joists 600 mm and deeper, unless otherwise noted. Install bridging by bolting to welded gussets at top and bottom chords and at the

intersection of diagonals. Such connections shall permit continuous transfer of loads in bridging through the chords.

- .15 Where horizontal top and bottom bridging is used, cross brace joists every 20 joists or 20 m, whichever is less.
- .16 Install ceiling extensions where required.
- .17 Composite open-web steel joists.
 - .1 Design open-web steel joists with shear studs to act compositely with the concrete slab.
 - .2 Camber open-web steel joists for the sum of dead load and one-quarter of live load deflections.
 - .3 Supply shear studs to steel deck subcontractor for welding through metal deck.

PART - 3 EXECUTION

3.1 EXAMINATION

- .1 Verify, before delivery of structural steel, that work of other sections on which work of this section is dependent is correctly installed and located.

3.2 PREPARATION

- .1 Supply anchor bolts, base and bearing plates and other members to be built in under work of other sections as work progresses. Co-operate with installers of this work and provide instructions for its setting.
- .2 Where new work connects to existing construction, determine site conditions and dimensions accurately in field before making any necessary adjustments. Report adjustment to Consultant.

3.3 ERECTION

- .1 Repair all small bends and kinks received during transportation before the members are erected. Replace, as directed, members seriously damaged.
- .2 Make adequate provision for all loads acting on the structure during erection. Provide temporary bracing to keep the structure stable, plumb and in true alignment during construction. Any bracing members or connections shown on the plans are those required for the finished structure, and may not be sufficient for erection purposes. Such additional temporary bracing as may be required is the responsibility of the contractor. Temporary bracing shall remain in place until concrete slabs, masonry etc., required for final stability are completed.
- .3 Set column base plates on levelling screws or on steel shims to the required elevation ready for grouting. Locate steel shims at the corners of the base plate to permit full grouting.
- .4 The use of levelling plates for beams or columns is not permitted.
- .5 Report failure of material to fit together properly and report to obtain approval for corrective measures.
- .6 Level all lintel angles and head supports attached to the steel frame only after nearly all the dead loads have been put on the steel frame, and immediately prior to the installation of the windows, door or screens below or walls that they support. Do this to eliminate as much dead load deflection as possible.
- .7 Structural drawings do not show all loose lintels required. Refer to general notes on the drawings.

- .8 Bolt together multiple angle lintels. Provide spacers where separated. Provide steel packing where angle seats are at different elevations.
- .9 Connect ends of suspended lintels to the structure and/or extend into masonry to provide adequate bearing and restraint.
- .10 Provide diagonal or cantilevered support angles at sides of columns where required for bearing support of interrupted deck.

3.4 **WELDING**

- .1 Do not weld in the field in rain, snow, sleet, or direct wind.
- .2 Evaporate moisture from all surfaces by heat before commencing any welding.
- .3 Weld members only when the air temperature is above -18°C (0°F). If the air temperature is above -18°C (0°F) but is cold enough to prevent the welder from producing sound work, then welding will not be permitted.

3.5 **COATING TOUCH-UP**

- .1 Clean welds to remove all residue from electrodes.
- .2 After erection is complete, give one coat of touch-up paint to field bolts, field connections, burnt areas, and abrasions or damage to prime coats.
 - .1 Use a compatible primer to touch-up 1-73a or 2-75 shop applied primer.
 - .2 Use a compatible zinc-rich paint to touch-up shop or field applied zinc-rich paint.
- .3 Give areas of bare metal on galvanized members two coats of zinc-rich paint.

3.6 **FIELD QUALITY CONTROL**

- .1 Inspection and Testing Company shall provide:
 - .1 Inspection of erection and fit-up, including placing, plumbing, levelling and temporary bracing and conformance with specified tolerances.
 - .2 Inspection of bolted connections.
 - .3 Inspection of welded joints, including slag removal.
 - .4 General inspection of field cutting and alterations.
 - .5 General inspection of shop coating touch-up.
 - .6 Inspection of zinc primer and zinc-rich paint, including surface preparation and coating thickness.

3.7 **DEFECTIVE WORK**

- .1 Variations in excess of specified tolerances, and failure of materials or workmanship to meet requirements of this specification, and which cannot be repaired by approved methods, will be considered defective work performed by this section.
- .2 Replace defective work, as directed by Consultant.
- .3 Contractor shall pay for additional inspection and testing and related expenses if work has proven to be deficient.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

.1 Section Includes:

- .1 Labour, Products, equipment, and services necessary to complete the work of this Section for modifications and cutting and patching of the existing roof.
- .2 Obtain written authorization from roofing manufacturer prior to any modifications, alterations, and repairs are made to the existing roofing system (currently under warranty).
- .3 Maintain the existing building watertight at all times. Provide required temporary protection, and enclosures. Seal off or temporarily dam open roof edges to prevent any incidence of water into existing building or structure.

.2 Related Requirements

- .1 Comply with Conditions of the Contract, and Division 01 - General Requirements.

1.2 QUALITY ASSURANCE

- .1 The existing roof is under warranty. Before starting any work on existing roofing assembly, notify the warrantors, roofing contractor and membrane manufacturer. Obtain written authorization from roofing manufacturer and follow their instructions on proper procedures not to void standing warranties.
- .2 Arrange for roofing material manufacturer's representative to visit the site and discuss roofing application and any special requirements, prior to commencement of work.
- .3 Applicators:
 - .1 Provide work of this section by roofing contractor who is certified by manufacturer of roofing membranes. Submit a copy of the certificate to the Consultant before starting work.
 - .2 Member in good standing of the Canadian Roofing Contractors Association and which has a minimum of 5 years of proven satisfactory experience in the Work of this Section.
- .4 Pre-installation meeting: Two weeks prior to commencing work of this Section, arrange for manufacturer's technical representative to visit the site and review preparatory and installation procedures to be followed, conditions under which the work will be done, and inspect the surfaces to receive the work of this Section. Advise the Consultant of the date and time of the meeting.
- .5 Manufacturer's site inspection: Have the manufacturer's technical representative inspect the Work at suitable intervals during application and at conclusion of the work of this Section, to ensure the Work is correctly installed. When requested, submit manufacturer's inspection reports and verification that the work of this Section is correctly installed.
- .6 Tie-in new work with adjacent existing roofing system in accordance with the manufacturer's recommendations for the products used. All products to be compatible with the existing and new roofing system components.
- .7 Do work to maintain existing roof warranty.
- .8 All work shall meet the requirements of the Canadian Roofing Contractors Association (CRCA.), including all amendments.
- .9 Ensure surfaces to receive work of this Section are clean, level, smooth, solid, and dry before commencing work each day.

- .10 Ensure temperatures during application are not less than the minimum recommended by the material manufacturer. Do not perform work during inclement weather conditions.
- .11 Stop work when temperature remains consistently below recommended temperature.
- .12 Use only dry materials and apply only during weather that will not introduce moisture into roofing system.

1.3 **SUBMITTALS**

- .1 Submit 3 copies of the roofing materials manufacturers' recommended inspection and maintenance procedures for inclusion in the maintenance instructions and data book.

1.4 **PROTECTION**

- .1 Provide all necessary protection measures to prevent fumes, dust particles, odours and other foreign matter created or caused by roofing operation from entering the building, including the return air ducts.
- .2 Provide temporary protection at work areas or access to work areas with minimum 13 mm plywood underlaid with 25 mm polystyrene insulation board extending 900 mm beyond work area. Remove protection at completion of work.
- .3 Prevent bitumen, precipitation and debris entering openings and drains during work.
- .4 Cover walls and adjacent work where materials hoisted or used. Locate kettles so that smoke and fumes will not discolour the building or adjacent buildings or become a nuisance to adjacent owners or the public.
- .5 Use warning signs and barriers. Maintain in good order until completion of work.
- .6 At end of each day's work or when stoppage occurs due to inclement weather, provide protection for completed work and materials out of storage.

1.5 **DELIVERY, STORAGE AND HANDLING**

- .1 Deliver materials in original containers, sealed, with labels intact.
- .2 Do not store insulation in direct contact with the earth, road surface, or roof deck. Place suitable supports under the insulation upon delivery to protect it from absorbing dampness from the surrounding terrain or deck.
- .3 Store materials to manufacturers' instructions. Provide and maintain dry, off-ground weatherproof storage. Take particular care to prevent materials from absorbing moisture. Remove unsatisfactory materials promptly and provide new dry materials.
- .4 Deliver fasteners in boxes or kegs and keep in protective storage until used. Do not oil or grease fasteners.
- .5 Remove materials only in quantities required for same day use.
- .6 Remove and replace damaged, wet or broken materials.
- .7 Cover gravel during inclement weather.
- .8 Store materials away from open flame or ignition sources.

1.6 **WARRANTY**

- .1 Provide Canadian Roofing Contractors' Association (CRCA) Standard Form of Warranty, complete with a copy of the CRCA's Preventative Maintenance Manual or similar written warranty acceptable to the Owner and the Consultant. The warranty shall be for a period of two years from date of Substantial Performance.
- .2 Provide material and material/labour warranties offered by the material manufacturers.

- .3 Repair defects within 24 hours of notification.
- .4 Inspect the roof 30 days before expiry of warranty and correct defects within 15 days of inspection. This inspection shall be performed at no additional cost to the Owner.
- .5 Carry out repair work required under the warranty in accordance with the recommendation of the Consultant.

PART - 2 PRODUCTS

2.1 MATERIALS

- .1 Roofing products: Matching and compatible with existing installed materials.

PART - 3 EXECUTION

3.1 EXAMINATION

- .1 Examine site conditions and surfaces to ensure that they are in satisfactory condition for the commencement of the work of this section. Do not proceed with work until surfaces are satisfactory.
- .2 Examine existing work to ensure materials used for work of this Section are compatible with and matching existing roofing system.

3.2 ROOFING

- .1 Remove only areas of the existing roofing system which can be replaced, complete with membrane flashings, on the same day.
- .2 Adequately install cants at junctions between horizontal and vertical surfaces. Provide tight flush joints between length of cants and mitre corners.
- .3 Provide roofing and flashing construction to matching existing.
- .4 Install sheet metal work in accordance with CRCA specifications, using concealed fastenings except where approved before installation.
- .5 Fabricate metal flashings and other sheet metal work to details shown. Form pieces in 2400 mm maximum lengths. Make allowance for expansion at joints.
 - .1 Hem exposed edges on underside 50 mm. Miter and seal corners with sealant.
 - .2 Form sections square, true and accurate to size, free from distortion and other defects detrimental to appearance or performance.
 - .3 Apply isolation coating to metal surfaces to be embedded in concrete or mortar.
 - .4 Counterflash membrane flashings at intersections of roof with vertical surfaces and curbs. Flash joints using S-lock forming tight fit over hook strips.
 - .5 Lock end joints and caulk with sealant.

3.3 CLEANING

- .1 Remove all existing debris from all roof areas.
- .2 Clear out roof drains, scuppers, eaves troughs and down spouts of debris resulting from work of this Section and ensure they are free draining at project completion.
- .3 Daily as the work proceeds and on completion, remove all surplus materials and debris resulting from work.
- .4 Remove stains, caulking or other adhesive from all affected surfaces.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section Includes: Labour, Products, equipment, and services necessary to complete the work of this Section.
- .2 Related Requirements
 - .1 Comply with Conditions of the Contract, and Division 01 - General Requirements.

1.2 REFERENCES

- .1 American Society for Testing and Materials (ASTM):
 - .1 ASTM E2174, Standard Practice for On-Site Inspection of Installed Fire Stops
- .2 Underwriters' Laboratories of Canada (UL Canada):
 - .1 CAN/ULC-S102, Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.
 - .2 CAN/ULC-S104, Standard Method for Fire Tests of Door Assemblies
 - .3 CAN/ULC-S105, Standard Specification for Fire Door Frames Meeting the Performance Required by CAN/ULC-S104.
 - .4 CAN/ULC-S115, Standard Method of Fire Test of Firestop Systems.

1.3 REQUIREMENTS OF REGULATORY AGENCIES

- .1 Fire rated assemblies: Labelled and listed by a nationally recognized testing agency having factory inspection service in conformance with CAN/ULC-S104 and CAN/ULC-S105 for ratings indicated.

1.4 SYSTEM DESCRIPTION

- .1 Work of this Section is inclusive of all firestopping specified herein and indicated on Drawings except for firestopping and smoke seal within mechanical assemblies (i.e. inside ducts, dampers, intumescant pipe sleeves) and electrical assemblies (i.e. inside bus ducts) shall be provided as part of work of the Mechanical and Electrical Divisions respectively. Firestopping and smoke seals around outside of such mechanical and electrical assemblies, where they penetrate fire rated separations, shall be part of work of this Section.
- .2 Fire stopping materials and/or systems intended to act as firestop and smoke seal for any through-penetrating items, termination devices, receptacles or any cut-out openings or joints, including openings and spaces at perimeter edge conditions, with wall and floor assemblies having fire-resistance rating.
- .3 Fire stop and seal (draft-tight) gaps, expansion joints and penetrations in fire separations and fire walls against passage of fire, smoke, gasses, fire fighter's hose stream and, where designated, passage of liquids. Smoke seal at angle support at fire dampers.
- .4 Materials and systems capable of providing effective barrier against passage of fire, smoke, gasses, and where specifically indicated passage of liquids.
- .5 Ensure firestopping system provides fire-resistance rating (flame and temperature) not less than fire resistance rating of surrounding floor, wall or assembly, in accordance with requirements of OBC.
- .6 Firestop system rating: Comply with F, FH, FT, or FTH ratings as required by authorities having jurisdiction.

- .7 Firestopping seals except for wall joints in visible areas must be of easily identifiable colour, such as red or yellow to be clearly distinguished from other building materials.
- .8 Supply asbestos-free and PCB-free materials and systems tested in accordance with CAN/ULC S115, be ULC listed, or be acceptable by authorities having jurisdiction.
- .9 Ensure suitability of products for application and compatibility of materials with surfaces to which it will be applied.
- .10 Site system assembly shall be in accordance with ULC listed system design limitations, unless proposed assembly is approved by authorities having jurisdiction and meets Consultant's approval.
 - .1 Technical submissions that propose deviations from a listed assembly must be prepared, stamped, and signed by a Professional Engineer, licensed to practice in the Province of Ontario.

1.5 **SUBMITTALS**

- .1 Shop Drawings: Submit complete and detailed shop for each condition encountered on Site. Indicate following:
 - .1 ULC assembly number certification, unless proposed assembly is approved by authorities having jurisdiction and meets Consultant's approval
 - .2 Required temperature rise and flame rating
 - .3 Hose stream rating (where applicable)
 - .4 Thickness
 - .5 Proposed installation methods
 - .6 Material of firestopping and smoke seals, primers, reinforcements, damming materials, reinforcements and anchorages/fastenings
 - .7 Size of opening
 - .8 Adjacent materials
 - .9 Number of penetrations
 - .10 Location of penetrations
- .2 Product Data: Submit up-to-date manufacturer's product data proposed for use under this Section. Include manufacture printed instructions for installation.
- .3 Samples: If requested, submit samples of each type of firestopping systems, smoke seals and accessories. Indicate location where material/system shall be used
- .4 Certification: Submit current ULC listings and certified copies of test reports and/or smoke seals indicating that firestopping material/systems conforms to or exceeds specified requirements.

1.6 **QUALITY ASSURANCE**

- .1 Provide work of this Section using competent installers experienced, trained and approved by material or system manufacturer for application of materials and systems being used. Installers shall have minimum 5 years experience in installation of firestopping materials as systems for multiple trade projects.
 - .1 Approved applicators of fireproofing materials shall select, with manufacturer's recommendations, ULC rated assembly to achieve the required fire resistance rating.

- .2 Work of this Section shall be by one Sub-Contractor responsible for firestopping materials and systems for all of the Work except as outlined above.
- .3 Pre-installation meeting: Prior to commencing work of this Section, arrange for manufacturer's technical representative to visit the site and review procedures to be adopted, conditions under which the work will be done, and inspect the surfaces to receive the work of this Section. Advise the Consultant of the date and time of the meeting.
- .4 Manufacturer's site inspection: Have the manufacturer's technical representative inspect the work at suitable intervals during application and at conclusion of the work of this Section, to ensure the work is correctly installed. When requested, submit manufacturer's inspection reports and verification that the work of this Section is correctly installed.
- .5 Request inspection by Consultant of completed systems before they are covered.
- 1.7 **COORDINATION**
 - .1 Coordinate with Sections involved (and advise dates) where work will take place throughout various areas of Work.
- 1.8 **DELIVERY, STORAGE AND HANDLING**
 - .1 Deliver materials to Site in manufacturer's sealed and labelled containers. Materials shall be subject to Consultant's inspection.
 - .2 Store materials inside building for 24 hours prior to use; store in area designated by Consultant; protect from damage and environmental conditions detrimental to material.
- 1.9 **ENVIRONMENTAL CONDITIONS**
 - .1 Maintain minimum temperature of 40 deg F for minimum period of 1 week before application, during application and until application is fully cured.
 - .2 Conform to manufacturer's recommended temperatures, relative humidity and substrate moisture content for storage, mixing, application and curing of firestopping materials.
 - .3 Ventilate areas in which firestopping is being applied. Protect water-soluble material from wetting until fully cured.
- 1.10 **WARRANTY**
 - .1 Warrant work of this Section against defects and deficiencies for period of 5 years commencing at the date of Substantial Performance. Promptly correct any defects or deficiencies which become apparent within warranty period, to satisfaction of Consultant and at no additional cost to Owner. Defects shall include but shall not be limited to cracking, breakdown of bond, failure to stay in place or bleeding.
- PART - 2 PRODUCTS**
- 2.1 **MATERIALS**
 - .1 Primer: As recommended by firestopping material manufacturer for specific substrate and use.
 - .2 Damming and backup materials, support and anchoring devices: Non-combustible, in accordance with tested assembly and as recommended by manufacturer. Combustible material for damming purpose may be permitted only if they are removed after permanent firestop materials are cured. Sheet steel covers over temporarily unused sleeves shall be minimum 0.8 mm (1/32") thick galvanized steel sheet.
 - .3 Pipe and duct insulation and wrappings: Compatible with firestopping material as recommended by manufacturer.

- .4 Fire stopping and smoke seals at opening intended for ease of re-entry such as cable: Elastomeric seal. Do not use cementitious or rigid seal at such locations.
- .5 Fire stopping and smoke seals at opening around penetrations for ductwork and other mechanical items requiring sound and vibration control: Elastomeric seal. Do not use cementitious or rigid seal at such locations.
- .6 Sealants at vertical surfaces: Non-sagging.
- .7 Sealants on floor surfaces requiring level finish: Self-levelling.
- .8 Firestop insulation / packing material: Intertek certified mineral wool batt insulation, pre-formed, semi-rigid, non-combustible, minimum 64 kg/m³ (4 lbs/ft³) density.

PART - 3 EXECUTION

3.1 PREPARATION

- .1 Remove combustible material and loose material detrimental to bond from edges of penetration. Clean, prime or otherwise prepare substrate material to manufacturer's recommendation.
- .2 Do not apply firestop material to surfaces previously painted or treated with sealer, curing compound, water repellent or other coatings unless tests have been performed to ensure compatibility of materials. Remove coatings as required.
- .3 Verify openings, dimensions and surfaces conform to fire and smoke seal assembly.
- .4 Comply with manufacturer's recommended requirements for temperature, relative humidity, moisture content and presence of any sealer or release agents on substrate during application and curing of materials. Surfaces shall be dry, dust and frost free.
- .5 Fully protect walls, windows, floors and other surfaces around areas to be firestopped from marring or damage.
- .6 Prime surfaces in accordance with manufacturer's directions. Mask where necessary to avoid spillage on to adjoining surfaces. Remove stains on adjacent surfaces as required.
- .7 Remove insulation from area of insulated pipe and duct where such pipes or ducts penetrate fire separation unless ULC certified assembly permits such insulation to remain within assembly.
- .8 Provide temporary forming, packing and bracing materials necessary to contain firestopping. Upon completion, remove forming and damming materials not required to remain as part of system.
- .9 Install damming and firestopping materials as per manufacturer's instructions.
- .10 Mix materials at correct temperature and in strict accordance with manufacturer's directions.

3.2 INSTALLATION

- .1 Seal penetrations through and gaps in fire rated separations. Fill gap in accordance with ULC details for tested system selected.
- .2 Apply firestopping materials in strict accordance with manufacturer's written instructions and tested designs to provide required temperature and flame rated seal. Apply with sufficient pressure to properly fill and seal openings to ensure continuity and integrity of fire separation. Tool or trowel exposed surfaces as required.
- .3 Remove excess compound promptly as work progresses and upon completion.

- .4 Examine sizes, anticipated movement and conditions of opening and penetration to establish correct system and depth of backup materials and of firestopping material required. Use firestopping and smoke seals best suited for specific application as required, indicated or specified. Use only components specified in fire test of system. Do not eliminate any component for firestop system that was present in fire tests.
- .5 Do not cover materials until full cure has taken place.
- .6 Provide firestop systems at following locations, without being limited to:
 - .1 At openings, voids and penetrations through floor slabs except openings within shafts constructed with a fire resistance rating and slabs on granular fill.
 - .2 At openings, voids and penetrations through fire rated masonry, concrete and gypsum board walls, partitions and shaft walls.
 - .3 At openings, voids and penetrations installed for future use through fire rated masonry, concrete and gypsum board walls, partitions, and shaft walls.
 - .4 Around mechanical and electrical assemblies penetrating fire assemblies.
 - .5 Between perimeter of floor and roof slabs and exterior wall construction, and cladding systems.
 - .6 Between tops of fire rated walls and partitions and underside of floor or roof slabs.
 - .7 At all expansion joints in walls, floors and assemblies as detailed
- .7 Refer to all other sections of Specifications and the Drawings to ascertain where firestops are to be used and, if noted, type of firestop required.
- .8 Cure materials in accordance with manufacturer's directions.

3.3

CLEANING

- .1 Remove excess materials and debris and clean adjacent surfaces immediately after application to satisfaction of Consultant. Remove and/or correct staining and discolouring of adjacent surfaces as directed.
- .2 Remove temporary combustible damming materials after initial set of firestopping materials. Such dams may be required to remain in place if flame spread rating is below 25, in accordance with CAN/ULC-S102.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section Includes: Labour, Products, equipment, and services necessary to complete the work of this Section, including but not limited to:
 - .1 Sealants not specified in other Sections.
- .2 Related Requirements
 - .1 Comply with Conditions of the Contract, and Division 01 - General Requirements.

1.2 QUALITY ASSURANCE

- .1 Applicators: Recognized and established sealant applicators with at least five years experience and having skilled mechanics thoroughly trained and competent in the use of sealant equipment and the specified materials.
- .2 Pre-installation meeting: Two weeks prior to commencing work of this Section, arrange for manufacturer's technical representative to visit the site and review preparatory and installation procedures to be followed, conditions under which the work will be done, and inspect the surfaces to receive the work of this Section. Advise the Consultant of the date and time of the meeting.
- .3 Single source responsibility: Use sealants from single manufacturer for each different product required to ensure compatibility.
- .4 Pre-installation compatibility and adhesion testing: Provide sealant manufacturer samples of actual materials that will contact or affect their sealants in the Work for compatibility and adhesion testing. This testing will not be required where sealant manufacturer is able to furnish data acceptable to Consultant based on previous testing for adhesion and compatibility to materials matching those of the Work.
- .5 Pre-installation field adhesion testing:
 - .1 Conduct site field-tests for adhesion of sealants to actual joint substrates using proposed preparation methods and materials recommended by manufacturer.
 - .2 Conduct tests for each type of sealant and substrate.
 - .3 Locate field-test joints where inconspicuous or as directed by Consultant. Include areas typical of those requiring removal of existing sealants and utilize methods proposed for sealant removal.
 - .4 Test method: Use manufacturer's standard field adhesion test methods and methods proposed for joint preparation to verify proper priming and joint preparation techniques required to obtain optimum adhesion of joint sealants to joint substrate.
 - .5 Evaluate and report results of field adhesion testing.
 - .6 Do not use joint preparation methods or sealants that produce less than satisfactory adhesion to joint substrates during testing.
- .6 Standard of acceptance: Retain at least one 1500 mm long acceptable joint for each type of sealant and substrate installed during pre-installation field adhesion testing as standard of acceptability for the Work. Acceptable joints may form part of the Work.

1.3 SUBMITTALS

- .1 Product Data: Submit to Consultant Product information from sealant manufacturer prior to commencement of work of this Section verifying:
 - .1 Selected sealant materials are from those specified.
 - .2 Composition and physical characteristics.
 - .3 Surface preparation requirements.
 - .4 Priming and application procedures.
 - .5 Suitability of sealants for purposes intended and joint design.
 - .6 Test report on adhesion, compatibility, and staining effect on samples of adjacent materials used on Project.
 - .7 Sealants compatibility and adhesion with other materials and Products with which they come in contact including but not limited to sealants provided under other Sections, insulation adhesives, bitumens, membranes, stone, concrete, masonry, metals and metal finishes, ceramic tile, plastic laminates and paints.
 - .8 Suitability of sealants for temperature and humidity conditions at time of application
- .2 Samples: Submit duplicate samples of each type of material and colour. Submit samples of primer, bond breaker tape and joint backing material, if requested.

1.4 DELIVERY, STORAGE, AND HANDLING

- .1 Deliver and store materials in original wrappings and containers with manufacturer's seals and labels, intact. Protect from freezing, moisture, and water.

PART - 2 PRODUCTS

2.1 MATERIALS

- .1 Sealant-general:
 - .1 Provide exterior and interior elastomeric joint sealants establishing and maintaining watertight, water resistant and air tight continuous joint seals without staining or deteriorating joint substrates
 - .2 Ensure elastomeric sealants comply with specified type, grade, class and uses.
 - .3 Provide Products with capability, when tested for adhesion and cohesion under maximum cyclic movement in accordance with ASTM C719, to withstand required percentage change in joint width existing at time of installation and remain in compliance with other requirements of ASTM C920 for uses indicated
 - .4 Where elastomeric sealants shall be non-staining to porous substrates, provide Products that have undergone testing according to ASTM C1248 and have not stained porous joint substrates indicated for the project.
 - .5 Allow for special colours as selected by the Consultant.
- .2 Sealants, cleaning solvents and primers: Compatible with each other.
- .3 Type A Sealant: Provide 1 of following:
 - .1 Non-sag type, 1 component ultra-low-modulus, pre-pigmented, neutral cure elastomeric silicone sealant conforming to ASTM C920, Type S, Grade NS, Class 100/50, Use NT, G, M, A and O. Supply in standard colours as selected.

- .2 Non-sag type, 1 component medium-modulus, pre-pigmented, neutral cure elastomeric silicone sealant conforming to ASTM C920, Type S, Grade NS, Class 50, Use NT, G, M, A and O. Supply in standard colours as selected.
- .4 Type B Sealant: Non-sag type, 1 component, mildew resistant silicone containing non-toxic fungicidal agents sealant conforming to ASTM C920, Type S, Grade NS, Class 25, Use NT.
- .5 Type C Sealant: Provide 1 of following:
 - .1 Non-sag type, 1 component, acrylic latex sealant conforming to ASTM C834, Type OP, Grade -18°C. Supply in standard colours as selected.
 - .2 Non-sag type, multi-component polyurethane sealant conforming to ASTM C920, Type M, Grade NS, Class 50, Use T, I, M, A and O. Supply in standard colours as selected.
 - .3 Non-sag type, 1 component polyurethane sealant conforming to ASTM C920, Type S, Grade NS, Class 25, Use NT, M, A and O. Supply in standard colours as selected.
- .6 Type D Sealant: Provide 1 of following:
 - .1 Pour grade, 1 component polyurethane sealant conforming to ASTM C920, Type S, Grade P, Class 25, Use T, M, A, I and O. Supply in standard colours as selected.
 - .2 Pour grade, multi-component, polyurethane sealant conforming to ASTM C920, Type M, Grade P, Class 25, Use T, M, A, I and O.
 - .3 Pour grade, 1 component ultra-low modulus, pre-pigmented, neutral cure elastomeric silicone sealant. Supply in standard colours as selected.
 - .4 Non-sag type, 1 component low-modulus, pre-pigmented, neutral cure elastomeric silicone sealant conforming to ASTM C920, Type S, Grade NS, Class 50, Use NT, G, M, A and O. Supply in standard colours as selected.
- .7 Type E Sealant: Self-levelling type, epoxy modified joint sealant, cold-applied, 2 component, pour grade, grey colour.
- .8 Joint primer: As recommended by sealant manufacturer for substrates, conditions and exposures indicated.
- .9 Bond breaker: Polyethylene tape or other adhesive faced tape as recommended by sealant manufacturer to prevent sealant contact where it would be detrimental to sealant performance.
- .10 Joint backer: Polyethylene foam rod or other compatible non-waxing, non-extruding, non-staining resilient material in dimension 25 percent to 50 percent wider than joint width as recommended by sealant manufacturer for conditions and exposures indicated. Ensure backing is compatible with sealant, primer and substrate
- .11 Masking tape: Non-staining, non-absorbent tape product compatible with sealants and adjacent joint surfaces that is suitable for masking.
- .12 Cleaning Material: Non-corrosive, non-staining, solvent type, xylol, MEK, toluol, IPA or as recommended by sealant manufacturer and acceptable to material or finish manufacturers for surfaces adjacent to sealed areas free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way and formulated to promote optimum adhesion of sealants with joint substrates.

PART - 3 EXECUTION

3.1 PREPARATION

- .1 Prepare surfaces to receive work in accordance with sealant manufacturer's instructions and recommendations except where more stringent requirements are indicated.
- .2 Thoroughly clean joint surfaces using cleaners approved by sealant manufacturer whether primers are required or not.
- .3 Remove all traces of previous sealant and joint backer by mechanical methods, such as by cutting, grinding and wire brushing, in manner not damaging to surrounding surfaces.
- .4 Remove paints from joint surfaces except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer.
- .5 Remove wax, oil, grease, dirt film residues, temporary protective coatings and other residues by wiping with cleaner recommended for that purpose. Use clean, white, lint-free cloths and change cloths frequently.
- .6 Remove dust by blowing clean with oil-free, compressed air.
- .7 Joint backer: Provide joint backer uniformly to depth required for proper joint design using a blunt instrument. Fit securely by compressing backer material 25 percent to 50 percent so no displacement occurs during tooling. Avoid stretching or twisting joint backer.
- .8 Bond breaker: Provide bond-breaker recommended by sealant manufacturer, adhering strictly to the manufacturer's installation requirements.
- .9 Priming: Prime joint substrates where required. Use and apply primer to sealant manufacturers recommendations. Confine primers to sealant bond surfaces; do not allow spillage or migration onto adjoining surfaces.
- .10 Taping: Use masking tape, where required, to prevent sealant or primer contact with adjoining surfaces that would be permanently stained or otherwise damaged by such contact or the cleaning methods required for removal. Apply tape so as not to shift readily, and remove tape immediately after tooling without disturbing joint seal.

3.2 INSTALLATION

- .1 Do not apply sealants to joint surfaces treated with sealer, curing compound, water repellent, or other coatings unless tests have been performed to ensure compatibility of materials. Remove coatings as required.
- .2 Install sealants immediately after joint preparation.
- .3 Mix, apply and cure sealants in accordance with manufacturer's printed instructions.
- .4 Install sealants to fill joints completely, without voids or entrapped air, using proven techniques, proper nozzles and sufficient force that result in sealants directly contacting and fully wetting joint surfaces.
- .5 Install sealants to uniform cross-sectional shapes with depths relative to joint widths that allow optimum sealant movement capability as recommended by sealant manufacturer.

- .6 Dry tool sealants in manner that forces sealant against back of joint, ensures firm, continuous full contact at joint interfaces and leaves a finish that is smooth, uniform and free of ridges, wrinkles, sags, air pockets and embedded impurities.
 - .1 Tooling liquids that are non-staining, non-damaging to adjacent surfaces and approved by sealant manufacturer may be used if necessary when care is taken to ensure that the liquid does not contact joint surfaces before the sealant.
 - .2 Provide concave tooled joints unless otherwise indicated to provide flush tooling or recessed tooling.
 - .3 Provide recessed tooled joints where the outer face of substrate is irregular.
- .7 Remove sealant from adjacent surfaces in accordance with sealant and substrate manufacturer recommendations as work progresses.
- .8 Do not cover up sealants until proper curing has taken place.
- .9 Protect joint sealants from contact with contaminating substances and from damages. Cut out, remove and replace contaminated or damaged sealants immediately, so that they are without contamination or damage at time of Substantial Performance.

3.3 **LOCATION SCHEDULE**

- .1 Use one of the sealants specified for each type in following locations. Ensure sealant chosen from several specified types listed under Part 2 Materials, and recommended by manufacturer for use for conditions encountered:
 - .1 Type A: Typically used in joints between metal frames and adjacent masonry and/or concrete construction in exterior walls, exterior and interior sides; control and expansion joints in exterior and interior surfaces of poured-in-place concrete walls, precast architectural wall panels and unit masonry walls; sealing of joints between underside of pre-stressed precast concrete floor slabs and masonry; and other locations where sealant is required or noted on Drawings except in locations designated for Type B, C, D, E and S and except where sealant is specified in other Sections.
 - .2 Type B: Typically used in joints between urinals and walls, around washrooms accessories, at corners of walls, between splash backs and walls, in shower, damp or wet areas, at ceramic tiles where mildew resistant sealant is required.
 - .3 Type C: Typically used in joints between interior metal and/or wood frames and adjacent construction in interior partitions.
 - .4 Type D (traffic bearing): Typically used in joints with movement in horizontal surfaces between concrete slabs, pavers, and precast concrete panels.
 - .5 Type E (load bearing): Typically used in static joints in horizontal surfaces where self-levelling sealants are required.
- .2 Refer to Drawings for sealing work not specifically listed in this Section.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section Includes: Labour, Products, equipment, and services necessary to complete the work of this Section, including but not limited to:
 - .1 Hollow metal doors, non-rated and fire rated types.
 - .2 Non-rated and fire rated steel frames.
- .2 Related Requirements
 - .1 Comply with Conditions of the Contract, and Division 01 - General Requirements.

1.2 REFERENCES

- .1 American Society for Testing and Materials (ASTM):
 - .1 ASTM A568/A568M-11b, Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for
 - .2 ASTM A653/A653M-11, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- .2 Canadian Standards Association (CSA):
 - .1 CSA-W59: Welded Steel Construction (Metal Arc Welding).
- .3 Canadian General Standards Board (CGSB):
 - .1 CAN/CGSB-1.40: Anti-corrosive Structural Steel Alkyd Primer.
- .4 Underwriters' Laboratories of Canada (ULC):
 - .1 CAN4 S104M: Standard Method for Fire Tests of Door Assemblies
 - .2 CAN4 S105M: Standard Specification for Fire Door Frames Meeting the Performance Required by CAN4-S104
 - .3 CAN/ULC-S702: Standard for Thermal Insulation, Mineral Fibre, for Buildings.
 - .4 Underwriters Laboratories of Canada, List of Equipment and Materials.
- .5 DHI (Door Hardware Institute) - The Installation of Commercial Steel Doors and Steel Frames, Insulated Steel Doors in Wood Frames and Builder's Hardware.
 - .1 ANSI/DHI A115.IG-1994: Installation Guide for Doors and Hardware.
- .6 CSDFMA (Canadian Steel Door and Frame Manufacturers Association).
- .7 NFPA 80 - Fire Doors, Fire Windows.
- .8 NFPA 252 - Fire Tests for Door Assemblies.
- .9 Steel Door Institute: ANSI/SDI A250.8-17, Specifications for Standard Steel Doors and Frames (SDI-100).
- .10 NAAMM HMMA 802-07: Manufacturing of Hollow Metal Doors and Frames.
- .11 NAAMM HMMA 840-07: Guide Specification for Installation and Storage of Hollow Metal Doors and Frames.
- .12 NAAMM HMMA 805-12: Recommended Selection and Usage Guide for Hollow Metal Doors and Frames.

1.3 **REQUIREMENTS OF REGULATORY AGENCIES**

- .1 Fire rated assemblies: Labelled and listed by a nationally recognized testing agency having factory inspection service in conformance with CAN4 S104M and CAN4 S105M for ratings indicated.
- .2 Install fire rated assemblies to NFPA 80 except where specified otherwise.

1.4 **SUBMITTALS**

- .1 Shop drawings: Indicate each type of door and frame, door and frame elevations, configurations, material, steel core thicknesses, mortises, reinforcements, anchor types and spacing, location of exposed fasteners, openings, arrangement of hardware, cut-outs for hardware, glazing, louvers, finishes, and fire rating.
- .2 Product Data: manufacturer's standard data sheet illustrating standard door and frame construction.
- .3 Samples: Submit samples indicating 1 cut-away corner sample and minimum 300 mm square for each type of door to indicated following:
 - .1 Core.
 - .2 Reinforcing.
 - .3 Facing.
 - .4 Frame.
- .4 Submit a copy of NAMMA-HMMA 840 to the contractor responsible for the storage and installation of hollow metal doors and frames.

1.5 **QUALITY ASSURANCE**

- .1 Qualifications: Provide evidence that the:
 - .1 Manufacturer has fabricated product of types under this Section, for projects of similar size and scope, for a continuous period of not less than five (5) years prior to award off Subcontract, has personnel and plant equipment capable of fabricating steel door and frame product of the types specified and has a written quality control system in place.
 - .2 Product supplier is a qualified direct distributor of the products to be furnished, and has in his regular employ, an AHC, CDC, or person of equivalent experience, available at reasonable times to consult with the Consultant, Subcontractor and/or Owner.
 - .3 Installer is a firm with five (5) years continuous experience prior to the award of Subcontract, in installing product covered by this Section and Section 08 71 00 and is knowledgeable of the manufacturers', and ANSI/NFPA 80, requirements relating to the installation of labelled fire rated products covered by this section and Section 08 71 00 Door Hardware.
- .2 Quality Criteria: All door and frame Products shall meet performance requirements specified herein. Fabricate assemblies in strict accordance with reviewed submittal drawings.
- .3 Conform to Canadian Steel Door and Frame Manufacturers Association standards.
- .4 Welding: to CSA W59.

.5 Performance/Design Criteria:

- .1 Ensure door and frame assembly meets acceptance criteria of ANSI A224.1 and is certified as Level "A" (1,000,000 cycles) and Twist Test Acceptance Criteria (deflection not to exceed 6 mm/13.6 kg (1/4"/30 lb) force, total deflection at 136 kg (300 lb) force not to exceed 64 mm (2-1/2") and permanent deflection not to exceed 3 mm (1/8")) when tested in accordance with ANSI A250.4. Ensure tests are conducted by an independent nationally recognized accredited laboratory.
- .2 Test fire rated doors, frames, transom frames and sidelight assemblies in accordance with requirements of CAN4-S104-M and NFPA 252. Test borrowed lights and screens in accordance with CAN4-S106-M and NFPA 257. Ensure Products are listed by a nationally recognized testing agency acceptable to authorities having jurisdiction and approved by Architect of Record having factory inspection services.
- .3 Ensure Product quality meets standards set by CSDMA.

1.6 **DELIVERY, STORAGE, AND HANDLING**

- .1 Brace and protect assemblies to prevent distortion during shipment. Store in a secure dry location.
- .2 Store doors vertically, resting on planks, with blocking between to allow air to circulate.

1.7 **WARRANTY**

- .1 Steel door and frame Products provided under this Section, touched up only with zinc-rich rust inhibitive primer where coating has been removed during its manufacture, shall be warranted by the manufacturer for a period of ten (10) years from the date of supply:
 - .1 Against rust perforation, when stored, installed and finish painted in accordance with manufacturer's published instructions.
 - .2 For finish paint adhesion, when stored and cleaned in accordance with manufacturer's application recommendation, and finish painted with commercial quality paint in accordance with Section 09 91 00 and to paint manufacturer's application recommendations.

PART - 2 PRODUCTS

2.1 **MATERIALS**

- .1 Sheet Steel: Commercial grade steel to ASTM A568/A568M, Class 1, hot-dip galvanized to ASTM A653/A653M, ZF120 (A40), known commercially as "Colourbond", "Satincoat", or "Galvanneal". Steel sheet thicknesses specified are base metal thicknesses prior to galvanizing.
- .2 Standard Duty Interior Hollow Metal Doors and Transom Panels:
 - .1 1.519 mm thick (16 ga) minimum commercial quality steel sheet faces, flush design, paintable galvanneal finish.
 - .2 Core: Honeycomb core for non-insulated doors; fiberglass insulation for insulated doors.
- .3 Heavy Duty Interior Hollow Metal Doors and Transom Panels:
 - .1 Face Sheets: 1.519 mm thick (16 ga) minimum steel sheet.
 - .2 Core - Vertical Stiffeners: 0.912 mm thick (20 ga) minimum steel sheet.

- .4 Standard Duty Interior Fire Rated Hollow Metal Doors:
 - .1 Face Sheets: 1.519 mm thick (16 ga) minimum steel sheet.
 - .2 Core: Honeycomb core for non-insulated doors; polystyrene insulation for insulated doors.
- .5 Heavy Duty Interior Fire Rated Hollow Metal Doors:
 - .1 Face Sheets: 1.519 mm thick (16 ga) minimum steel sheet.
 - .2 Core - Vertical Stiffeners: 0.912 mm thick (20 ga) minimum steel sheet.
- .6 Core - Interior Doors:
 - .1 Steel Stiffened: vertically stiffened with 0.912 mm steel ribs at 152mm o.c. maximum, with all voids filled completely with semi-rigid blanket and batt insulation. Fabricate door faces with a single sheet of steel welded to steel stiffeners.
 - .2 Honeycomb: Structural small cell, 25 mm maximum kraft paper 'honeycomb'; weight: 36.3 kg per ream minimum; density: 16.5 kg/m³ minimum. Provide items sanded to required thickness.
 - .3 Insulation – Standard non-insulated doors: Loose batt type, density: 1.5 pcf (24kg/m³) minimum, conforming to ASTM C665.
 - .4 Insulation – Fire rated insulated doors: Rigid extruded polystyrene, fire retardant, closed cell board, Type 1, density: 1 to 2 pcf (16 to 32 kg/m³), thermal values: R 6.0 (RSI 1.06) (minimum), conforming to ASTM C578.
- .7 Standard and Heavy Duty Interior Hollow Metal Door Frames, Transom Frames, Sidelight and Window Frames: Minimum 1.60 mm (16 ga.) thick steel, cold-rolled commercial quality steel; paintable galvaneal finish; sizes as indicated on Door Schedule and Drawings.
- .8 Insulation for door frames: Fiberglass, loose batt type, density: 1.5 pcf (24kg/m³) minimum, conforming to ASTM C665.
- .9 Fire Rated Door and Frame Assemblies: Conform to CAN4-S104-M, CAN4-S105-M, NFPA 80 and NFPA 252.

2.2 **ACCESSORIES**

- .1 Reinforcements: regular galvaneal steel, thicknesses as follows:
 - .1 Flush Bolt, Lock and Strike Reinforcement: minimum 1.6 mm (16 ga).
 - .2 Hinge Reinforcements: minimum 3.5 mm (10 ga).
 - .3 Door Closer and Holder Reinforcements: minimum 2.6 mm thick (12 ga) steel.
 - .4 Reinforcement for Surface Applied Hardware: minimum 1.2 mm thick (18 ga) steel.
 - .5 Concealed Door Closer or Holder Reinforcements: minimum 2.6 mm thick (12 ga) steel.
 - .6 Top and Bottom End Channels – Interior Doors:
 - .1 1.2 mm thick (18 ga) steel for 0.912 mm thick (20 ga) hollow metal doors and transom panels.
 - .2 1.519 mm thick (16 ga) steel for 1.519 mm thick (16 ga) hollow metal doors and transom panels.
 - .3 Channels to be continuously welded to face sheet.
 - .7 Jamb Spreaders: minimum 0.912 mm thick (20 ga) steel

- .2 Anchors: regular galvalume steel, as follow:
 - .1 T-Strap Type: 1.2 mm thick.
 - .2 Stirrup-strap Type: 50 x 250mm size, 1.6 mm thick.
 - .3 Jamb Floor Type: 1.6 mm thick.
 - .4 Stud Type: 1.0mm thick.
- .3 Bituminous Coating: fibrous asphalt emulsion.
- .4 Mortar Guard Boxes: regular galvalume steel, 0.8 mm thick.
- .5 Joint Sealer: as specified in Section 07 92 00.
- .6 Fasteners for Stops: Cadmium plated steel, counter sunk flat or oval head sheet metal Phillips screws.
- .7 Adhesives:
 - .1 Steel Components: Heat resistant, spray grade, resin reinforced neoprene/rubber (polychloroprene) based, low viscosity, contact cement.
 - .2 Polyisocyanurate Cores: Heat resistant, epoxy resin based, low viscosity, contact cement.
 - .3 Lock-Seam Doors: Fire resistant, RRPC, fire resistant, high viscosity sealant/adhesive.
- .8 Resilient bumpers: Round, black rubber, stud mount.
- .9 Primer: Zinc rich primer.

2.3 **FABRICATION - GENERAL**

- .1 Blank, reinforce, drill and tap doors and frames for mortised hardware. Reinforce doors and frames for surface mounted hardware.
- .2 Apply, at factory, touch up primer to doors and frames manufactured from galvanized steel where coating has been removed during fabrication.
- .3 Make provisions in doors and frames to suit requirements of Section providing security devices.
- .4 Fabricate fire rated assemblies to ULC requirements and bearing ULC, ULI or Warnock-Hersey International Ltd., label, as acceptable to authorities having jurisdiction.
- .5 Locate fire rating labels on the inside of the frame hinge jamb and door hinge edge midway between the top hinge and the head of the door.

2.4 **FABRICATION - DOORS**

- .1 Fabricate doors to HMMA 802, HMMA 810, ANSI/SDI A250.8, and to the standards and specifications published by the Canadian Steel Door and Frame Manufacturer's Association.
- .2 Provide continuous faces free from joints, tool markings and abrasions; with hardware reinforcement plates welded in place.
- .3 Welding: to CSA W59. Grind exposed welds smooth and flush. Fill open joints, seams, and depressions with filler or by continuous brazing or welding. Grind and sand to a smooth, true, uniform finish.
- .4 Fabricate fire-rated doors in accordance with Canadian Fire Labelling Guide for Steel Doors and Frames as published by the Canadian Steel Door and Frame Manufacturer's Association.

- .5 Attach fire rated label to each fire rated door unit.
- .6 Completely fill door cores with specified core materials.
- .7 Preparation for hardware:
 - .1 Prepare doors for heavy weight oversize butt hinges, mortise locksets, rim and surface vertical rod exit devices, surface door closers and concealed overhead stops.
 - .2 Conform to approved finish hardware schedule.
 - .3 Blank, mortise, reinforce, and drill doors to receive template hardware, as required. Coordinate with Section 08 71 00.
 - .4 Where electrified hardware is specified on the approved hardware schedule, steel door and frame product, shall be provided with Electrolynx system consisting of CSA approved conduit, junction boxes and wire harness complete with modular plugs for coordinated connection directly to the electrified hardware.
- .8 Reinforce door edges with channel reinforcing.
- .9 Door faces of all steel doors shall be fabricated without visible seams, free of scale, pitting, coil brakes, buckles, and waves.
- .10 Longitudinal edges of doors shall be mechanically interlocked, and adhesive assisted.
- .11 Seams between faces and door edges of doors:
 - .1 Tack weld and fill seam between faces and door edges of doors for standard and heavy duty interior hollow metal doors and transom panels.
 - .2 For extra-heavy duty interior hollow metal doors and transom panels provide continuously welded edges between faces and door edges of doors.
- .12 Bevel stiles minimum 3mm.
- .13 Fabrication Tolerances:
 - .1 Fabricated door deformation (bow, cup, twist, warp) shall not exceed 3 mm when measured with a straight edge placed diagonally across door extending from top to bottom.
 - .2 Widths of door openings shall be measured from inside of frame jamb rebates with a tolerance of +1.5 mm, -1 mm.
 - .3 Unless builders' hardware requirements dictate otherwise, doors shall be sized so as to fit openings and allow a 3 mm clearance at jambs and head. Provide 19 mm clearance between bottom of door and finished floor (exclusive of floor coverings). Tolerances on door sizes shall be 1.2 mm.
 - .4 Provide doors with 1.5 mm clearance at heads and jambs, and no more than 3 mm door and threshold.

2.5 **FABRICATION - FRAMES**

- .1 Fabricate frames as welded units. Knock down frames will not be allowed.
- .2 Conform to HMMA 802. Conform to HMMA 805 for frame thickness selection in relation to door thickness.
- .3 Welding: to CSA W59. Grind exposed welds smooth and flush. Fill open joints, seams, and depressions with filler or by continuous brazing or welding. Grind and sand to a smooth, true, uniform finish.

- .4 Mitre corners of frames. Cut frame mitres accurately and weld continuously on inside of frame.
- .5 Protect strike and hinge reinforcements and other openings with mortar guard boxes welded to frame.
- .6 Reinforce frames wider than 1.2 metres with roll formed steel channels fitted tightly into frame head, flush with top.
- .7 Fit frames with channel or angle spreaders, minimum two per frame, to ensure proper frame alignment. Install stiffener plates to spreaders between frame trim where required to prevent bending of trim and to maintain alignment when setting and during construction.
 - .1 Channel or angle spreaders are to be removed prior to installation and are not to be used as part of the installation process.
- .8 Attach fire rated label to each fire rated unit.
- .9 Provide 3 bumpers on strike jamb for each single door.
- .10 Preparation for hardware:
 - .1 Prepare frames for heavy weight oversize butt hinges, mortise locksets, rim and surface vertical rod exit devices, surface door closers and concealed overhead stops.
 - .2 Conform to approved finish hardware schedule.
 - .3 Blank, mortise, reinforce, drill, and tap frames to receive template hardware, as required. Coordinate with Section 08 71 00.
 - .4 Where electrified hardware is specified on the approved hardware schedule, steel door and frame product, shall be provided with Electrolynx system consisting of CSA approved conduit, junction boxes and wire harness complete with modular plugs for coordinated connection directly to the electrified hardware. Refer to Finish Hardware Schedule for openings that require electrified hardware.
- .11 Fabrication Tolerances:
 - .1 Widths of door openings shall be measured from inside of frame jamb rebates with a tolerance of +1.5 mm, -1 mm.
 - .2 Manufacturing tolerances on formed frame profiles shall be 1 mm for faces, stop heights and jamb depths. Tolerances for throat openings and door rebates shall be 1.5 mm and 0.5 mm respectively. Hardware cutout dimensions shall be as per template dimensions, +0.38 mm, -0.

PART - 3 EXECUTION

3.1 INSTALLATION - GENERAL

- .1 Touch up with primer galvanized finish damaged during installation.

3.2 INSTALLATION - FRAMES

- .1 Install frames plumb, square, aligned, without twist at correct elevation, to HMMA 840, ANSI/DHI A115.IG, Canadian Steel Door and Frame Manufacturers Association standards and manufacturer's instructions and templates.
- .2 Provide suitable anchors to suit construction. Use one base anchor and two wall anchors per jamb side for frames up to 1500 mm and one additional wall anchor per jamb side for each additional height of 750 mm or fraction thereof.
- .3 Secure anchorages and connections to adjacent construction.

- .4 Brace frames rigidly in position while building-in. Install temporary horizontal wood spreader at third points of door opening to maintain frame width. Remove temporary spreaders after frames are built-in.
- .5 Make allowances for deflection of structure to ensure structural loads are not transmitted to frames.
- .6 Fill open sections (jambs, heads and sills) of exterior door frame voids, or where door frames are indicated to be insulated, with batt insulation.
- .7 Seal openings between frames and walls as specified in Section 07 92 00.

3.3 **INSTALLATION - DOORS**

- .1 Install doors to HMMA 840, ANSI/DHI A115.1G, Canadian Steel Door and Frame Manufacturers Association standards and manufacturer's instructions and templates.
- .2 Coordinate installation of finish hardware.
- .3 Provide even margins between doors and jambs and doors and finished floor and thresholds as follows:
 - .1 Hinge side: 3 mm.
 - .2 Latchside and head: 3 mm.
 - .3 Finished floor for non-rated assemblies: 12 mm.
 - .4 Finished floor for rated assemblies: 6 mm.

3.4 **ADJUSTING**

- .1 Adjust door for smooth and balanced door movement.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section Includes:
 - .1 Labour, Products, equipment, and services necessary to complete the work of this Section for interior aluminum screens, including:
 - .2 Related Requirements
 - .1 Comply with Conditions of the Contract, and Division 01 - General Requirements.

1.2 SUBMITTALS

- .1 Product Data: Submit product data including manufacturer's literature for aluminum, components, and accessories, indicating compliance with specified requirements and material characteristics.
- .2 Shop drawings:
 - .1 Indicate materials and profiles and provide full-size, scaled details of components for each type of door. Indicate:
 - .1 Core thicknesses of components.
 - .2 Type and location of exposed finishes.
 - .3 Size of opening and tolerances.
 - .4 Glazing.
 - .2 Show connection to and continuity with adjacent thermal, weather, air, and vapor barriers.
 - .3 Include catalogue details for each type of door illustrating profiles, dimensions, and methods of assembly.
- .3 Samples:
 - .1 Submit duplicate 300 x 300 mm sample sections showing prefinished aluminum surface, finish, colour, and texture, and including frame corner details.
- .4 Maintenance Data and Operating Instructions: Three (3) copies of instructions covering reglazing, adjustments, and other relevant maintenance data.

1.3 QUALITY ASSURANCE

- .1 Manufacturer Qualifications: A manufacturer capable of fabricating aluminum screens that meet or exceed performance requirements indicated and of documenting this performance by test reports, and calculations.
- .2 Installer Qualifications: An installer acceptable to aluminum screen manufacturer for installation of units required for this Project.

1.4 DELIVERY, STORAGE AND HANDLING

- .1 Deliver aluminum materials in manufacturer's original packaging with identification labels intact and in sizes to suit project.
- .2 Material Handling: To AAMA CW-10.
- .3 Storage and Handling Requirements: Store materials off ground and protected from exposure to harmful weather conditions and at temperature conditions recommended by manufacturer. Comply with requirements of AAMA CW-10.

1.5 **PROTECTION**

- .1 Provide suitable means of protection to finished aluminum surfaces to prevent damage by mortar, plaster, jointing compound, or similar deleterious substances and to prevent physical damage to finished surfaces.

PART - 2 PRODUCTS

2.1 **MATERIALS**

- .1 Aluminum Extrusions: Aluminum Association alloy AA 6063-T5, free from scratches and surface blemishes.
- .2 Aluminum Sheet: Aluminum Association alloy AA 1100, free from all scratches and surface blemishes.
- .3 Steel Reinforcements: CAN/CSA-G40.20-M and CAN/CSA-G40.21-M, Grade 300 W.
- .4 Screws, Bolts, Nuts, Washers, and Other Fastening Devices: Stainless steel with not less than 12% chromium content to prevent galvanic action, and of sufficient strength for the purpose. Exposed screws or pop rivets are not acceptable.
- .5 Zinc Chromate Primer: CAN/CGSB-1.40-M.
- .6 Bituminous Paint: CAN/CGSB-1.108-M, Type 2.
- .7 Insulation - packing in voids and cavities: Mineral fibre batt insulation conforming to CAN/ULC-S702, Type 1.
- .8 Glass and Glazing: In accordance with Section 08 80 00 Glazing.
- .9 Sealants: Multi-component, chemical curing, Type C polyurethane sealant as per Section 07 92 00, or 1 component chemical curing, Type A silicone sealant per Section 07 92 00. Colour as selected from manufacturer's standard colours.

2.2 **FINISHES - ALUMINUM**

- .1 Fluoropolymer Thermal Setting Enamel: Fluoropolymer coating (50% PVDF), conforming to AAMA 2604, in colour to selected by Consultant.

2.3 **FABRICATION - GENERAL**

- .1 Form or extrude aluminum shapes before finishing.
- .2 Do all fitting and assembly in the factory.
- .3 Trial fit units in the shop if permanent shop assembly is not practical.
- .4 Fabricate components that, when assembled, have the following characteristics:
 - .1 Profiles that are sharp, straight, and free of defects or deformations.
 - .2 Accurately fitted joints with ends coped or mitered.
 - .3 Physical and thermal isolation of glazing from framing members.
 - .4 Accommodations for thermal and mechanical movements of glazing and framing to maintain required glazing edge clearances.
 - .5 Fasteners, anchors, and connection devices that are concealed from view to greatest extent possible.

- .5 Welding:
 - .1 Do aluminum welding to CAN/CSA W59.2.
 - .2 Weld in concealed locations to greatest extent possible to minimize distortion or discoloration of finish. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.
- .6 Aluminum Frames and Screens
 - .1 Frames and Screens: Extruded aluminum sections having a minimum wall thickness of 2.4mm suitably reinforced to ensure proper rigidity. Cross-section dimensions of frames for screens shall be as detailed on Drawings, but a minimum of 44.4mm x 114.3mm.
 - .2 Drill, tap, weld, hole, or slot members for proper installation and fixing of all components and accessories, and supplied complete with all necessary anchors, clips, bolts, screws, etc.
 - .3 Make members with sharply defined profiles, straight, square, and true with surfaces in proper planes and exposed finished surfaces and edges smooth and free from defects.
 - .4 Frame, brace, reinforce and anchor work to safely sustain and withstand strains and stresses to which they will be subjected.
 - .5 Make provision for proper expansion and contraction.
 - .6 Joints and intersections accurately formed and tightly fitted; units water and weathertight.
 - .7 Bolts tight and threads nicked to prevent loosening of nuts; bolting made as inconspicuous as possible.
 - .8 Prepare for glazing as required.

PART - 3 EXECUTION

3.1 PREPARATION

- .1 Take field measurements from actual structure and verify prior to commencement of fabrication.
- .2 Concealed surfaces of aluminum which would otherwise come in direct contact with structural steel, concrete, masonry, or plaster shall be given a heavy protective coating of bituminous paint or zinc chromate primer prior to installation.

3.2 INSTALLATION

- .1 Do not install damaged components.
- .2 Fit joints to produce hairline joints free of burrs and distortion.
- .3 Rigidly secure nonmovement joints.
- .4 Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration and to prevent impeding movement of moving joints.
- .5 Seal perimeter and other joints watertight unless otherwise indicated.
- .6 Prior to installation, apply heavy coat of isolation coating to concealed surfaces of aluminum in direct contact with structural steel, concrete, or masonry.
- .7 Set work of this Section plumb, square, level at correct elevation and in alignment with adjacent work. Anchor securely. Brace work rigidly for building-in.

- .8 Accurately fit frames to provide weathertight installation and provide clearances required due to expansion, contraction and deflection of building structure and frames.
- .9 Provide packing insulation in voids between framing members and adjacent constructions and where detailed.
- .10 Caulk joints between masonry or other adjacent material and frames and between frames, sills, and other material. Use methods specified in Section 07 92 00. Caulk inside and outside.
- .11 Completed installation shall be of adequate strength to support operating doors, and normal wind loading without glass shaking or vibrating when doors are in use.

3.3

INSTALLATION - GLAZING

- .1 Free rabbets, stops and glass edges of dust, dirt, moisture, oil and other foreign matter detrimental to glazing material adhesion. Ensure drainage holes are not blocked.
- .2 Place two setting blocks under each unit at quarter points. Place spacers on all edges of glass, located directly opposite each other when on both sides of the glass, located at maximum 600 mm centres and maximum 300 mm from corners and uniformly spaced.
- .3 Install glazing tapes and gaskets to ensure complete contact on surface of glass and stops. Make joints only at corners of sash or frame. Fit accurately with tight joints, free from tension, gaps, cracks and embedded foreign matter.
- .4 Set glass properly centered with uniform bite and face and edge clearance, free from twist, warp or other distortion likely to develop stress.
- .5 Ensure water and airtight seal for glass between glazed element and frame is flush with sight line.
- .6 Perform glazing only when the temperature is above 5°C.

3.4

CLEANING

- .1 Immediately prior to final cleaning of glass and before handing over building to Owner, make good damage and disfigurement to this work, remove any protective coatings, stains, and foreign matter from exposed exterior and interior surfaces of aluminum work supplied under this Section and leave in a uniform colour, to Consultant's satisfaction.
- .2 Clean using soap and water, or water and approved solvents not injurious to aluminum, glass, glazing and sealant compounds. Do not use abrasives.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section Includes:
 - .1 Labour, Products, equipment, and services necessary to complete the work of this Section for fixed thermally broken aluminum framed windows and accessories.
- .2 Related Requirements
 - .1 Comply with Conditions of the Contract, and Division 01 - General Requirements.
 - .2 Section 08 80 00, Glazing.

1.2 ADMINISTRATIVE REQUIREMENTS

- .1 Co-ordination: Co-ordinate work of this Section with work of other trades for proper time and sequence to avoid construction delays.
- .2 Pre-installation Meeting: Convene pre-installation meeting after Award of Contract and one week prior to commencing work of this Section to verify project requirements, substrate conditions and coordination with other building sub-trades, and to review manufacturer=s written installation instructions.
 - .1 Notify attendees 2 weeks prior to meeting and ensure meeting attendees include as minimum:
 - .1 Owner.
 - .2 Consultant.
 - .3 Glazing subcontractor.
 - .4 Manufacturer's Technical Representative.
 - .2 Ensure meeting agenda includes review of methods and procedures related to aluminum window installation including co-ordination with related work.
 - .3 Record meeting proceedings including corrective measures and other actions required to ensure successful completion of work and distribute to each attendee within 1 week of meeting.

1.3 SUBMITTALS

- .1 Product Data: Submit product data including manufacturer's literature for aluminum window frames, glazing, components, and accessories, indicating compliance with specified requirements and material characteristics.
 - .1 Submit list on window manufacturer's letterhead of materials, components, and accessories to be incorporated into Work.
 - .2 Include product names, types, and series numbers.
 - .3 Include contact information for manufacturer and their representative for this Project.

- .2 Shop drawings:
 - .1 Submit drawings stamped and signed by Professional Engineer registered or licensed in Province of Ontario.
 - .2 Indicate materials and details in full size scale for head, jamb and sill, profiles of components, interior and exterior trim, junction between combination units, elevations of unit, anchorage details, glazing, description of related components and exposed finishes, fasteners, and caulking.
- .3 Samples:
 - .1 Submit duplicate 300 x 300 mm sample sections showing prefinished aluminum surface, finish, colour, and texture, and including frame corner details.
 - .2 Submit duplicate 300 x 300 mm sample sections of insulating glass unit showing glazing materials and edge and corner details.
- .4 Test Reports: Submit test reports showing compliance with specified performance characteristics and physical properties including air and water infiltration.
- .5 Field Reports: Submit manufacturer's field reports within 3 days of manufacturer representative's site visit and inspection.
- .6 Operation and Maintenance data: On completion of work of this Section, submit the following:
 - .1 3 copies of maintenance and glazing instructions.
 - .2 List materials used in windows work.
 - .3 Warranty documents specified.

1.4 **QUALITY ASSURANCE**

- .1 Manufacturer Qualifications: A manufacturer capable of fabricating aluminum windows that meet or exceed performance requirements indicated and of documenting this performance by test reports, and calculations.
- .2 Installer Qualifications: An installer acceptable to aluminum window manufacturer for installation of units required for this Project.
- .3 Window fabrication and installation: To requirements of CAN/CSA-A440.

1.5 **DELIVERY, STORAGE AND HANDLING**

- .1 Deliver aluminum windows in manufacturer's original packaging with identification labels intact and in sizes to suit project.
- .2 Brace frames to maintain squareness and rigidity during shipment.
- .3 Storage and Handling Requirements: Store materials off ground and protected from exposure to harmful weather conditions and at temperature conditions recommended by manufacturer. Comply with requirements of AAMA CW-10.
- .4 Provide adequate protection to windows to prevent damage to frames and glass during delivery, storage, and handling.

1.6 **WARRANTY**

- .1 Submit a 10-year warranty, commencing from date of Substantial Performance, against defects in the insulating glass units. Defects shall include but not necessarily limited to:
 - .1 Obstruction of vision as a result of dust or film formation on the internal glass surfaces and seal failure.
 - .2 Glass breakage, under design conditions, other than extrinsic glass breakage, but including breakage due to thermal shock and temperature differential due to inherent glass faults.

PART - 2 PRODUCTS

2.1 **ACCEPTABLE MANUFACTURERS**

- .1 Manufacturer: Alumicor Limited, 290 Humberline Drive, Toronto, Ontario, Canada M9W 5S2, Phone: (416) 745-4222 or (877) ALUMICOR, e-mail: info@Alumicor.com, URL: www.Alumicor.com.

2.2 **DESIGN CRITERIA**

- .1 Description: Thermally broken, rain screen designed, aluminum framed, windows with double glazed insulating glass units and exterior applied feature caps.
- .2 Design aluminum components to CAN/CSA S157.
- .3 Window Classification: To NAFS - AAMA/WDMA/CSA 101/I.S.2/A440.
 - .1 Air tightness: FW-CW - Canadian level: Fixed.
 - .2 Water tightness: FW-CW100.
 - .3 Wind load resistance: FW-CW70.
 - .4 Forced entry resistance test: Grade 10.

2.3 **MATERIALS**

- .1 Aluminum framing members, glass stops and feature caps: Extruded aluminum to ASTM B221, 6063 alloy with T5 or T6 temper.
- .2 Thermal Break: Glass fibre reinforced polyamide porthole extrusion.
- .3 Primary seal gasket: Dual Durometer PVC.
- .4 Rain screen gasket: EPDM, 60 Durometer.
- .5 Glass stop pressure gasket: EPDM, 70 Durometer.
- .6 Interior and Exterior Sills: Extruded aluminum to ASTM B209, of type and size to suit project conditions; minimum 3 mm thick, complete with joint covers, jamb drip deflectors, chairs, anchors and anchoring devices.
- .7 Flashing: Aluminum, finished to match aluminum framing members, minimum 0.6 mm thick.

- .8 Air Barrier: Equip window frames with air barrier material for sealing to building air barrier as follows:
 - .1 Material: identical to, or compatible with, building air barrier materials to provide required air tightness and vapour diffusion control throughout exterior envelope assembly.
 - .2 Material width: adequate to provide required air tightness and vapour diffusion control to building air barrier from interior.
- .9 Gasketing: Black EPDM and PVC gaskets.
- .10 Setting Blocks: to ASTM D2240, neoprene or EPDM, 80-90 Shore A Durometer hardness. Manufacturer's standard, notched to permit water drainage through the glazing cavity.
- .11 Spacers: to ASTM D2240, neoprene or EPDM, 50-60 Shore A Durometer hardness.
- .12 Fasteners: Tamperproof, cadmium plated stainless steel 300 or 400 series to meet window requirements and as recommended by manufacturer.
- .13 Sealant: ASTM C920, one component silicone sealant, SCS2000 SilPruf by GE Silicones, Dowsil 795 by Dow Corning, Spectem 2 by Tremco or other acceptable equivalents.
- .14 Joint backing: Non-absorbent, non-gassing, closed cell polyolefin foam, over sized 25%, Sof Rod by Tremco Ltd.
- .15 Isolation coating: Best grade, quick drying non-staining alkali resistant bituminous paint.
- .16 Liquid Foam Insulation: Single component, moisture cure, low expansion rate spray-in-place polyurethane liquid foam insulation to ULC-S710.1 and in accordance with manufacturer's written recommendations.
- .17 Glass and Glazing: refer to Section 08 80 00, Glazing.

2.4

FABRICATION

- .1 Fabricate windows to CAN/CSA A440/A440.1 and manufacturer's instructions.
- .2 Take field measurements prior to fabrication.
- .3 Fabricate aluminum assemblies of extruded sections to sizes and profiles indicated.
 - .1 Ensure vertical and horizontal members are tubular extrusions designed for shear block and/or screw spline corner construction.
 - .2 Install exterior feature caps as indicated on drawings.
 - .3 Provide drainage path from glazing cavity in accordance with rain screen design practices and manufacturer's instructions to permit drainage of extraneous water to the exterior.
- .4 Construct units square, plumb and free from distortion, waves, twists, buckles or other defects detrimental to performance or appearance. Brace frames to maintain squareness and rigidity during installation.
- .5 Fabricate units square and true with tolerance of plus or minus 1.5 mm (0.06 inches) maximum for units with diagonal measurement of 1800 mm (6 feet) maximum and plus or minus 3 mm (0.125 inches) maximum for units with diagonal measurement greater than 1800 mm (6 feet).

- .6 Accurately fit and secure joints and corners.
 - .1 Ensure joints are flush, hairline, and weatherproof.
 - .2 Seal joints and corners in accordance with manufacturer's instructions.
- .7 Face dimensions detailed are maximum permissible sizes.
- .8 Use only concealed tamperproof fasteners.
 - .1 Where fasteners cannot be concealed, countersunk screws finished to match adjacent material may be used upon receipt of written approval from Consultant.
- .9 Visible manufacturer's labels are not permitted.

2.5 **FABRICATION - GLAZING**

- .1 Accurately size glass to fit openings allowing clearances following trade practices. Cut glass clean and carefully; nicks, damaged edge conditions will not be accepted. Replace all glass with nicked or damaged edges.

2.6 **FINISHES - ALUMINUM**

- .1 Exterior exposed aluminum surfaces: to AAMA 2605, 3-coat, thermal setting enamel consisting of primer, colour coat and clear coat] with 70% minimum fluoropolymer resin and polvinylidene fluoride (PVDF), 0.03 mm (1.2 mil) minimum total thickness; Duranar XL by PPG Canada Inc., or equivalent by Sherwin Williams.
- .2 Interior exposed aluminum surfaces: to AAMA 2605, 2-coat, thermal setting enamel consisting of primer and colour coat with minimum 70% fluoropolymer resin and polvinylidene fluoride (PVDF), 0.03mm (1.2mil) minimum total thickness; Duranar by PPG Canada Inc., or equivalent by Sherwin Williams.

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 window installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Consultant.
 - .2 Inform 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 Consultant.

3.2 **INSTALLATION**

- .1 Install windows in accordance with manufacturer's written instructions and to CAN/CSA A440/A440.1.
- .2 Prior to installation, apply heavy coat of isolation coating to concealed surfaces of aluminum in direct contact with structural steel, concrete, or masonry.
- .3 Set work of this Section plumb, square, level at correct elevation and in alignment with adjacent work. Anchor securely. Brace work rigidly for building-in.

- .4 Accurately fit frames to provide weathertight installation and provide clearances required due to expansion, contraction and deflection of building structure and frames.
- .5 Gun-apply a continuous bead of sealant to all joints with adjacent construction. Liberally butter screw fastenings with sealant.
- .6 Provide insulation in voids between framing members and adjacent constructions and where detailed.
- .7 After adjustment the anchorage devices shall be rivetted, welded or positively locked to prevent movement once alignment is achieved.
- .8 Assume all responsibility for the design of the assembly, reinforcing and anchoring to suit each specific condition complying with the requirements specified herein and as shown on the reviewed shop drawings.

3.3 **INSTALLATION - GLAZING**

- .1 Free rabbets, stops and glass edges of dust, dirt, moisture, oil and other foreign matter detrimental to glazing material adhesion. Ensure drainage holes are not blocked.
- .2 Place two setting blocks under each unit at quarter points. Place spacers on all edges of glass, located directly opposite each other when on both sides of the glass, located at maximum 600 mm centres and maximum 300 mm from corners and uniformly spaced.
- .3 Install glazing tapes and gaskets to ensure complete contact on surface of glass and stops. Make joints only at corners of sash or frame. Fit accurately with tight joints, free from tension, gaps, cracks and embedded foreign matter.
- .4 Set glass properly centered with uniform bite and face and edge clearance, free from twist, warp or other distortion likely to develop stress.
- .5 Ensure water and airtight seal for glass between glazed element and frame is flush with sight line.
- .6 Perform glazing only when the temperature is above 5°C.

3.4 **INSTALLATION - SEALANT**

- .1 Seal all joints between work of this Section and adjacent surfaces, with sealant to provide a completely weathertight enclosure. Apply joint backing to achieve correct joint depth and shape in accordance with manufacturer's instructions.
- .2 Mix, apply and cure sealant in strict accordance with manufacturer's instructions. Apply sealant to clean, dry, grease and oil free surfaces.
- .3 Apply sealant in continuous full beads, using gun with proper size nozzle and sufficient pressure to fill voids and joints solid.
- .4 Form surfaces smooth, free from ridges, wrinkles, sags, air pockets, embedded impurities.
- .5 Tool exposed surfaces to slightly concave shape.
- .6 Remove excess compound promptly as work progresses and upon completion.

3.5 FIELD QUALITY CONTROL

- .1 Site Installation Tolerances: Install windows square and true with tolerance of plus or minus 1.5 mm maximum for units with diagonal measurement of 1800 mm maximum and plus or minus 3 mm maximum for units with diagonal measurement greater than 1800 mm.
- .2 Schedule manufacturer's review of work procedures at stages listed:
 - .1 Product Application: 1 off site review.
 - .2 Fabrication and Handling: 1 review at authorized installers fabrication facilities.
 - .3 Installation: 2 site reviews at commencement of Work, and one at 50% of glazing installed.
- .3 Submit manufacturer's written reports to Consultant describing:
 - .1 The scope of work requested.
 - .2 Date, time, and location.
 - .3 Procedures performed.
 - .4 Observed or detected non-compliances or inconsistencies with manufacturers' recommended instructions.
 - .5 Limitations or disclaimers regarding the procedures performed.
 - .6 Obtain reports within seven days of review and submit immediately to Consultant.

3.6 CLEANING AND PROTECTION

- .1 Clean exposed surfaces immediately after installing windows. Use soap and water, or water and approved solvents not injurious to aluminum, glass, glazing and sealant compounds. Do not use abrasives. Avoid damaging protective coatings and finishes.
 - .1 Remove excess sealants, glazing materials, dirt, and other substances.
 - .2 Keep protective films and coverings in place until final cleaning.
- .2 Remove and replace glass that has been broken, chipped, cracked, abraded, or damaged during construction period.
- .3 Protect window surfaces from contact with contaminating substances resulting from construction operations. If contaminating substances do contact window surfaces, remove contaminants immediately according to manufacturer's written instructions.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

.1 Section Includes:

.1 Labour, Products, equipment, and services necessary to complete the work of this Section.

.2 Related Requirements

.1 Comply with Conditions of the Contract and Division 01 - General Requirements.

1.2 SUBMITTALS

.1 Maintenance data: Submit installation, maintenance and operating data for incorporation in project record manual.

1.3 QUALITY ASSURANCE

.1 Conduct pre-installation meeting to verify project requirements, manufacture's installation instructions and manufacturer's warranty requirements.

.2 Have the supervision, administration and servicing of the work of this Section performed by a hardware specialist certified as an Architectural Hardware Consultant (AHC).

.3 Have the installation of hardware performed by a firm which specializes in this work.

.4 Have the hardware installer fully cooperate with the hardware specialist to ensure doors and hardware are properly and securely installed and that the installed doors and hardware are functioning properly.

1.4 DELIVERY, STORAGE, AND HANDLING

.1 Package hardware and label with description of contents and installation location. Refer on labels to hardware list designation, and with door number when applicable.

PART - 2 PRODUCTS

2.1 HARDWARE SCHEDULE AND ALTERNATIVES

.1 Door Hardware schedule is indicated on Drawings. This schedule will be used for the purposes of establishing the hardware requirements and the hardware quality level.

.2 While certain manufacturer's catalogue numbers are used in the schedule of finishing hardware, it is not the intent that these items are specified exclusively. The manufacturer's numbers are used to denote minimum quality, style, design function, finish. Specified items that must be supplied without substitution are electrical strikes, locksets and latchsets, automatic door operators, security contracts, and alarms.

.3 Other manufacturer's products may be used providing the items are equal in all respects to the items specified, except as noted above.

.4 The Hardware Contractor shall submit a complete physical sample of each hardware type for review prior to the preparation of shop drawings. All hardware delivered to the job sites shall be equal in all respects to the accepted sample.

.5 List all manufacturer's names and complete catalogue number of all alternative hardware types proposed for supply and submit this list for review before preparing shop drawings.

.6 The Consultant's decision on the quality of proposed alternative products shall be final.

- .7 Any proposed item that in the opinion of the Consultant is not equal to the item specified will be rejected and the supplier shall be required to supply items equal to the one specified at no extra cost.

2.2 **MATERIALS**

- .1 General:
 - .1 Hardware shall be as specified in the hardware schedule prepared under the direction of the Consultant and as specified in this Section.
 - .2 Installed hardware shall comply with applicable fire and building codes and requirements of local authorities having jurisdiction over doors and hardware.
 - .3 All hardware applied to metal doors and frames shall be made to template.
 - .4 Supply hardware complete with all necessary screws, bolts and other fastening of suitable size and type to anchor the hardware in position neatly and properly in accordance with the best practices and to the Consultant's approval.
 - .5 All fastenings shall harmonize with the hardware as to materials and finishes.
 - .6 Hardware for fire rated and labelled door and frame assemblies: ULC listed or as accepted by authorities having jurisdiction.
 - .7 Finish on all stainless steel items (C32D) shall be equal to No. 4 finish.
- .2 Keying:
 - .1 Provide two change keys per lock.
- .3 Miscellaneous Accessories:
 - .1 All other items, not specifically described but required for complete and proper installation of finish hardware, shall be as selected by Hardware Supplier subject to approval of the Consultant.

PART - 3 EXECUTION

3.1 **EXAMINATION**

- .1 Verification of Conditions: Examine doors, frames, related items and conditions under which work of this section is to be performed and identify conditions detrimental to proper and timely completion. Do not proceed until unsatisfactory conditions have been corrected.
- .2 Confirm kickplate and threshold sizes before ordering.

3.2 **INSTALLATION**

- .1 Install hardware to standard hardware location dimensions in accordance with Canadian Metric Guide to Steel Doors and Frames (Modular Construction) prepared by Canadian Steel Door and Frame Manufacturers' Association, except as otherwise indicated in this Section and elsewhere in the Contract Document.
- .2 Where door stop contacts door pulls, mount stop to strike bottom of pull.
- .3 Barrier Free Access: Mount all hardware in full conformity with authorities having jurisdiction. Confirm mounting heights with Consultant prior to commencement of frame and door preparation.
- .4 Install all miscellaneous hardware as shown on details and specified.
- .5 Do not use wall stops on gypsum board, demountable or moveable partitions.
- .6 Provide even margins between doors and jambs and doors and flooring and/or thresholds as follows:

- .1 Hinge side: 1.6 mm.
- .2 Latchside and head: 1.6 mm.
- .3 Flooring and/or thresholds: 12 mm.
- .4 Flooring, fire rated assemblies: 6 mm.

3.3 **HARDWARE MOUNTING HEIGHTS**

- .1 Install and mount hardware as follows:
 - .1 Door knobs and lever: 965 mm centre line from finish floor
 - .2 Deadlock cylinder: 1370 mm centre line from finish floor
 - .3 Deadlatch cylinders: 1370 mm centre line from finish floor
 - .4 Door pulls: 1069 mm centre line from finish floor
 - .5 Push plates: 1090 mm centre line from finish floor
 - .6 Push bars: 1069 mm centre line from finish floor
 - .7 Top hinges: 125 mm down from top of door to top of hinge
 - .8 Bottom hinges: 250 mm up from finish floor to bottom of hinge
 - .9 Intermediate hinges: equally spaced between top and bottom hinges
 - .10 Floor stops: maximum 150 mm from lock edge when door is in fully open position
 - .11 Exit devices: to manufacturer's instructions
 - .12 Kickplates: maximum 3 mm from bottom of door to bottom of kickplate

3.4 **ADJUSTING AND CLEANING**

- .1 Clean hardware with materials and methods as recommended by hardware manufacturer. Repair or replace defective hardware.
- .2 Remove protective material where present.
- .3 Adjust operable parts for correct function.
- .4 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section Includes: Labour, Products, equipment, and services necessary to complete the work of this Section.
 - .1 This Section includes glazing work not specified in other Sections. Refer to other Sections for other glazing.
- .2 Related Requirements
 - .1 Comply with Conditions of the Contract, and Division 01 - General Requirements.

1.2 SUBMITTALS

- .1 Shop drawings: Submit shop drawings indicating manufacturing and installation details.
- .2 Product Data: Submit manufacturer's product specifications, including the PVB interlayer products. Include documentation of compliance with specified requirements, referenced tests, and compatibility of all products in contact with glazing.
 - .1 Provide Installer signed letter listing all products to be used, with signed letters from each glass, sealant, glazing tape, and blocking manufacturer certifying their compatibility.
 - .2 Provide a sample warranty and instructions for handling, storing, installing, cleaning, and protecting each type of glass and glazing material.
- .3 Samples:
 - .1 Submit samples for each type of glass and of glazing materials identifying quality and type of glass if required by the Consultant before commencing work.
 - .2 Ensure samples are clearly labelled with manufacturer's name and type.
- .4 Certificates: Submit manufacturer's certification compatibility of glass and glazing materials.
- .5 Test Results: Provide test results in accordance with ASTM C1087 and ASTM C794 showing compatibility of applied sealants with accessories used in butt-joint glazing systems and determine strength, and ability of cured sealant to maintain a bond to substrate under severe conditions and characteristics of peel properties of a cured-in-place elastomeric joint sealants for use in butt-joint glazing. Provide a statement and test data confirming sealant used in design indicated to accommodate design load requirements without failure.
- .6 Operations and Maintenance Manual: Information on cleaning, maintenance, and replacement of all types of glass or glazing products shall be included in the Operations and Maintenance Manual.

1.3 QUALITY ASSURANCE

- .1 Installer Qualifications: Glazier shall have minimum five (5) years' experience in the successful installation of glazing products similar to those specified for this Project.
- .2 Glazing Installation Standard: Comply with recommendations of the GANA (Glass Association of North America), "Glazing Manual" and "Glazing Sealing Systems Manual" except where more stringent requirements are called for by manufacturers or these specifications. Refer to GANA for definitions of glass and glazing terms not otherwise defined.

- .3 Safety Glazing Standard: Where safety glass is indicated or required by authorities having jurisdiction, provide type of products indicated which comply with OBC, ANSI Z97.1, and requirements of CPSC 16 CFR Part 1201 for category II materials.
- .4 Single Source Responsibility: Provide materials obtained from one source for each type of glass and glazing product indicated, and for visually related areas.
- .5 Pre-installation Conference: at least two weeks prior to commencing work of this Section, arrange for manufacturer's technical representative to visit the site and review preparatory and installation procedures to be followed, conditions under which the work will be done, and inspect the surfaces to receive the work of this Section. Advise the Consultant of the date and time of the meeting.
- .6 Manufacturer's site inspection: Have the manufacturer's technical representative inspect the Work at suitable intervals during application and at conclusion of the work of this Section, to ensure the Work is correctly installed. When requested, submit manufacturer's inspection reports and verification that the work of this Section is correctly installed.

1.4 **DELIVERY, STORAGE AND HANDLING**

- .1 Handle and store materials and products in accordance with manufacturer's recommendations. Deliver and store packaged materials and products in original, undamaged containers with manufacturer's labels and seals intact.

1.5 **WARRANTY**

- .1 Laminated glass products: Provide written 5-year warranty from date of manufacture for laminated glass. Warranty shall cover deterioration due to normal conditions of use and not to handling, installing, and cleaning practices contrary to the glass manufacturer's published instructions. Warranty shall be manufacturer's standard form in which laminated-glass manufacturer agrees to replace laminated-glass units.
- .2 Double glazed units: Provide written 10-year warranty against defects in the insulating glass units and warrant them to be free from material obstruction of vision resulting from dust or film formation on the internal glass surfaces by any cause, under design conditions, other than extrinsic glass breakage, but including breakage due to thermal shock and temperature differential due to inherent glass faults.

PART - 2 PRODUCTS

2.1 **GENERAL**

- .1 Glass: Each unit bearing manufacturer's label indicating quality and thickness.
- .2 Thickness of glass: Glass thicknesses indicated or scheduled in the Contract Documents are minimums required. Exact thickness of glass to be engineered to account for size of glass and application, to satisfy building code requirements and requirements of authorities having jurisdiction.

2.2 **GLASS**

- .1 Float glass (GL-F): to CAN/CGSB-12.3, annealed, clear, glazing quality, minimum 6 mm thick.
- .2 Tempered Safety Glass (GL-T):
 - .1 ASTM C1048, Kind FT (fully tempered), Condition A (uncoated surfaces), Type I (transparent glass, flat), Class 1 (clear), Quality q3 (glazing select), and meeting requirements of ANSI Z97.1, tong and roller marks free, minimum thickness 6 mm.
 - .2 Ensure surface compression is equal to or greater than 68.9 MPa (10 000 psi)

- .3 Tempered glass material to come from one tempering furnace and be tempered to minimize distortion variance.
 - .1 Roller-wave distortion not to exceed 0.127 mm (0.005") from peak to valley.
 - .2 Maximum peak to valley roller-wave 0.8 mm (0.003") in the central area and 0.20 mm (0.008") within 267 mm (10.5") of the leading and trailing edge.
 - .3 Maximum bow and warp 0.79 mm per lineal 305 mm (1/32" per lineal foot).
- .3 Insulating glass units (IGU): Factory sealed insulating glass units to requirements of CAN/CGSB-12.8 using dual seal and composed of two lites of minimum 6 mm thick glass separated by a 12.7 mm wide space, double sealed and atmospheric pressure equalized to prevent bowing of the glass lites in the vertical position. Dehydrate air space and hermetically seal inner and outer panes at periphery with flexible sealer. Edges of glass shall be straight cut, free of nicks and other imperfections conducive to breakage.
 - .1 Glass types:
 - .1 Window vision units (IGU-1): Double glazed, double sealed insulating glass units, outer lite clear float glass having low emissivity coating on surface No. 2, inner lite clear float glass.
 - .4 Low emissivity coating: High performance, sputtered Low-E coating, SunGuard SuperNeutral 68 (SN 68) by Guardian Glass, or other acceptable manufacturer, as approved by the Consultant.
 - .1 Uniformly apply Low 'E' coating to glass. Edge delete Low 'E' coating where silicone sealant is in contact with glass.

2.3

GLAZING MATERIALS

- .1 General - Glazing materials (fire-rated and non-fire-rated): Select glazing sealants, tapes, gaskets and additional glazing materials of proven compatibility with other materials they will contact, including glass products, seals of insulating glass units and glazing channel substrates, under conditions of installation and service, as demonstrated by testing and field experience.
- .2 Shims, spacers and setting blocks: 45, 70 and 90 Durometer A hardness plus/minus 5 respectively, neoprene rubber, resistant to oxidation and permanent deformation under load.
- .3 Glazing gaskets: Extruded neoprene or EPDM of approved profile. Tensile strength of 7300 kPa; Durometer A hardness of 50 plus/minus 5; 25% maximum permanent set; 300 % minimum elongation at break; and resistant to ozone, showing no cracks.
- .4 Glazing tape: Extruded, ribbon shaped, non-drying, non-skinning, non-oxidizing polyisobutylene tape with continuous synthetic rubber spacer rod, sufficiently wide and thick as to completely cover the bite area of the glazing unit when the unit is pushed into place, Polyshim tape by the Tremco Manufacturing Company, Canada, Limited, or other acceptable equivalents.
- .5 All glazing materials, products, primers and cleaning solvents: Mutually compatible, types recommended by manufacturer of glass and gaskets.
- .6 Colours for glazing materials: to match colour of entrance and screen frames.

2.4 **FABRICATION**

- .1 Accurately size glass to fit openings allowing clearances recommended by the Flat Glass Marketing Association. Cut glass clean and free of nicks and damaged edges. Grind smooth and polish exposed glass edges. Do not cut or abrade tempered, heat treated, or coated glass.
- .2 Take field measurements and levels required to verify and supplement those shown on the Drawings for the proper layout and installation of the work. Co-ordinate dimensional tolerances in adjacent building elements and confirm prior to commencement of work.

PART - 3 EXECUTION

3.1 **INSPECTION**

- .1 Verify dimensions at the site before proceeding with fabrication or glazing units.
- .2 Ensure that openings are free from distortion, and that surfaces are free from protrusions that will obstruct face and edge clearances.
- .3 Ensure that wood is sealed; ferrous metals are painted, or zinc coated; and that surfaces are suitable for adhesion of the glazing materials.
- .4 Ensure that movable units to be glazed are adjusted for proper operation.
- .5 Ensure that surfaces to receive mirrors are sealed.
- .6 Ensure that ambient and surface temperatures are above 5°C.

3.2 **PREPARATION**

- .1 Inspect hollow metal and other glass framing for compliance with manufacturing and installation tolerances, including those for size, squareness, offsets at corners, existence of minimum required face or edge clearances, and effective sealing of joinery.
- .2 Provide written report listing conditions detrimental to performance of glazing work.
- .3 Do not perform glazing work prior to correction of unsatisfactory conditions. Commencement of installation indicates Installer's acceptance of substrate.
- .4 Ensure rabbets, stops and glass edges are free of dust, dirt, moisture, oil and other foreign matter detrimental to, or obstructing the glazing material.
- .5 Clean contact surfaces with solvent and apply primers to surfaces to receive tapes and sealants in accordance with the manufacturer's instructions. Ensure surfaces are free of moisture and frost.
- .6 Immediately before glazing clean glazing channels and other framing members to receive glass.
 - .1 Remove coatings which are not firmly bonded to substrates.
 - .2 Promptly complete glazing both sides of a lite once started, to prevent re-entry of dust and dirt in glazing channels.

3.3 **INSTALLATION - GENERAL**

- .1 Handle and install glass in accordance with manufacturer's directions. Prevent nicks, abrasions and other damage likely to develop stress on edges.
- .2 Remove and replace glazing stops in original locations, using original fasteners, securely set and undamaged.
- .3 Use setting blocks and spacers as required to properly support the glass, centred in place in the glazing space independent of the materials and to uniformly distribute its load.

- .4 Use a minimum of 2 setting blocks, located at the quarter points. Locate spacers at jamb edges of glass, uniformly spaced at 600 mm o.c. maximum, and 300 mm maximum from top and bottom.
- .5 Assess glass units for colour uniformity and arrange to avoid abrupt variation in appearance.
- .6 Set glass properly centred with uniform bite and face and edge clearance, free from twist, warp or other distortion likely to develop stress.
- .7 Leave labels on glass until it has been set and inspected and approved. Leave glass whole and without cracks, scratches, or other defects and with setting in perfect condition at completion, to the approval of the Consultant.
- .8 Remove rejected, broken or damaged glass due to defective materials or improper setting and replace with perfect materials. Units producing distorted vision will be rejected and replaced at the reasonable discretion of the Consultant.

3.4 **INTERIOR GLAZING**

- .1 Unless otherwise specified, all interior glazing shall be dry glazing.
- .2 Provide glazing gasket around entire perimeter of glass. Make tight butt joint at corners of lights. Place setting blocks at sill and spacers at both jambs as required to centre the unit in the frame. Place the unit into the frames and apply the stops against the gaskets. Tighten the screws or clips to obtain positive uniform pressure avoiding excessive pressure.
- .3 Ensure rattle-free cushioning.
- .4 Install fire-rated glazing materials in accord with manufacturer's product data complying with specified fire testing standard. Use specified fire-rated glazing sealant for installation of fire tested glass materials.
- .5 Remove non-permanent labels promptly after installation and promptly clean adhesive and other residue from both surfaces of all glass.

3.5 **PROTECTION AND CLEANING**

- .1 Protect glass from contact with contaminating substances resulting from construction operations or cleaning of adjacent materials.
- .2 Remove and replace glass which is broken, chipped, cracked, abraded, scratched or damaged in other ways during the construction period, including natural causes, accidents and vandalism.
- .3 Clean glass on both faces not more than 4 days prior to date scheduled for inspections intended to establish date of Substantial Performance in each area of project. Clean glass by method recommended by glass manufacturer.
- .4 Clean and make good to the approval of the Consultant, surfaces soiled or otherwise damaged in connection with the work of this Section. Pay the cost of replacing finishes or materials that cannot be satisfactorily cleaned.
- .5 Upon completion of the work, remove all debris, equipment and excess material resulting from the work of this Section from the site.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section Includes: Labour, Products, equipment, and services necessary to complete the work of this Section, including but not limited to:
 - .1 Interior gypsum board.
 - .2 Non-load-bearing steel framing systems for interior gypsum board assemblies.
 - .3 Suspension systems for interior gypsum ceilings, soffits, and grid systems.
- .2 Related Requirements
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.

1.2 ACTION SUBMITTALS

- .1 Product Data:
 - .1 Submit manufacturer's printed product datasheets for each type of product, confirming compliance with the specified or named product or material.
 - .2 Include product characteristics, performance criteria, physical size, finish, and limitations for products listed in selected designs.
- .2 Access Panels: Determine specific locations and sizes for access panels needed to gain access to concealed equipment and provide schedule with the product datasheet for each type of the access panels. Obtain Consultant's approval for all access panel sizes and locations.
- .3 Samples: For the following products:
 - .1 Trim Accessories: Full size sample in 300 mm long length for each trim accessory indicated.

1.3 QUALITY ASSURANCE

- .1 Install work level to tolerance of 3 mm in 3000 mm.
- .2 Fire test response characteristics: For gypsum board assemblies with fire-resistance ratings, provide materials and construction identical to those tested in assembly indicated according to ASTM E119 by an independent testing and inspecting agency acceptable to authorities having jurisdiction.
- .3 Sound transmission characteristics: For gypsum board assemblies with STC ratings, provide materials and construction identical to those tested in assembly indicated according to ASTM E90 and classified according to ASTM E413 by a qualified independent testing agency.

1.4 ENVIRONMENTAL REQUIREMENTS

- .1 Install work only in areas closed and protected against weather, and maintained between 10°C and 21°C. In cold weather ensure that heat is introduced in sufficient time, before work commences, to bring surrounding materials up to these temperatures; and maintained until materials installed by this Section have cured.
- .2 Do not install work in any area unless satisfied that work in place has dried out, and that no further installation of damp materials is contemplated.
- .3 Do not install panels that are wet, those that are moisture damaged, and those that are mold damaged.

- .4 Remove from the site and replace panels that are wet, moisture damaged, and mold damaged at no additional cost to the Contract.
 - .1 Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
 - .2 Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.
- .5 Remove and replace panels that are wet, moisture damaged, and mold damaged at no additional cost to the Owner.

1.5 **COORDINATION WITH EXISTING CONDITIONS**

- .1 Coordinate location of new partitions with existing overhead ducting, piping and conduits. Request written confirmation from the Consultant on final locations prior commencing the installation.
- .2 Minor revisions to partition locations shown on the drawings shall be expected in order to accommodate potential conflicts with existing overhead conditions.

1.6 **DELIVERY, STORAGE, AND HANDLING**

- .1 Deliver materials in original packages, containers, or bundles bearing brand name and identification of manufacturer or supplier.
- .2 Store materials inside, under cover, and keep them dry and protected against damage from weather, direct sunlight, surface contamination, corrosion, construction traffic, and other causes. Stack gypsum panels flat to prevent sagging.

PART - 2 PRODUCTS

2.1 **PERFORMANCE/DESIGN CRITERIA**

- .1 Single source responsibility: Obtain gypsum board products from a single manufacturer, or from manufacturers recommended by the prime manufacturer of gypsum boards.
- .2 Fire resistance rating: Where gypsum board systems with fire resistance ratings are indicated or required, provide materials and installations that are identical with those of applicable assemblies tested by fire testing laboratories acceptable to authorities having jurisdiction.
- .3 Follow applicable requirements of ASTM C754 for installation of steel framing.
- .4 Design system members to withstand own dead load, super-imposed dead loads, to maximum allowable deflection of L/240, without permanent deformation.
- .5 Loads on walls acting as guards: Where the floor elevation on one side of a wall is more than 600 mm (24") higher than the elevation of the floor or ground on the other side, the wall shall be designed to resist the lateral design loads prescribed in the building code or 0.5 kPa (0.07 PSI), whichever produces the greatest effect.
 - .1 For walls acting as guards provide engineered shop drawings, load diagrams, and design calculations signed and stamped by a professional engineer licensed in the Province of Ontario.
 - .2 Upon completion of the parts of the Work covered by the engineered submittal, the professional engineer responsible for the preparation of the engineered submittal, shall prepare and submit to the Consultant and authorities having jurisdiction, as required, a letter of conformance for those parts of the Work, certifying that they have been provided in accordance with the requirements of the Contract.

- .6 Sheet metal thicknesses indicated herein pertains to the “minimum base steel thickness exclusive of coating”.

2.2 **GYPSUM BOARD PANELS**

- .1 Gypsum board: ASTM C 1396/C 1396M, paper faced, regular and fire rated Type X core, 1200 mm (48") wide x maximum practical length, ends square cut, square edged base layer and taper edged face layer, thickness as indicated.

2.3 **FRAMING SYSTEMS**

- .1 Steel studs: ASTM C645, minimum 0.48 mm (0.019") base metal thickness, hot-dipped galvanized to ASTM A653/A653M G60 (Z180) zinc coating, roll formed, 36.5 mm (1-7/16") flange size, of widths as indicated, with knock-out holes for mechanical and electrical services.
- .2 Floor and ceiling tracks: ASTM C645, minimum 0.46 mm (0.018") base metal thickness, hot-dipped galvanized to ASTM A653/A653M G60 (Z180) zinc coating, roll formed, width to suit studs, in widths to suit stud sizes, and as follows:
 - .1 Slotted Deflection Track: Premanufactured slotted top runner with 63 mm down standing legs, having 6 mm x 38 mm slots spaced at 25 mm on centre along length of runner; tested and certified for fire rated wall construction.
 - .2 Base Runner: Bottom track with 33 mm upstanding legs.
- .3 Furring runners and channels: ASTM C645, minimum 0.46 mm (0.018") base metal thickness, hot-dipped galvanized to ASTM A653/A653M G60 (Z180) zinc coating, roll formed.
- .4 Resilient steel furring channels: ASTM C645, 12.7 mm x 65 mm, 0.46 mm (0.018") base metal thickness, hot-dipped galvanized to ASTM A653/A653M G60 (Z180) zinc coating, roll formed; Hat shaped resilient furring channel for direct wall furring where resilient channels are indicated.
- .5 Channel bridging: 1.37 mm (0.0538") bare steel thickness, 38 mm (1-1/2") deep with minimum 12.7 mm (1/2") wide flange.
- .6 Backing plate: Galvanized steel sheet for blocking and bracing in length and width indicated, minimum base metal 1.27 mm (18 ga.) thick.
- .7 Hangers, tie wires, inserts, anchors: Manufacturer's standard.

2.4 **TRIM ACCESSORIES AND AUXILIARY MATERIALS**

- .1 Attachment clips: Sized to suit acoustical ceiling grid members, complete with screws and other fastening system, Revoe Clips by Revoe Manufacturing Ltd.
- .2 Insulating strip: Rubberized, moisture resistant 3 mm (1/8") thick foam strip, 12 mm (1/2") wide, with self-sticking adhesive on one face, lengths as required.
- .3 Casing beads, corner beads: 0.48 mm (25 gauge) hot dipped galvanized steel, perforated flanges, designed to be concealed with joint compound; one piece length per location.
- .4 Acoustical sealant: single component, sound damping, non-skinning, non-hardening synthetic rubber sealant.
 - .1 For fire-rated partitions, acoustical Sealant to be fire caulk in accordance with UL-Classified joint systems.
- .5 Joint and laminating compounds: As recommended by gypsum board and cement board manufacturer, high bond, low shrinkage and asbestos-free.
- .6 Joint tape: 50 mm (2") wide reinforced tape.

- .7 Acoustical insulation (Sound Attenuation Batts): CAN/ULC-S702, mineral (glass and rock wool) fibre, flame spread and smoke developed in conformance with OBC requirements and other authorities having jurisdiction in accordance with CAN/ULC-S102. Non-combustible in accordance with requirements of CAN/ULC-S114. Sufficient thickness to meet required STC rating for sound-rated partitions and of width to suit metal framing spacing and other miscellaneous spacings.

PART - 3 EXECUTION

3.1 EXAMINATION

- .1 Examine areas and substrates including welded hollow-metal frames and framing for compliance with requirements and other conditions affecting performance.
- .2 Examine panels before installation. Reject panels that are wet, moisture damaged, and mold damaged.
- .3 Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION - GENERAL

- .1 Comply with ASTM C840, Standard Specification for Application and Finishing of Gypsum Board.

3.3 INSTALLATION - PARTITION AND WALL FRAMING

- .1 Align partition top and bottom tracks and secure by screws at 600 mm o.c. maximum.
- .2 Place studs vertically at 400 mm oc, unless otherwise noted, and not more than 50 mm from abutting walls, and at each side of openings and corners. Position studs in top and bottom tracks.
- .3 Screw attach end studs to top and bottom tracks. Screw attach intermediate studs to bottom tracks. Secure intermediate studs to top tracks by crimping or by other means of fastening acceptable to Consultant.
- .4 Continuously cross brace steel studs at 1500 mm on centre to provide rigid installation to manufacturer's instructions.
- .5 Maintain clearance under beams and structural slabs to avoid transmission of structural loads to studs.
- .6 Provide two studs extending from floor to ceiling at each side of openings wider than stud centres specified. Secure studs together, 50 mm apart using clips or other approved means of fastening placed alongside frame anchor clips.
- .7 Erect track at head of door/window openings and sills of sidelight/window openings to accommodate intermediate studs. Secure track to studs at each end, in accordance with manufacturer's instructions. Install intermediate studs above and below openings in same manner and spacing as wall studs.
- .8 Frame openings and around built-in equipment, cabinets, access panels, on four sides. Extend framing into reveals. Check clearances with equipment suppliers.
- .9 Provide stud, furring channel, and backing plates secured between studs for attachment of fixtures, electrical boxes, grab bars, washroom accessories, and other items. Comply with details indicated and with stud and gypsum board manufacturers' written recommendations.
- .10 Terminate partitions at ceiling height except where indicated otherwise.
- .11 Install continuous insulating strips to isolate studs from exterior window framing.
- .12 Furr duct shafts, beams, columns, pipes and exposed services where indicated.

- .13 Apply two continuous beads of acoustical sealant at junctions of metal framing and structure, including bottom and top tracks, where partitions abut fixed building components. Fill junction completely and continuously from floor to ceiling, or to structure for full height partitions.
- .14 Frame for gypsum board faced vertical bulkheads within and at termination of ceilings.
- .15 Mechanically fasten resilient channels perpendicular to wall framing starting at 50 mm up from floor and end with 150 mm to the underside of structure at no more than 610 mm o.c. Install where indicated.

3.4 **INSTALLATION – ATTACHMENT CLIPS**

- .1 Place attachment clips over acoustic ceiling main/cross tee from top. Line up pre-drilled hole on clip with hole on main/cross tee and screw clip to main/cross tee with 13 mm wafer screw.
- .2 Screw through pre-drilled holes in attachment clip into top track of stud partition. Do not screw through ceiling grid.
- .3 Do not damage ceiling grid system during installation of these clips.

3.5 **INSTALLATION - WALL FURRING**

- .1 Space wall furring runners vertically at 600 mm o.c., and secure through alternate flanges of runners. Shim runners as required to present a true, plumb line for application of gypsum board.
- .2 Locate furring not more than 50 mm away from all openings, interior corners, intersections, frames, jambs, control joints and the like.
- .3 At windows, doors or similar openings having returns, and around corners, install lengths of mitred and bent pieces of furring horizontally spaced approximately 600 mm o.c. Form mitres by cutting the flanges and bending the web. Do not cut web to form corners.
- .4 Mechanically fasten resilient channel perpendicular to wall framing starting at 50 mm up from floor and end within 150 mm to the underside of structure, at no more than 600 mm o.c. Install where indicated.

3.6 **INSTALLATION - SUSPENDED CEILING FRAMING**

- .1 Erect hangers and runner channels for suspended gypsum board ceilings in accordance with ASTM C840 except where specified otherwise.
- .2 Provide additional ceiling suspension hangers within 150 mm of each corner and at maximum 600 mm around perimeter of light fixtures and diffusers.
- .3 Furr above suspended ceilings for gypsum board fire and sound stops and to form plenum areas as indicated.

3.7 **SEMI-EXPOSED LOCATIONS GYPSUM BOARD CEILINGS (SOFFITS)**

- .1 Provide suspension ceiling as specified for suspended ceilings using all galvanized material. Apply soffit boards horizontally with end joint occurring over supports. Allow 2 mm to 3 mm space between butted ends. Fasten board at 300 mm oc. Finish joints and fasteners as specified using compounds recommended by manufacturer of board.
- .2 Cut board to fit within 6 mm of fixtures and other vertical surfaces. Apply galvanized casing bead.
- .3 Provide control joints at 9000 mm oc maximum.

3.8 **INSTALLATION - GYPSUM PANELS**

- .1 Do not apply gypsum panels until bucks, anchors, blocking, electrical and mechanical work are approved.
- .2 Apply gypsum panels to furring or framing using screw fasteners, at 300 mm oc., and at closer spacings as required for fire resistance rated assemblies. Space fasteners in tile baker boards a maximum of 200 mm o.c.
- .3 Install ceiling board panels across framing to minimize the number of abutting end joints and to avoid abutting end joints in the central area of each ceiling. Stagger abutting end joints of adjacent panels not less than one framing member.
- .4 Install gypsum panels with face side out. Butt panels together for a light contact at edges and ends with not more than 1.6 mm of open space between panels. Do not force into place.
- .5 Locate edge and end joints over supports, except in ceiling applications where intermediate supports or gypsum board back blocking is provided behind end joints. Do not place tapered edges against cut edges or ends. Stagger vertical joints on opposite sides of partitions. Do not make joints other than control joints at corners of framed openings.
- .6 Attach gypsum panels to framing provided at openings and cutouts.
- .7 **Control Joints**
 - .1 Prior to installation review exact locations of control joints with the Consultant. Install purpose made control joint metal trim at following locations:
 - .1 Where partition, wall, or ceiling traverses a construction joint (expansion, or building control element) in the base building structure.
 - .2 Furring or partition abuts a structural element or dissimilar wall or ceiling.
 - .3 Ceiling abuts a structural element, column or dissimilar wall, partition, or other vertical penetration.
 - .4 Construction changes within a partition or ceiling.
 - .5 Partition or furring runs exceeding 9100 mm (30 ft) and total area between control joints exceeding 84 m² (900 sq.ft.).
 - .6 Partition and ceiling runs on column lines or at joints in ceiling runs.
 - .7 In interior ceilings without perimeter relief exceeding 9100 mm (30 ft.) in either direction and total area between control joints exceeding 84 m² (900 sq.ft.).
 - .8 In interior ceilings with perimeter relief exceeding 15000 mm (50 ft.) and total area between control joints exceeding 230 m² (2500 sq.ft.).
 - .2 Install control joints full height floor to ceiling or door header to ceiling in partitions and furring runs.
 - .3 Install control joints from wall to wall in ceiling areas.
- .8 Cover both faces of steel stud partition framing with gypsum panels in concealed spaces.
 - .1 Unless concealed application is indicated or required for sound, fire, air, or smoke ratings, coverage may be accomplished with scraps of not less than 0.7 sq.m. (8 sq.ft.) in area.
 - .2 Fit gypsum panels around ducts, pipes, and conduits.

- .3 Where partitions intersect open joists and other structural members projecting below underside of slabs and decks, cut gypsum panels to fit profile formed by joists and other structural members; allow 6 mm to 10 mm wide joints to install sealant.
 - .9 Gypsum board single layer application:
 - .1 On ceilings, apply gypsum panels before wall/partition board application to the greatest extent possible and at right angles to framing, unless otherwise indicated.
 - .2 On partitions and walls, apply gypsum panels parallel to framing, unless otherwise indicated or required by fire resistance rated assembly, and minimize end joints.
 - .3 Stagger abutting end joints not less than one framing member in alternate courses of board.
 - .10 Gypsum board multilayer application - ceilings: Apply gypsum board indicated for base layers before applying base layers on partitions and walls; apply face layers in same sequence. Apply base layers at right angles to framing members and offset face layer joints one framing member, 400 mm minimum, from parallel base layer joints, unless otherwise indicated or required by fire resistance rated assembly.
 - .11 Gypsum board multilayer application – partitions and walls: Apply gypsum board indicated for base layers and face layers parallel to framing with joints of base layers located over stud or furring member and face-layer joints offset at least one stud or furring member with base-layer joints, unless otherwise indicated or required by fire-resistance-rated assembly. For acoustic rated partitions greater than STC 40 offset the horizontal joints of the face-layer by 400 mm minimum from the base-layer joints. Stagger joints on opposite sides of partitions.
 - .1 Furring members: Apply base layer parallel to framing and face layer either vertically parallel or perpendicular to framing with vertical joints offset at least one furring member. Locate edge joints of base layer over furring members.
 - .12 Single layer fastening method: Fasten gypsum panels to supports with steel drill screws.
 - .13 Multilayer fastening method: Fasten base layers with screws; fasten face layers with adhesive and supplementary fasteners, unless otherwise indicated or required by fire resistance rated assembly.
 - .14 Laminating to substrate: Where gypsum panels are indicated as directly adhered to a substrate, comply with gypsum board manufacturer's written recommendations and temporarily brace or fasten gypsum panels until fastening adhesive has set.
- 3.9 **INSTALLATION - ACOUSTICAL INSULATION**
- .1 Install acoustical insulation to partitions indicated. Provide continuous coverage between studs and run continuously from floor to ceiling, or to structure for full height partitions, over door frames and openings and around corners.
 - .2 Pack acoustical insulation around cut openings in gypsum board, behind outlet boxes around plumbing, heating or structural items passing through the system and at abutting walls.
 - .3 Secure acoustical insulation to one interior face of gypsum board with adhesive or mechanical fasteners or by other approved means.
 - .4 For partitions receiving acoustical insulation, seal construction at perimeters, behind control joints, and at openings and penetrations with a continuous bead of acoustical sealant. Install acoustical sealant at both faces of partitions at perimeters and through penetrations. Comply with ASTM C919, Standard Practice for Use of Sealants in Acoustical Applications, and with manufacturer's written recommendations for locating edge trim and closing off

sound-flanking paths around or through assemblies, including sealing partitions above acoustical ceilings.

3.10 **INSTALLATION - FIRE RATED ASSEMBLIES**

- .1 Construct fire rated assemblies where indicated, to requirements of authorities having jurisdiction.

3.11 **INSTALLATION - ACCESSORIES**

- .1 Erect casing beads, corner beads straight, plumb or level, rigid and at proper plane. Use full length pieces where practical. Make joints tight, accurately aligned and rigidly secured by screw fasteners. Fit corners accurately, free from rough edges.
- .2 Provide corner beads at external corners of gypsum board partitions and where indicated.
- .3 Provide casing beads at gypsum board terminations, at gypsum board wall/ceiling junctions, where gypsum board butts against surfaces having no trim concealing junction and where indicated.
- .4 Construct control joints of two back-to-back casing beads set in gypsum board facing and supported independently on both sides of joint. Provide continuous polyethylene dust barrier behind and across control joints.

3.12 **INSTALLATION - ACCESS PANELS AND DOORS**

- .1 Install access doors to electrical and mechanical fixtures specified in respective Sections.
- .2 Rigidly secure frames to furring or framing systems.

3.13 **INSTALLATION TOLERANCES**

- .1 Provide and install studs, framing, shimming, and furring to provide proper support for gypsum board to achieve the following installation tolerances:
 - .1 Do not exceed 3 mm (1/8") in 3 m (10') variation from plumb, level, and plane.
 - .2 Do not exceed 10 mm (3/8") from drawings locations.
 - .3 Do not exceed 1.5 mm (1/16") variation between planes of abutting edges or ends.
 - .4 Install each framing member so fastening surfaces vary not more than 3.2 mm (1/8") from the plane formed by faces of adjacent framing.
- .2 Suspended and furred ceilings:
 - .1 Level cross furring channels to maximum tolerance of 3 mm in 3 m (1/8" in 10 ft).
- .3 Installation tolerances gypsum and cement board panels:
 - .1 Do not exceed 3 mm (1/8") in 3 m (10') variation from plumb, level, and plane in exposed surfaces, except at end joint between gypsum board panels.
 - .2 Do not exceed 10 mm (3/8") from indicated location.
 - .3 Do not exceed 1.5 mm (1/16") variation between planes of abutting edges or ends.
 - .4 Surface flatness shall not exceed 1.5 mm (1/16") within 305 mm (12") straight edge. For non-tapered-edge end joints between boards, measure flatness tolerance with end of straight end at centreline of joint.
- .4 Installation tolerances accessories:
 - .1 Alignment with board panels shall not exceed tolerances specified above.
 - .2 End joints shall be flush aligned to maximum offset of 0.5 mm (0.020").

3.14 **INSTALLATION - TAPING AND FILLING**

- .1 Gypsum Board Finish: finish gypsum board walls and ceilings to following levels in accordance with Association of the Wall and Ceiling Industries (AWCI) International Recommended Specification on Levels of Gypsum Board Finish:
 - .1 Levels of finish:
 - .1 Level 1: in plenum areas above ceilings or in areas where the assembly would generally be concealed
 - .2 Level 2: where water resistant gypsum backing board is used as a substrate for tile)
 - .3 Level 3: All service areas; for surfaces receiving medium- or heavy-textured finishes before painting or heavy wallcoverings where lighting conditions are not critical.
 - .4 Level 4: All staff areas.
 - .5 Level 5: All public areas, including courtrooms.
 - .2 Fill joints, casing beads, corner beads, screwholes and depressions on gypsum board surfaces exposed to view to provide smooth seamless surfaces and square neat corners.
 - .3 Apply joint compounds and reinforcing tapes in accordance with manufacturer's specifications.
 - .4 Fill joints and apply joint compounds by three-coat method. Apply cover coat 175 mm wide, level coat 250 mm wide, and skim coat 300 mm wide.
 - .5 Embed reinforcing tape in a cover coat of joint compound. Apply level coat of joint compound when cover coat has dried. Apply skim coat of compound when level coat has dried.
 - .6 Feather edges of compounds into surfaces of gypsum boards. After skim coat has dried for at least 24 hours sand to leave smooth for decoration. Do not sand paper face of gypsum board.
 - .7 At internal corners: First fill gaps between boards with joint compound. Embed creased reinforcing tape into a thin coat of joint compound applied 50 mm wide at each side of corner. Apply cover coat. Apply skim coat to one side of joint, and when dry apply skim coat to other side.
 - .8 At external corners: Fill to nose of corner bead with joint compound and sand smooth.
 - .9 At screwheads and nailheads: Fill holes and depressions with a two coat application of joint compound and sand smooth.
 - .10 Finish gypsum board joints above finished ceiling with tape and first coat of joint compound.

3.15 **PROTECTION**

- .1 Protect adjacent surfaces from drywall compound and promptly remove from floors and other non-drywall surfaces. Repair surfaces stained, marred, or otherwise damaged during drywall application.
- .2 Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section Includes:
 - .1 Labour, Products, equipment, and services necessary to complete the work of this Section.
- .2 Related Requirements
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.

1.2 SUBMITTALS

- .1 Submit a letter of certification written by the manufacturer that states the installer is a current "approved applicator" fully trained in the installation of the specified materials.
- .2 Product data: Submit manufacturer's technical data, installation instructions and general recommendations for each type of flooring material required.
- .3 Samples: Submit 300 mm x 300 mm sample of flooring for approval. Submit additional samples until approval is obtained. Make changes in aggregate mix as required to secure correct colour and texture.
- .4 Maintenance data: Submit maintenance data, include specific instructions for maintenance, preservation, and cleaning. Provide adequate warning of maintenance materials or practices which may be detrimental to flooring.

1.3 QUALITY ASSURANCE

- .1 Installer: having a minimum ten (10) years' experience in the installation of the work described in this Section and can show evidence of satisfactory completion of projects of similar size, scope and type.
 - .1 The Installer must be an "Approved Applicator" of the material manufacturer.
- .2 Maintenance seminars: Provide, to the Owner, training seminars and recommendations on Product maintenance procedures.
- .3 Pre-installation meeting: Prior to commencing work of this Section, arrange for manufacturer's technical representative to visit the site and review preparatory and installation procedures to be followed, conditions under which the work will be done, and inspect the surfaces and test substrates to receive the work of this Section. Advise the Consultant of the date and time of the meeting.
- .4 Manufacturer's site inspection: Have the manufacturer's technical representative inspect the Work at suitable intervals during application and at conclusion of the work of this Section, to ensure the Work is correctly installed. When requested, submit manufacturer's inspection reports and verification that the work of this Section is correctly installed.

- .5 Testing of concrete floors: Test floors that have been cured for minimum 28 days, and after preparation for Product installation is complete and patching or levelling compound is fully cured. Conduct testing simultaneously on floors free of sealer, curing compounds, oil, grease, and other agents detrimental to the test and Product performance. Locate test sites to cover representative installation areas. Do not proceed with work when the test results do not conform to the specified allowable.
 - .1 Tensile Bond: Minimum 1.5 MPa in accordance with ASTM C1583. Do one test for every 100 sq.m. or fraction thereof.
 - .2 Moisture vapour transmission: To ASTM D4263 plastic sheet method, no visible condensation or vapour allowed. Do one test for every 50 sq.m. or fraction thereof.
 - .3 Surface moisture content: Maximum 4%, tested by moisture meter. Do one test for every 50 sq.m. or fraction thereof.
 - .4 Surface temperature: Minimum 3 degree C above the measured Dew Point.
- .6 Sample Installation: Provide site sample floor area of 1 sq.m for each type of flooring, including waterproofing membrane, primer, and necessary number of coats to obtain specified finish, showing colour range, bond, and quality of work. Erect additional sample, if required, to obtain approval. Approved samples shall become standard of comparison for flooring work on Site and shall not be destroyed or moved until authorized by Consultant.

1.4 **TOLERANCES**

- .1 Finish seamless flooring surfaces to produce plumb and level floor, or straight where sloped to drains, within tolerance of 3 mm in 3 m

1.5 **DELIVERY, STORAGE AND HANDLING**

- .1 Deliver materials to Site in original, unopened containers with manufacturer's labels and seals intact. Labels shall identify manufacturer's name, brand name of product, grade and type, application directions and shelf life and/or expiry date of product.
- .2 Handle and store materials indoors at a temperature range of 15°C to 21°C in a dry location in accordance with manufacturer's printed directions.
- .3 Store flammable materials in safe, approved containers to eliminate fire hazards and remove from Site at end of each work shift.
- .4 Do not use materials that have been stored for period of time exceeding maximum recommended shelf life of materials.

1.6 **PROJECT CONDITIONS**

- .1 Maintain minimum air and surface temperatures at 20°C for 48 hours before, during, and for 48 hours following application, or until cured.
- .2 Maintain well-lit and well-ventilated area.
- .3 Comply with flooring manufacturer's directions for maintenance of substrate temperatures, ventilation and other conditions required to execute and protect work.
 - .1 At the time of application ensure the minimum substrate temperature is above 7°C and the substrate temperature is 3°C above the measured dew point.
- .4 Protect adjacent surfaces from damage resulting from work of this Section. If necessary, cover or mask adjacent surfaces to those receiving flooring including fixtures and equipment.

- .5 Materials soiled by coatings during application and storage, and from which soil cannot be completely removed, shall be replaced by this Section at no extra cost.
- .6 Erect barriers to prevent entry and presence of workers not performing work of this Section during application of flooring and for 48 hours following completion of application.
- .7 Post "No Smoking" signs while work is in progress and curing. Ensure that spark-proof electrical equipment is used in areas where inflammable materials are being applied. Prevent use of open flames or equipment that may cause sparks during this phase of work.

PART - 2 PRODUCTS

2.1 MATERIALS

- .1 General: Materials used in application of each flooring system shall be of same manufacturer and same supplier.
- .2 Basis of Design – Epoxy Flooring (EPF): Refer to Drawings, for complete list of products, designations, manufacturers, sizes, thickness, finishes and colours.
 - .1 Products by other manufacturers similar in function, design, performance, and construction complying with requirements of this Section may be incorporated into the Work subject to Consultant's acceptance in accordance with the substitution procedures of Division 01.
- .3 Additional materials: Fill all joints, cracks, depressions, or any other surface irregularities using additional materials recommended by the manufacturer of the specified product.
- .4 Divider strips: L shape to required floor thickness, white alloy zinc.
- .5 Cove strips: type recommended by flooring manufacturer.
- .6 Joint backing: Preformed, compressible strips of closed cell polyethylene or urethane foam, rubber tubing or non-migrating plasticized vinyl with shore 'A' hardness of 20 and tensile strength between 140 kPa and 200 kPa. Sizes and shapes to suit various conditions, diameter 25% greater than joint width. Compatible with sealant, primer, epoxy flooring and substrate.
- .7 Joint sealant: Single-component, non-sag, polyurethane joint sealant meeting specified requirements of ASTM C 920, Type S, Grade NS, Class 35, for Use NT, compatible with floor finish and as recommended by flooring manufacturer.

PART - 3 EXECUTION

3.1 EXAMINATION

- .1 Ensure that concrete slab has been properly cured and dry for minimum of 28 days.
- .2 Ensure that no curing and sealing compounds, hardeners or other chemical additives have been used on concrete.
- .3 Verify that specified environmental conditions are maintained before commencing work. Be familiar with manufacturer's product literature and Material Safety Data Sheets and comply with precautions, handling procedures and equipment requirements.
- .4 Report concrete floor test results to Consultant and obtain manufacturer's representative's approval before proceeding.

- .5 Monitor the Dew Point during application and initial cure. The surface must be at least 3°C above the measured Dew Point at all times during application and cure.
- .6 Do not start work until unsatisfactory conditions have been corrected. Commencement of work indicates acceptance of all surfaces and conditions.

3.2 **PREPARATION**

- .1 Clean subfloor free of laitance, oil, grease, and other foreign matter detrimental to flooring application.
- .2 Prepare concrete floors with shot blasting or other method recommended by manufacturer. Remove uneven joints, rough areas, foreign and projection off surfaces. Surface to be hard, sound, and roughened to irregular surface with weak concrete removed and surface holes and voids exposed. Equip blasting machine with vacuum to minimize dust.
- .3 Repair cracks, holes, or other deficiencies in accordance with manufacturer's recommendations.
- .4 Blow clean control joints, sawcuts and cracks with compressed air and grout with material compatible with floor coating materials.
- .5 Ensure that backing surfaces for cove bases are free of voids and irregularities. Fill recessed joints with recommended material.
- .6 All edges that do not terminate at a wall or curb shall be keyed to avoid feathered edges. All through floor penetrations such as drains, and trenches require a keyed edge that maintains a uniform 6 mm thickness.
- .7 Obtain flooring manufacturer's approval of prepared substrate before commencement of work.
- .8 Procedures to follow in dealing with exposed synthetic fibres after shot blasting is performed.
 - .1 Remove the visible fibres with a Tiger Torch, running the flame across the floor.
 - .2 Sweep and vacuum remnants
 - .3 Apply primer coat of system specified
 - .4 Let primer set over night
 - .5 Next day, sand floor to remove any remaining fibres
 - .6 Sweep and vacuum
 - .7 Proceed with installation of epoxy system.

3.3 **INSTALLATION**

- .1 Prime concrete substrates to prevent the possibility of blisters, debonding, and pinholes. Apply primer over prepared substrate at manufacturer's recommended spreading rate with timing of application coordinated with subsequent application of topping mix to ensure optimum adhesion between flooring materials and substrate.
- .2 Prepare, mix materials, and apply each component of flooring system in strict accordance with CGSB 81-GP-10M and manufacturer's printed directions to produce uniform monolithic wearing surface of thickness indicated for each system, with integral cove bases, uninterrupted except at divider strips, sawn joints or other types of joints required.

- .3 Apply work to ensure that no laps, pin holes, voids, crawls, skips or other marks or irregularities are visible, and to provide uniform appearance.
- .4 Apply work into corners and other restricted areas, up and over equipment bases, and into recesses in floors to ensure full coverage.
- .5 Make clean true junctions with no visible overlap between adjoining applications of flooring.
- .6 Match approved sample for colour, sheen, texture, and slip resistance.
- .7 For large areas, stop each day's production at metal dividing strip at lines approved by Consultant.
- .8 Primer: Apply primer over prepared substrate, at manufacturer's recommended spreading rate with timing of application coordinated with subsequent application of topping mix to ensure optimum adhesion between flooring materials and substrate.
- .9 Epoxy matrix: Combine aggregate to blended resin to form trowellable mortar. Place mortar over tacky primer and spread in number of coats and at spreading rates required to produce minimum thickness specified. Take care to spread newly mixed materials across the transition of previous applied mixes before the surface begins to set. Allow mortar to stand for a few minutes to permit entrapped air to escape. Allow matrix to harden minimum time recommended by manufacturer before applying finish coats.
- .10 When trowelled epoxy matrix has hardened, remove imperfections by lightly abrading surface and vacuum clean. Apply finish coats at spreading rate and following method recommended by manufacturer to achieve minimum thickness and to obtain non-slip finish to match approved samples. Allow minimum recommended drying time between coats.
- .11 Cove base: Provide 150 mm high cove base struck straight to provide line for wall finish. Cap with manufacturer's recommended cove strip. Seal floor-wall interface with non-sag joint sealant as recommended by flooring manufacturer, CFIA acceptance.
- .12 Thresholds:
 - .1 Where flooring terminates at doorways, and difference in height occurs between seamless flooring and other floor finishes, cut back slab for 32 mm width to allow full thickness of seamless flooring to be flush with adjacent floor finish (chasing).
 - .2 Where flooring terminates at doorways, and floor finishes are of same thickness, provide metal divider strips flush with surfaces.
- .13 Floor drains: Slope flooring to drains minimum of 1:100 from furthest surface point. Grind concrete around perimeter to provide 6 mm thickness of flooring material which is flush with top of drain and slopes as indicated on Drawings.
- .14 Control joints: Where substrate is interrupted by isolation, control, or expansion joints, provide saw-cut joint in flooring after floor installation, install backer rod and fill with manufacturer's recommended epoxy or urethane sealant.

3.4 **ADJUSTMENT AND CLEANING**

- .1 Touch up and refinish minor defects in work. Refinish entire coated surface areas where finish is damaged or otherwise unacceptable.
- .2 Remove promptly as work progresses spilled or splattered coating materials from adjacent surfaces. Clean floors on completion of Work. Do not mar surfaces while removing splatters.

- .3 Protect completed work from contact with water, chemical exposure, and traffic by suitable means for at least 7 days to allow proper curing of floor finish.
- .4 Protect work from any trades using area after completion of installation.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section Includes:
 - .1 Labour, Products, equipment, and services necessary to complete the work of this Section which includes surface preparation and the application of paint systems on exterior and interior substrates.
- .2 Related Requirements
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.

1.2 SUBMITTALS

- .1 Product Data:
 - .1 For each type of product, confirming compliance with the specified or named product or material.
 - .2 Prior to ordering products or materials, submit manufacturer's printed product datasheets for each type of product. Include product characteristics, performance criteria, physical size, finish, and limitations for products listed in selected designs.
- .2 Samples: Provide duplicate minimum 300 mm square samples of surfaces or acceptable facsimiles requested painted with specified paint or coating in colours, gloss, sheen, and textures required to MPI Painting Manual standards for review. When approved, samples become acceptable standard of quality for appropriate on-site surface with one of each sample retained on-site.
- .3 List of painting materials: If requested by Consultant submit duplicate copy of list of painting materials for review prior to ordering materials. If requested, provide an invoice list of all paint materials ordered for project work indicating manufacturer, types and quantities for verification and compliance with specification and design requirements.
- .4 Material Safety Data Sheets (MSDS): Submit duplicate copies prior to commencement of work for review and for posting at job site as required.
- .5 Project Data Manual: At project completion provide an itemized list complete with manufacturers' application instructions, paint type and colour coding for all colours used for Owner's later use in maintenance.

1.3 QUALITY ASSURANCE

- .1 Applicator experience: Having minimum of five years proven satisfactory experience. When requested, provide a list of the last three comparable projects including, name and location, consultant, start and completion dates, and value of the painting work.
- .2 Applicator qualification: Qualified journeypersons, painters, as defined by local jurisdiction shall be engaged in painting and decorating work. Apprentices may be employed provided they work under the direct supervision of a qualified journeyperson in accordance with trade regulations.
- .3 Materials, preparation, and quality of work: In conformance with requirements of the latest edition of the Architectural Painting Specification Manual by the Master Painters Institute, referred to as the MPI Painting Manual in this Section, issued by the local MPI Accredited Quality Assurance Association having jurisdiction.

- .4 Manufacturers and products: Listed under the Approved Product List section of the MPI Painting Manual.
- .5 The best practices specified or recommended in CAN/CGSB-85.100 shall govern for painting materials, methods, and procedures.
- .6 Maintenance seminars: Provide, to the Owner, training seminars and recommendations on Product maintenance procedures.
- .7 Pre-installation meeting: Two weeks prior to commencing work of this Section, arrange for manufacturer's technical representative to visit the site and review preparatory and installation procedures to be followed, conditions under which the work will be done, and inspect the surfaces to receive the work of this Section. Advise the Consultant of the date and time of the meeting.
- .8 Manufacturer's site inspection: Have the manufacturer's technical representative inspect the Work at suitable intervals during application and at conclusion of the work of this Section, to ensure the Work is correctly installed. When requested, submit manufacturer's inspection reports and verification that the work of this Section is correctly installed.
- .9 Ensure written confirmation is received from steel fabricators of the specific surface preparation procedures and primers used for steel work to ascertain appropriate and compatible finish materials.

1.4 **SAMPLES AND MOCK-UPS**

- .1 Samples: Provide duplicate minimum 300 mm square samples of surfaces or acceptable facsimiles requested painted with specified paint or coating in colours, gloss, sheen, and textures required to MPI Painting Manual standards for review. When approved, samples become acceptable standard of quality for appropriate on-site surface with one of each sample retained on-site.
- .2 Sample installations: When requested by the Consultant prepare and paint designated surface, area, room, or item in each colour scheme to requirements specified, with specified paint or coating showing selected colours, gloss, sheen, textures, and quality of work to MPI Painting Manual standards for review and approval. When approved, surface, area, room, and items become acceptable standard of finish quality and workmanship for similar on-site work.

1.5 **PRODUCT DELIVERY, STORAGE AND HANDLING**

- .1 Deliver all painting materials in sealed, original labelled containers bearing manufacturer's name, brand name, type of paint or coating and colour designation, standard compliance, materials content as well as mixing and/or reducing and application requirements.
- .2 Store all paint materials in original labelled containers in a lockable, dry, heated and well ventilated single designated area meeting the minimum requirements of both paint manufacturer and authorities having jurisdiction and at a minimum ambient temperature of 7°C. Only material for use on this project is to be stored on site.
- .3 Where toxic, volatile, explosive, flammable materials are being used, provide adequate fireproof storage lockers, and take all necessary precautions and post adequate warnings such as no smoking signs as required.
- .4 Take necessary precautionary and safety measures to prevent fire hazards and spontaneous combustion and to protect the environment from hazard spills. Store materials that constitute a fire hazard in suitable closed and rated containers and removed from the site on a daily basis.

- .5 Comply with requirements of authorities having jurisdiction, in regard to the use, handling, storage and disposal of hazardous materials.

1.6 **SCHEDULING**

- .1 Schedule painting operations to prevent disruption of and by other Sections.
- .2 Schedule painting operations in occupied facilities to prevent disruption of occupants in and about the building. Perform painting after facility working hours or on weekends in accordance with Owner's operating requirements. Schedule work such that painted surfaces will have dried before occupants are affected. Obtain written authorization from Consultant for changes in work schedule.

1.7 **PROJECT CONDITIONS**

- .1 Unless specifically pre-approved by the Consultant, and the product manufacturer, do not perform work when the ambient air and substrate temperatures are below 10°C for both interior and exterior work.
- .2 Do not perform exterior work unless environmental conditions are within MPI and manufacturer's requirements or until adequate weather protection is provided. Where required, provide suitable weatherproof covering and sufficient heating facilities to maintain minimum ambient air and substrate temperatures for 24 hours before, during and after work is completed.
- .3 Do not perform interior work unless adequate continuous ventilation and sufficient heating facilities are in place to maintain ambient air and substrate temperatures above minimum requirements for 24 hours before, during and 48 hours after work is complete, unless required otherwise by manufacturer's instructions. Provide supplemental ventilating and heating equipment if ventilation and heating from existing system is inadequate to meet minimum requirements.
- .4 Do not perform work when the relative humidity is above 85% or when the substrate temperature is less than 3°C above the measured dew point.
- .5 Do not perform work when the maximum moisture content of the substrate exceeds:
 - .1 12 % for concrete and masonry.
 - .2 15% for wood.
 - .3 12 % for plaster and gypsum board.
- .6 Conduct all moisture tests using a properly calibrated electronic Moisture Meter, except test concrete floors for moisture using a simple cover patch test.
- .7 Test concrete, masonry and plaster surfaces for alkalinity as required.
- .8 Apply work only to dry, clean, properly cured and adequately prepared surfaces in areas where dust is no longer generated by construction activities such that airborne particles will not affect the quality of finished surfaces.
- .9 Do not perform work unless a minimum lighting level of 323 Lux () is provided on surfaces to be painted or decorated.

1.8 **EXTRA STOCK**

- .1 At project completion provide 6 litres of each type and colour of paint from same production run used in unopened cans, properly labelled, and identified for Owner's later use in maintenance. Store where directed.

1.9 **WASTE MANAGEMENT AND DISPOSAL**

- .1 Paint, stain and wood preservative finishes and related materials such as thinners, solvents are regarded as hazardous products and are subject to regulations for disposal. Obtain information on these controls from applicable authorities having jurisdiction.
- .2 Separate and recycle waste materials. Where paint recycling is available, collect waste paint by type and provide for delivery to recycling or collection facility. Materials that cannot be reused must be treated as hazardous waste and disposed of in an appropriate manner.
- .3 Place materials defined as hazardous or toxic waste, including used sealant and adhesive tubes and containers, in containers or areas designated for hazardous waste.
- .4 Strictly adhere to the following procedures to reduce the amount of contaminants entering waterways, sanitary and storm drain systems or into the ground:
 - .1 Retain cleaning water for water-based materials to allow sediments to be filtered out. In no case shall equipment be cleaned using free draining water.
 - .2 Retain cleaners, thinners, solvents and excess paint and place in designated containers and ensure proper disposal.
 - .3 Return solvent and oil-soaked rags used during painting operations for contaminant recovery, proper disposal, or appropriate cleaning and laundering.
 - .4 Dispose of contaminants in an approved legal manner in accordance with hazardous waste regulations.
 - .5 Empty paint cans are to be dry prior to disposal or recycling (where available).
 - .6 Close and seal tightly partly used cans of materials including sealant and adhesive containers and store protected in well ventilated fire-safe area at moderate temperature.
- .5 Set aside and protect surplus and uncontaminated finish materials not required by the Owner and deliver or arrange collection for verifiable re-use or re-manufacturing.

PART - 2 PRODUCTS

2.1 **MATERIALS**

- .1 Only materials listed in the latest edition of the MPI Approved Product List (APL) are acceptable for use on this project. Provide material from a single manufacturer for each system used.
- .2 Other materials not listed in the APL shall be the highest quality product of an MPI listed manufacturer and shall be compatible with paint materials being used as required.
- .3 All materials used shall be lead and mercury free and shall have low VOC content where possible.
- .4 Where required, use only materials having a minimum MPI Environmentally Friendly E1, E2 E3 rating based on VOC (EPA Method 24) content levels.

- .5 Where indoor air quality is an issue, use only MPI listed materials having a minimum E2 E3 rating.
- .6 Provide materials having good flowing and brushing properties and capable to dry or cure free of blemishes, sags, air entrapment.
- .7 Where required, paints and coatings shall meet flame spread and smoke developed ratings to code requirements and authorities having jurisdiction.
- .8 Metallic Paste Filler: non-rusting repair paste, reinforced with aluminium, of metallic appearance, quick drying; Bondo Metal Reinforced Filler by 3M.

2.2 **EQUIPMENT**

- .1 Painting and Decorating Equipment: to best trade standards for type of product and application.
- .2 Spray Painting Equipment: of ample capacity, suited to the type and consistency of paint or coating being applied and kept clean and in good working order at all times.

2.3 **MIXING AND TINTING**

- .1 Unless otherwise specified or pre-approved, provide materials ready-mixed and pre-tinted. Re-mix materials in containers prior to and during application to ensure break-up of lumps, complete dispersion of settled pigment, and colour and gloss uniformity.
- .2 Mix paste, powder, or catalyzed materials in strict accordance with manufacturer's written instructions.
- .3 Do not exceed amount of thinner beyond manufacturer's recommendations. Do not use kerosene or organic solvents to thin water-based materials.
- .4 If required, thin paint for spraying according in strict accordance with paint manufacturer's instructions. If directions are not on container, obtain instructions in writing from manufacturer and provide copy of instructions to Consultant.

2.4 **FINISH AND COLOURS**

- .1 Refer to Drawings for identification and location of colours.
- .2 Where required by authorities having jurisdiction, finish exit and vestibule doors in contrasting colour to walls and a different colour than any other door in the same area.
- .3 Access doors, prime coated butts and other prime painted hardware, registers, radiators and covers, exposed piping and electrical panels: To match adjacent surfaces, unless otherwise noted or where pre-finished.
- .4 Low headroom areas: Minimum 100 mm wide yellow band on leading edge marked CAUTION - LOW CLEARANCE in 50 mm high black letters at suitable intervals and in accordance with requirements of authorities having jurisdiction.
- .5 Where other applied finishes and nosing are not specified at stairs, ramps and landings providing access and exit for persons with visual impairment, provide colour contrast slip resistant finish and warning strips at treads and landings.

2.5 GLOSS AND SHEEN RATINGS

- .1 Paint gloss shall be defined as the sheen rating of applied paint, in accordance with the following MPI values:

Gloss Level	Description	Units@ 60 degrees	Units@ 85 degrees
G1	Matte or Flat finish	Max. 5	Max. 10
G2	Velvet finish	Max. 10	10 to 35
G3	Eggshell finish	10 to 25	10 to 35
G4	Satin finish	20 to 35	Main. 35
G5	Semi-Gloss finish	35 to 70	
G6	Gloss finish	70 to 85	
G7	High-Gloss finish	More than 85	

PART - 3 EXECUTION

3.1 CONDITION OF SURFACES

- .1 Prior to commencement of work thoroughly examine and test as required conditions and surfaces scheduled to be painted. Do not commence work until adverse conditions and defects have been corrected and surfaces and conditions are acceptable.

3.2 SURFACE PREPARATION

- .1 Prepare all surfaces in accordance with MPI requirements.
- .2 Sand, clean, dry, etch, neutralize, and test surfaces under adequate illumination, ventilation and temperature requirements.
- .3 Remove and securely store miscellaneous hardware, surface fittings and fastenings such as electrical plates, mechanical louvers, door and window hardware, hinges, knobs, locks, trim, frame stops, removable rating/hazard/instruction labels, washroom accessories, light fixture trim, from wall and ceiling surfaces, doors and frames, prior to commencement of work. Carefully clean and replace items upon completion of work in each area. Do not use solvent or reactive cleaning agents on items that will mar or remove finishes. Remove doors to finish bottom and top edges and re-hang doors when work is complete.
- .4 Protect all adjacent interior surfaces and areas, including rating/hazard/instruction labels on doors, frames, equipment, piping, from painting operations and damage using drop cloths, shields, masking, templates, or other suitable protective means and make good damages caused by failure to provide such protection.
- .5 Make good substrate defects and sand ready for finishing particularly after the first coat is applied. Start of finishing on defective surfaces indicates acceptance of substrate and any costs of making good defects shall be borne by this Section including re-painting of entire defective surface.
- .6 Confirm preparation and primer used with fabricator of steel items.
- .7 Prepare dented or damaged metal plates or surfaces prior to priming and painting with metallic paste filler in accordance with manufacturer's recommendations.

3.3 APPLICATION

- .1 Do not perform work unless substrates are acceptable and until heating, ventilation, lighting, and completion of work of other Sections are acceptable for applications of products.
- .2 Apply materials in accordance with MPI Painting Manual Premium Grade finish and manufacturers' requirements.
- .3 Work specified is intended to cover surfaces satisfactorily when applied at proper consistency and in accordance with manufacturer's recommendations.
- .4 Tint each coat of finish progressively lighter to enable confirmation of number of coats.
- .5 Unless otherwise approved by the Consultant, apply a minimum of four coats of paint where deep or bright colours are used to achieve satisfactory results.
- .6 Sand between each coat to provide an anchor for next coat and to remove defects visible from a distance up to 1000 mm.
- .7 Do not apply finishes on surfaces that are not sufficiently dry. Unless manufacturer's directions state otherwise, each coat shall be sufficiently dry and hard before a following coat is applied.
- .8 Prime coat of stain or varnish finishes may be reduced in accordance with manufacturer's directions.
- .9 Paint finish shall continue through behind all wall-mounted items.

3.4 INTERIOR FINISHING SYSTEMS

- .1 Finish interior surfaces in accordance with MPI Painting Manual requirements:
- .2 Galvanized Metal: Doors, frames, railings, misc. steel, pipes, overhead decking, ducts.
 - .1 INT 5.3A: Latex.
- .3 Plaster and Gypsum Board:
 - .1 INT 9.2B: High performance architectural latex, primer only.

3.5 MECHANICAL, ELECTRICAL EQUIPMENT AND RELATED SURFACES

- .1 Unless otherwise specified or noted, finish all unfinished conduits, piping, hangers, ductwork, and other mechanical and electrical equipment with colour and texture to match adjacent surfaces, in the following areas:
 - .1 Where exposed-to-view in exterior and interior areas.
 - .2 In interior high humidity interior areas.
 - .3 In boiler room, mechanical and electrical rooms.
- .2 In unfinished areas leave exposed conduits, piping, hangers, ductwork, and other mechanical and electrical equipment in original finish and touch up scratches and marks.
- .3 Touch up scratches and marks on factory finished equipment with products compatible with factory finish.
- .4 Do not paint over nameplates.

- .5 Paint the inside of all ductwork where visible behind louvers, grilles and diffusers for a minimum of 450 mm or beyond sight line, whichever is greater, with primer and one coat of flat black paint.
- .6 Paint the inside of light valances gloss white.
- .7 Paint disconnect switches for fire alarm system and exit light systems in red enamel.
- .8 Paint or band all fire protection piping and sprinkler lines in accordance with mechanical specification requirements. Keep sprinkler heads free of paint.
- .9 Paint or band all natural gas piping in accordance with mechanical specification requirements.
- .10 Back prime and paint face and edges of plywood service panels for telephone and electrical equipment before installation to match adjacent wall surface. Leave equipment in original finish except for touch-up as required, and paint conduits, mounting accessories and other unfinished items.
- .11 Paint exterior steel electrical light standards. Do not paint outdoor transformers and substation equipment.

3.6 **FIELD QUALITY CONTROL AND STANDARD OF ACCEPTANCE**

- .1 Manufacturer's site inspection: Have the manufacturer's technical representative inspect the Work at suitable intervals during application and at conclusion of the work of this Section, to ensure the Work is correctly installed. When requested, submit manufacturer's inspection reports and verification that the work of this Section is correctly installed.
- .2 Painted exterior and interior surfaces will be considered to lack uniformity and soundness if any of the following defects are apparent:
 - .1 Brush and roller marks, streaks, laps, runs, sags, drips, heavy stippling, hiding or shadowing by inefficient application methods, skipped or missed areas, and foreign materials in paint coatings.
 - .2 Evidence of poor coverage at rivet heads, plate edges, lap joints, crevices, pockets, corners, and re-entrant angles.
 - .3 Damage due to touching before paint is sufficiently dry or any other contributory cause.
 - .4 Damage due to application on moist surfaces or caused by inadequate protection from the weather.
 - .5 Damage and/or contamination of paint due to blown contaminants (dust, spray paint, etc.).
- .3 Painted surfaces will be considered unacceptable if any of the following are evident under natural lighting source for exterior surfaces and final lighting source (including daylight) for interior surfaces:
 - .1 Visible defects are evident on vertical and horizontal surfaces when viewed at normal viewing angles from a distance of not less than 1000 mm.
 - .2 Visible defects are evident on ceiling, soffit and other overhead surfaces when viewed at normal viewing angles.
 - .3 When the final coat on any surface exhibits a lack of uniformity of colour, sheen, texture, and hiding across full surface area.

- .4 Make good painted surfaces rejected by the inspector to approval of Consultant and at the no extra cost to the Owner. Touch up small affected areas. Repaint large affected areas or areas without sufficient material dry film thickness. Remove runs, sags of damaged paint by scraper or by sanding prior to application of paint.

3.7 **PROTECTION**

- .1 Protect exterior surfaces and areas, including landscaping, walks, drives, adjacent building surfaces, equipment and any labels and signage from painting operations and damage by drop cloths, shields, masking, templates, or other suitable protective means and make good any damage caused by failure to provide such protection.
- .2 Protect interior surfaces and areas, equipment and any labels and signage from painting operations and damage by drop cloths, shields, masking, templates, or other suitable protective means and make good any damage caused by failure to provide such protection.
- .3 Erect barriers or screens and post signs to warn of or limit or direct traffic away or around work area as required.

3.8 **CLEAN-UP**

- .1 Remove paint where spilled, splashed, splattered, or sprayed as work progresses using means and materials that are not detrimental to affected surfaces.
- .2 Keep work area free from an unnecessary accumulation of tools, equipment, surplus materials and debris.
- .3 Remove combustible rubbish materials and empty paint cans each day and safely dispose of same in accordance with requirements of authorities having jurisdiction.
- .4 Clean equipment and dispose of wash water / solvents as well as all other cleaning and protective materials (e.g. rags, drop cloths, masking papers, etc.), paints, thinners, paint removers / strippers in accordance with the safety requirements of authorities having jurisdiction.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section Includes: Labour, Products, equipment, and services necessary to complete the work of this Section for laboratory casework, but not necessarily limited to the following:
 - .1 Laboratory furniture including casework, bench tops, sinks, service fittings.
 - .2 Laboratory equipment.
 - .3 All miscellaneous metal channels, angles, plates, closure plates and other items required to complete the work of this Section.
- .2 Related Requirements
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Related work to be performed by Mechanical and Electrical Trades:
 - .1 Final installation of all plumbing, service and electrical fixtures attached to casework or countertop (excluding piping and wiring within fume hoods).
 - .2 Final connection to service lines of all plumbing, service and electrical fixtures attached to laboratory casework or furniture.

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Show and describe items; dimensions; finishes, installation details; anchors and fastenings; details of furniture and equipment construction and related work.
 - .2 Clearly indicate:
 - .1 Details of laboratory furniture, including bench and construction sections.
 - .2 Location of each furniture unit in plan and elevation for each assembly.
 - .3 Location for roughing-in of plumbing, including sinks, faucets, strainers, cocks, and electrical services.
 - .4 Coordinate elevations to each related room plan. Similar repetitious elevations shall be repeated and included with each room plan for purposes of coordinating electrical wire mould, service ducts, and access panels.
 - .5 Provide dimensions of bench locations from building grid lines and walls.
- .2 Samples: Submit samples of the following:
 - .1 Each bench top material, 150 x 150 mm cut on external corner.
 - .2 Each standard colour of cabinet finish, on 150 x 150 mm steel sheet.
 - .3 Each item of cabinet hardware.
 - .4 Each item of plumbing brass.
 - .5 One base cabinet complete with cupboard and drawer.
 - .6 One cut-away wall case of sufficient size to show construction.
- .3 Quality Control Submittals: Provide certified test reports showing compliance with specified performance characteristics and physical properties.

- .4 Operation and Maintenance Data: Submit data for inclusion in Operation and Maintenance Manual; include the following:
 - .1 Prints of reference drawings.
 - .2 Prints of elementary wiring and connection diagrams.
 - .3 List and catalogue information on recommended spare parts.
 - .4 Description of operation.
 - .5 Descriptive literature on tracking down possible causes of breakdown or failure of equipment.

1.3 **QUALITY ASSURANCE**

- .1 Qualifications
 - .1 Fabricator: Skilled craftsmen in accordance with the best industry practice in shop of a company specializing in Work specified having a minimum 15 years of continued experience, having successfully completed other laboratory projects of similar or greater magnitude.
- .2 Supervision
 - .1 Prior to installation of equipment, arrange for each equipment manufacturer's qualified representative to meet and discuss the procedures to be adopted and conditions under which the equipment will be installed.
 - .2 During installation, arrange for each qualified representative to be present to ensure that such installation is in accordance with the manufacturer's requirements.
- .3 Determine detailed requirements of authorities having jurisdiction; give and post all notices, and comply with laws, ordinances, rules and regulations bearing on conduct of Work. If any Work is performed with knowledge that it is contrary to such laws and ordinances, rules and regulations and without such notice to Consultant, bear costs arising out of this action.

1.4 **DELIVERY, STORAGE AND HANDLING**

- .1 Protect against damage including excessive humidity.
- .2 Do not deliver until building is fully enclosed and conditions are acceptable.

PART - 2 PRODUCTS

2.1 **MATERIALS**

- .1 Sheet Steel: Mild steel, sold rolled furniture grade to requirements of ASTM A366/A366M, Grade C or higher, with smooth surfaces to furniture quality.
- .2 Galvanized Sheet Steel: Commercial quality galvanized sheet steel to ASTM A653/A653M, Designation Z275.
- .3 Stainless Steel:
 - .1 Sheet: ASTM A240, Type 316 alloy.
 - .2 Finish: Unless otherwise indicated, AISI no. 4 Brushed finish.

- .4 Sealant: One component, clear silicone base sealant, chemical curing conforming to CAN/CGSB 19.13, anti-fungus composition, DC-786 by Dow Corning, or Sanitary 1700 by GE Silicone.

2.2 COUNTERTOP MATERIALS

- .1 Stainless-Steel Sheet: ASTM A240/A240M, Type 316.
- .2 Epoxy: Factory-molded, modified epoxy-resin formulation with smooth, non-specular finish.
 - .1 Physical Properties:
 - .1 Flexural Strength: Not less than 10,000 psi (70 MPa).
 - .2 Modulus of Elasticity: Not less than 2,000,000 psi (1400 MPa).
 - .3 Hardness (Rockwell M): Not less than 100.
 - .4 Water Absorption (24 Hours): Not more than 0.02 percent.
 - .5 Heat Distortion Point: Not less than 260 deg F (127 deg C).
 - .2 Chemical Resistance: Epoxy-resin material has the following ratings when tested with indicated reagents according to NEMA LD 3, Test Procedure 3.4.5, white colour for sinks and black colour for countertops:
 - .1 No Effect: Acetic acid (98 percent), acetone, ammonium hydroxide (28 percent), benzene, carbon tetrachloride, dimethyl formamide, ethyl acetate, ethyl alcohol, ethyl ether, methyl alcohol, nitric acid (70 percent), phenol, sulfuric acid (60 percent), and toluene.
 - .2 Slight Effect: Chromic acid (60 percent) and sodium hydroxide (50 percent).

2.3 CABINET HARDWARE

- .1 Flush Finger Pulls: Provide handles for drawers and hinged doors in black PVC set flush within thickness of door and drawers.
- .2 Door Catches: Provide adjustable zinc-plated, spring-loaded, nylon roller.
- .3 Strike Plates: Provide strike plates fabricated of stainless steel, designed to be secured to cabinet stile without twisting, fixed with a single self-tapping screw.
- .4 Door Hinges: Provide five knuckle-type barrel door hinges of 14 Ga steel screwed into door and fastened to cabinet side stile with two counters sunk 8 – 32 cadmium-plated machine screws.
- .5 Locks: M4-00542 National Cabinet Lock. Keys shall be removable in locked or unlocked positions.
- .6 Drawer and Door Bumpers: Press fit, two tongue-type, white rubber.
- .7 Built-in Drawer Stops: Resilient type recommended by manufacturer.
- .8 Press Plugs: Provide plugs for cabinet sides and floors finished in nickel-plated steel.
- .9 Shelf Clips:
 - .1 Clips for base cabinets; zinc-finished steel. Acceptable Type; Roll-It #101.
 - .2 Clips for tall storage cabinets; zinc-finished steel. Acceptable Type; Roll-It #103.

2.4 **GENERAL FABRICATION REQUIREMENTS**

- .1 For shop welding conform to the requirements of CSA W59.1. Have work done by a firm fully certified according to CSA W47. All welders employed in the field shall be qualified as Class "O" as defined in CSA W47.
- .2 For welding operations, conform to other safety requirements of CSA W117.
- .3 Make work in true planes with adequate fastenings. Build and erect work plumb, true, square, straight, level and accurate to sizes detailed, free from distortion or defects detrimental to appearance or performance.
- .4 Fabricate all parts and sub-assemblies (doors, drawers, track, and back panels) to allow interchangeability in the field without requiring special tools.
- .5 Provide all cut-outs, holes, and other provisions, required for installing mechanical and electrical service fittings, located in service strip, fittings, equipment, turrets, and bench tops. Coordinate size and other requirements for cut-outs, and holes, with Mechanical and Electrical Works.
- .6 Align end panels, top rails, bottoms and vertical posts, at intersections in same plane, without overlap.
- .7 Grind exposed welds flush and smooth to match adjacent surfaces.

2.5 **BASE CABINET CONSTRUCTION**

- .1 Materials and Thickness: Use following minimum U.S. standard steel thickness for furniture manufacturing:
- .2 16 Ga for tubular rails and legs for tables.
- .3 14 Ga drawer slides and side suspension channels.
- .4 18 Ga for cabinet sides, vertical and horizontal front members, service cover panels, table and kneehole frames, front rails, gusset plates and gable legs.
- .5 18 Ga for drawer fronts, false panels, door fronts, cabinet floors and back panels, shelves, bottoms and sides of drawers, back of drawer bodies, drawer dividers, and closing panels, furring and filler panels, bin bodies, follow block spacers and pull-out shelves.
- .6 20 Ga for backs of drawer fronts and back of doors.
- .7 Casework shall be constructed in accordance with the best practices of the metal casework industry. Under bench units shall be suspended from leg frame countertop assembly or floor mounted where indicated. They shall be in sizes indicated on drawings, with a variation in width not more than ± 3 mm ($1/8$ "). First class quality shall be established by the use of proper machinery, tools, dies, fixtures and skilled workmanship such that the fit of doors and drawers shall allow vertical and horizontal openings of minimal tolerance.

2.6 **BASIC CABINET FRAME**

- .1 Cabinet frames shall be spot-welded into a rigid modular case construction.
- .2 Provide "HAT" shaped channels installed at rear vertical corners and at centre and third points respectively on 18", 24", 36", 48", and 58" frames, pre-punched to receive drawer suspension tracks and shelf clips.

- .3 Provide one-piece die-formed cabinet construction with return flanges turned up. Spot-weld flanges to cabinet sides. Provide sink cabinets with galvanized bottom painted to match cabinet.
- .4 Cabinet construction shall be electro spot-welded to form a strong well-fitted, one-piece unit.
- .5 Exposed horizontal structural cabinet members between doors and drawers are unacceptable.

2.7 **BASE CABINET COMPONENTS**

- .1 Provide removable back panels for cupboard section of base cabinets. Provide partial back panels 8-7/8" in height to accommodate plumbing at sink units.
- .2 Shelving edges; turned down on all four sides 1" and returned under on front and back 5/8".
- .3 Fabricate doors of 2 telescoping metal panels, coated internally with an acceptable laminated sound-deadening material extending continuously full-width and top to bottom. Reinforce hinged side of door adequately with cold-formed steel components to insure firm fastening and to prevent sagging. Secure recessed hinges in place, and provide positive door closer by nylon roller friction catches, mounted at a central location on the vertical height of pull side of doors. Provide each hinged door with black PVC flush fitting pull and 2 rubber bumpers.
- .4 Doors, drawers, tracks and back panels shall be interchangeable in the field without requiring special tools.

2.8 **DRAWERS**

- .1 Fabricate drawer fronts of 2 telescoping metal panels totally filled internally with sound-deadening material to eliminate possible drumming effect. Form removable outside panel with lip to fit over inside panel on top edge, and to lock into position at bottom with locking tabs to form a rigid, one-piece 3/4" thick drawer front.
- .2 Provide drawer operation on 1" diameter nylon wheels with steel ball bearings, with 1 wheel on drawer slide and 1 on drawer suspension track. Mechanically fix and lock drawer suspension tracks to vertical posts.
- .3 Provide built-in stops to prevent inadvertent removal of drawers, with allowance for drawer to be removed by lifting front of drawers and pulling out.
- .4 Provide flush fitting pulls on drawers.

2.9 **WALL AND FLOOR CABINET CONSTRUCTION**

- .1 Materials and Thickness: Use the following standard steel thickness for this furniture manufacturing.
 - .1 18 Ga sheet steel furniture steel for sides, top, back, bottom, false bottom, shelves and removable bases on tall storage cabinets.
 - .2 11 Ga sheet steel for leveling device brackets on floor storage cabinets only.

2.10 **COUNTERTOPS**

- .1 Countertops, General: Provide units with smooth surfaces in uniform plane, free of defects. Make exposed edges and corners straight and uniformly bevelled. Provide front and end overhang of 25 mm, with continuous drip groove on underside 13 mm from edge.

- .2 Sinks, General: Provide sizes indicated or laboratory casework manufacturer's closest standard size of equal or greater volume, as approved by Consultant.
 - .1 Outlets: Provide with strainers and tailpieces, NPS 1-1/2 (DN 40), unless otherwise indicated.
 - .2 Overflows: Where indicated, provide overflow of standard beehive or open-top design with separate strainer. Height 50 mm less than sink depth. Provide in same material as strainer.
- .3 Epoxy Countertops and Sinks:
 - .1 Countertop Fabrication: Fabricate with factory cutouts for sinks, holes for service fittings and accessories, and butt joints assembled with epoxy adhesive and concealed metal splines. White in colour.
 - .1 Countertop Configuration: As indicated.
 - .2 Countertop Construction: Uniform throughout full thickness.
- .4 Sink Fabrication: Molded in one piece with smooth surfaces, coved corners, and bottom sloped to outlet; 13-mm minimum thickness. White in colour.
 - .1 Provide with polypropylene strainers and tailpieces.
 - .2 Provide sinks for drop-in installation with 6-mm thick lip around perimeter of sink.
 - .3 Provide integral sinks in epoxy countertops, bonded to countertops with invisible joint line.
 - .4 Provide manufacturer's recommended adjustable support system for table- and cabinet-type installations.

2.11 **PEGBOARDS**

- .1 Boards: 25 mm (1") thick black epoxy.
- .2 Pegs: White polyethylene 163 mm (6.5") long x 10 mm (3/8") diameter, removable, set into predrilled holes in the face of the pegboard at a 45 degree angle. Pegboards shall be secured in place where shown on the drawings.

2.12 **STEEL FURNITURE FINISH**

- .1 Preparation and Painting
 - .1 Prepare all surface, make free of defects with welds ground smooth and indistinguishable from surrounding metal.
 - .2 Components shall be sprayed in an electro-static three-stage process with a high-temperature, high-solid (60% minimum), semi-gloss (50°), baking epoxy ester. The resulting paint coating shall provide a uniform coating on all surfaces of each component that has a minimum thickness of 1.2 mm Components shall be properly baked and cured to deliver the following performance requirements.
- .2 Colours: as selected by Consultant from manufacturer's standard selection.
- .3 Physical Performance of Coatings
 - .1 Pencil Hardness: 4H minimum per ASTM D3363
 - .2 Abrasion Resistance: 3.5 mg maximum weight loss per 100 cycles when tested on a calibrated E40101 Taber Abrasion Tester using 1000 mg wheel pressure from a CS10 wheel per ASTM D4060.

- .3 Humidity Resistance: No visible effect after a 100 hour exposure in saturated humidity at 100°F per ASTM D2247.
- .4 Moisture Resistance: No visible effect cause by 200°F +/- 5°F water trickled for 5 minutes over a test panel inclined at 45°. No visible effect caused by a 100 hour continuous application of a 70°F water soaked 2" x 3" x1" cellulose sponge that remains wet throughout the entire test period.
- .5 Salt Spray Resistance: No visible effect after a 250-hour salt spray test per ASTM B117.
- .6 Adhesion: Minimum of 100 squares retain finish after a test panel is scored into 100 squares 1/16" x 1/16" by a razor blade that cuts completely though the finish with a minimum of substrate penetration and any loose particles are removed by a soft brush per ASTM D3359, Method B.
- .7 Cold Crack: No effect cause by 10 cycles of temperature change form 20° for 60 minutes to 125°F for 60 minutes.
- .8 Adhesion and Flexibility: No peeling or cracking of finish or no metal exposure when a test sample is bent 180° once over a ¼" mandrel per ASTM D522.
- .9 Impact Resistance: No cracking of finish or metal exposure when a steel ball is dropped from a calibrated stand to deliver 100 inch pounds of impact per ASTM D2749.
- .10 Gloss: Gloss of 50 +/- 5 when the finish surface is measured at 60° reflectance per ASTM D523.
- .4 Chemical Resistance Performance
 - .1 Test panels shall withstand the following tests with no loss of adhesion or film protection, no discoloration or change in gloss, or no film softening.
 - .2 Acids: Minimum of 5 drops (0.25) shall be applied to the test site on panel and covered with a watch glass for 60 minutes, then washed and dried.
 - .1 Hydrochloric Acid 37%*, 30%, 20%, 10%
 - .2 Sulphuric Acid 70%*, 60%, 25%
 - .3 Nitric Acid 50%*, 30%, 10%
 - .4 Phosphoric Acid 75%, 25%
 - .5 Acetic Acid 98%, 50%
 - .6 Formic Acid 60%*
 - .5 Solvents: Minimum of 5 drops (0.25 ml) shall be applied to the test site on panel and covered with a watch glass for 60 minutes, then washed and dried. Volatile solvents shall be applied by a saturated cotton ball method.
 - .1 Ethyl Alcohol Butyl Alcohol
 - .2 Methyl Alcohol Ethyl Acetate
 - .3 Ethyl Ether Methylene Ketone
 - .4 Toluene Acetone
 - .5 Benzene Carbon Tetrachloride
 - .6 Formaldehyde (37%) Gasoline
 - .7 Naphtha Kerosene

- | | | |
|----|----------|-----------|
| .8 | Xylene | Glycerine |
| .9 | Furfural | Ether |
- .6 Bases and Salts: Minimum of 5 drops (0.25 ml) shall be applied to the test site on panel and covered with a watch glass for 60 minutes, then washed and dried.
- | | | |
|----|---------------------|-----------|
| .1 | Sodium Hydroxide | 40%, 10% |
| .2 | Ammonium Hydroxide | 28% |
| .3 | Potassium Hydroxide | 40%, 10% |
| .4 | Hydrogen Peroxide | 5% |
| .5 | Zinc Peroxide | Saturated |
| .6 | Sodium Sulphide | Saturated |
| .7 | Sodium Carbonate | Saturated |
| .8 | Sodium Chloride | Saturated |

2.13 **LABORATORY SERVICE FITTINGS**

- .1 Provide deck and backsplash-mounted mixing faucets, service cocks as required, including related parts and accessories from one of the following acceptable manufacturers. Fittings shall be CSA and CGA approved.
- | | |
|----|----------------|
| .1 | Delta |
| .2 | Chicago Faucet |
| .3 | T & S Bronze |
| .4 | WaterSaver |
- .2 Basis-of-Design: model numbers shown in this section are Delta and list the complete line of various service fittings.
- .3 Refer to drawings and legends for items to be supplied on project.
- .4 Materials and Fabrication
- | | |
|----|--|
| .1 | Use minimum 60% copper forging brass or 81% copper casting brass for valve bodies. Make handles and turrets of brass forgings. Use solid bar stock or specially selected alloys for assembly components and operating parts such as valve stems. Renewable seats and needle cones. |
| .2 | Completely enclose spring mechanisms. Design compression and needle valve stems to operate inside which shall be renewable for replacement. |
| .3 | Renewable seats shall be fabricated of stainless steel or brass with a "double chromium plate finish". Conical, self-centering needle valves shall be fabricated of stainless steel and/or celcon. |
| .4 | Valve bodies, handles (except three-arm Bakelite) and turrets shall be fabricated in one-piece construction from brass sand castings or brass forgings. |
| .5 | Service fitting outlets shall be mounted on turrets with lugs or projections on the bottom to lock bodies in position eliminating twisting. |

- .6 Model W6600-9 and W6700-9 Series compression valves for hot and cold water shall be sand castings or brass forgings with stems operating inside a cap nut sleeve so that all parts subject to wear may be easily replaced. 6" radius gooseneck complete with 1/4" serrated nozzle and inline vacuum breaker.
- .1 Water Faucets shall meet or exceed the following approvals and standards: CAN/CSA B125 and ANSI/ASME H112-18-1M
- .2 Vacuum Breakers (angle type) shall meet or exceed the following approvals and standards: tested and approved in conformance with ASSE Std 1001 and ANSI A112-1 and CSA B641-1.
- .3 Vacuum Breakers (in line) shall meet or exceed the following approvals and standards: ANSI/ASSE Std 1035, Lab Faucet Vacuum Breakers listed by IAPMO.
- .7 Provide fittings with wall flanges, shanks, locknuts, coupling nuts and tailpieces.
- .5 Model 54T5432A forged brass floor-mounted self-closing Foot Pedal Mixing Valve with Spout R2 Gooseneck and standard flow control aerator. Polished chrome plated, brass deck-mount flange, 3/8" IPS shank and locknut.

- .6 Maximum testing pressure and recommended operating ranges:

Valve Type	Maximum Testing Pressures
Compression	880 kPa (100 psi)
Distilled Water	414 kPa (60 psi)

Service	Recommended Operating Range
Water	345 to 552 kPa (50 to 80 psi)
Distilled Water	140 to 278 kPa (20 to 40 psi)

- .7 Colour Coded Index:

- .1 When specified, identify fittings as to type of service with colour coded plastic removable index buttons with engraved lettering filled with enamel corresponding to the following standards:
- .2 Lettering:

Service	English	French	Colour Coding
Hot Water	HW	EC	Red
Cold Water	CW	EF	Dark Green
Distilled Water	DW	ED	White
Type II Water	IIW	IIW	White
Deionized Water	DI	DI	White
Demineralized Water	DM	DM	White

2.14 **FINISHES**

- .1 Chrome finish shall be supplied as the standard finish on laboratory furniture service fittings.
- .2 Prepare surfaces for epoxy finish by a two-step procedure of immersion in phosphoric acid cleansng solution, removing foreign substances and fitting shall then be sand blasted with extra-fine grit to produce a uniform fine-grained surface.
- .3 Epoxy coating material shall be applied evenly to exposed surfaces by means of an electro-static spray method coating the surface after which fittings shall be baked at 204.4°C (400°F).

PART - 3 EXECUTION

3.1 **INSTALLATION GENERAL**

- .1 Cooperate and coordinate with Mechanical trades to ensure proper installation and/or final connections to service fixtures, sinks, or similar items. Cut necessary holes and/or openings in equipment which may be required for installation of mechanical and electrical service lines.
- .2 Fit and assemble work in shop where possible. Execute work according to details and reviewed shop drawings. Where shop fabrication is not possible, make trial assembly in shop.
- .3 Install laboratory furniture plumb with countertops level to 1.6 mm in 3000 mm.
- .4 Install components in a secure, neat, and complete installation with levelling to a tolerance of 6 mm in 3 m.
- .5 Level base cabinets by adjusting levelling screws.
- .6 Make joints to provide smooth surface, free of lips, cracks, or other defects.
- .7 Secure sink cabinets permanently to floor construction using masonry anchors or toggle bolts spaced at maximum of 750 mm o.c., minimum four for each cabinet.
- .8 After installation fit and adjust operation hardware.
- .9 Install casework plumb, true and level and anchor to floors or ceiling as required. Scribe accurately components to adjacent surfaces. Do not install any casework fixed to walls, but free standing against walls where indicated.
- .10 Provide continuous competent supervision for installation of work, which include unloading, uncrating and moving into building.

3.2 **INSTALLATION – BASE CABINETS**

- .1 Locate base cabinets accurately to accommodate all sinks where specified, set level, plumb and secure in place. For fixing components such as spring nuts, bolts and washers, galvanized finish. Install components to effect a secure, neat and complete installation.
- .2 Level floor-mounting base cabinets by adjusting leveling screws.

3.3 INSTALLATION - COUNTER TOPS

- .1 Install tops in accordance with reviewed shop drawings, securing them in position by rigid concealed fixing methods, free of movement, or rocking when completed.
- .2 Connect counter tops of similar or dissimilar materials with 6 mm x 25 mm blind spline and concealed tight-joint fasteners, level, flush with hairline joints. Fill joints with sealant. Clean sealant from exposed surfaces in a manner precluding surface damage.
- .3 Cut tops for self-rimming sinks only so large as to permit entry of sink into counter top, allowing sink rim to lay flush on top providing sufficient material for maximum support on all edges. Seal cut surfaces with black paint. Cut-outs shall be radicalized corner cuts to prevent splitting of the laminate. Angled corner cuts are unacceptable.

3.4 INSTALLATION - SINKS

- .1 Install sinks in accordance with reviewed shop drawings, securing them in position by rigid, concealed fixing methods which allows no movement or rocking on completion.
- .2 Sinks to be flush with counter top.

3.5 CLEAN-UP

- .1 Promptly as work proceeds and upon completion, clean up and remove from the site on a daily basis, all rubbish and surplus materials resulting from work under this section.
- .2 On completion, touch up marred or abraded finished surfaces.
- .3 Wipe down surfaces to remove fingerprints and marking, leave in clean condition.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 General provisions which are applicable to and govern all Sections of this Division and of Divisions 21, 22, 23 and 25.
- .2 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
- .3 The terms "Mechanical Work", "Mechanical Contractor", "Mechanical Division" or their derivatives includes all the Work of Divisions 20, 21, 22, 23 and 25 unless otherwise specified.
- .4 These Specifications are arranged generally in accordance with the specification-writing standard MasterFormat, latest edition. Sections of this Division are not intended to delegate functions or to delegate work to any specific trade.

1.2 DEFINITIONS

- .1 "Provide" means to supply and install the products and services specified.
- .2 "Work" means the total construction required by the Contract Documents, and includes all labour, products, and services.
- .3 "Products" means all material, machinery, equipment, and fixtures forming part of the completed Work as required by the Contract Documents.

1.3 INTENT

- .1 Provide all Work, including items, articles, materials, operations, and methods listed, mentioned, and scheduled in the Contract Documents. Include all labour, equipment, tools, scaffolds, and other incidentals necessary and required for the complete installation.
- .2 Consider the Specifications as an integral part of the Drawings, which accompany them. Do not use the Drawings or the Specifications alone. Consider any item or subject omitted from one, but mentioned or reasonably implied in the other, as properly and sufficiently specified and provided under the Mechanical Work.
- .3 This installation shall be made in strict accordance with the Drawings, Specifications, and all applicable codes, regulations, standards, bylaws, including the requirements of Authorities having jurisdiction, Owner's Insurer, and NFPA regulations.
- .4 All equipment and devices used shall be UL/cUL listed and/or CSA certified where applicable.
- .5 Each Contractor performing any part of the Mechanical Work is considered an expert in their field.

1.4 CODES, REGULATIONS AND STANDARDS

- .1 Comply with the requirements of the following codes, regulations and standards:
 - .1 Municipal and Provincial Regulations and/or Codes;

- .2 National Building Code in areas where Municipal or Provincial Regulations and/or Codes are not mandatory;
 - .3 Rules and Regulations of Authorities having jurisdiction;
 - .4 Occupational Health and Safety Act and Regulations for Construction Projects, Ontario Regulation 691;
 - .5 Relevant CSA Standards;
 - .6 Applicable standards of the Underwriters' Association.
 - .7 Owner's Health and Safety Requirements.
- .2 Codes, standards, and regulations referenced by these Specifications shall be the latest edition as applicable at the time of building permit application unless noted otherwise or specifically defined under the Provincial or National Building Code.
- .3 Codes, regulations and standards constitute an integral part of these Specifications. In case of conflict; codes, regulations and standards take precedence over the Contract Documents.
- .4 In no instance reduce the level of construction standard established by the Drawings and Specifications by applying any of the codes, regulations and standards referred to herein.

1.5

ABBREVIATIONS

- .1 Abbreviations with respect to government agencies, testing agencies, technical societies, and approval agencies are as listed below:
- .1 ABC Alberta Building Code
 - .2 AMCA Air Moving and Conditioning Association
 - .3 ANSI American National Standards Institute
 - .4 ARI Air Conditioning and Refrigeration Institute
 - .5 ASHRAE American Society of Heating, Refrigerating, and Air Conditioning Engineers
 - .6 ASME American Society of Mechanical Engineers
 - .7 ASTM American Society for Testing and Materials
 - .8 AWWA American Water Works Association
 - .9 CGA Canadian Gas Association
 - .10 CSA Canadian Standards Association
 - .11 FM Factory Mutual, FM Global
 - .12 IAO Insurers' Advisory Organization (CGI Information systems and Management Consultants Inc.)
 - .13 MICA Midwest Insulation Contractors Association
 - .14 NBC National Building Code
 - .15 NBFU National Board of Fire Underwriters (currently American Insurance Association)
 - .16 NEMA National Electrical Manufacturers Association
 - .17 NFPA National Fire Protection Association

- .18 OBC Ontario Building Code
- .19 SMACNA Sheet Metal and Air Conditioning Contractors National Association
- .20 TEMA Tubular Exchanger Manufacturers Association
- .21 ULC/cUL Underwriters' Laboratories of Canada

1.6 **EXAMINATION OF SITE AND CONTRACT DOCUMENTS**

- .1 Before Bid submission, visit the Site of the proposed Work and obtain all information as to existing conditions and limitations.
- .2 Examine the Specifications and all Drawings including the Specifications and Drawings of all other Divisions before commencing any portion of the Mechanical Work.
- .3 No allowance will be made for any consideration that may have been overlooked.
- .4 Unless exceptions are specifically noted at the time of Bid, the submission of a Bid confirms that the Bid Documents and site conditions are accepted without qualification.

1.7 **CONTRACT DRAWINGS AND DOCUMENTS**

- .1 The Contract Drawings are diagrammatic performance drawings; they describe the design intent, indicate general arrangement and approximate location of apparatus, fixtures, and pipe runs, but do not show the exact details for the installation. The Contract Drawings are not fabrication or installation drawings.
- .2 The Work is suitably outlined on the Drawings with regard to sizes, locations, intended arrangements, and the routing of services has been generally coordinated. The routing of ductwork and piping, and equipment arrangement represent a close approximation of the intent, except in certain cases the Drawings may include details conveying the exact locations and arrangements required.
- .3 Final and exact location of equipment and services shall be determined by the Contractor using the reviewed shop drawings together with actual site conditions. The Consultant reserves the right to make reasonable adjustment of up to 1 m to the location of equipment, fixtures, routing of major piping and ductwork, at no additional cost to the Owner.
- .4 In order to depict a clear arrangement of the Work, plans and sections do not show each valve, thermometer, pressure gauge and other accessories. Refer to schematic Drawings, to standard details and to the Specification for these requirements.
- .5 Where specific installation dimensions for the location of equipment and access space requirements are indicated on the Drawings, the installation shall adhere to these requirements.
- .6 Standard details show the general installation requirements, and are applicable to each occurrence in the Work, unless otherwise specified or shown.
- .7 Do not scale Drawings; obtain information involving accurate dimensions to structure from dimensions shown on architectural and structural drawings, or by site measurements. Consult general construction Drawings as well as detail drawings to become familiar with all conditions affecting the Mechanical Work and verify spaces in which the Work will be installed.

1.8 **PERMITS AND INSPECTIONS**

- .1 Apply for, obtain, and pay for all permits, licenses, inspections, examinations, and fees required.

- .2 Material approvals
 - .1 Obtain special inspection and approvals by CSA and/or local authorities, for materials where specified.
 - .2 Obtain such approval for the particular installation with the co-operation of the material supplier.
- .3 Permits
 - .1 Before starting any work, obtain the required number of copies of Drawings and Specifications from the Consultant for submission with application for permits. Submit all documents to the Authorities for their approval and comments. Comply with any changes requested as part of the Work, but notify the Owner immediately in writing of such changes for proper processing of these requirements. Prepare and furnish any additional drawings, details or information as may be required.
- .4 Inspections
 - .1 Arrange for inspection of all Work by the Authorities having jurisdiction over the Work. On completion of the Work, present to the Owner the final unconditional certificate of approval of the Inspection Authorities.
 - .2 Arrange, provide documentation, and pay for registration and inspection of the following systems and equipment:
 - .1 Plumbing and drainage
 - .2 HVAC
 - .3 Fire suppression including sprinkler and standpipe
 - .4 Pressure vessels
 - .5 Pressure piping and boilers
 - .6 Electrical installation
 - .7 Natural and propane gas piping
 - .8 Steam piping

1.9 **CONTRACTOR COORDINATION RESPONSIBILITIES**

- .1 Provide the services of a mechanical/electrical coordination supervisor, to coordinate the Mechanical Work, as well as providing coordination with Contractors of other Divisions. This supervisor may be full time or part time on site, as appropriate for the work stage and complexity of the Work, at the discretion of the Owner.
- .2 Where multiple Subcontractors are required to execute the Mechanical Work, the mechanical coordinating supervisor shall be the lead coordinator.
- .3 The Owner reserves the right to require the coordinating supervisor to increase their attendance at the Site, at no cost to the Owner, if in the Owner's opinion, the current level of coordination is insufficient for the progress of the Work.
- .4 Make changes and modifications to location and routing of equipment and services as necessary to ensure that the installation of the Mechanical Work is coordinated, to avoid interference and conflicts with the Work performed by Contractors of other Divisions while maintaining the design intent.

- .5 Make, at no additional cost to the Owner, all changes or additions to materials and/or equipment necessary to accommodate structural conditions such as runs around beams or columns.
- .6 The arrangement and layout of equipment and systems shown on the Contract Drawings is based on the requirements of one manufacturer for each equipment type. The installation on Site shall follow each manufacturer's installation requirements for the specific equipment supplied by the Contractor.

1.10 **INSTALLATION, INTERFERENCE AND FABRICATION DRAWINGS**

- .1 Coordinate Mechanical Work such that items will properly interface with the Work performed by Contractors of other Divisions.
- .2 Architectural Drawings, or in their absence, Mechanical Drawings govern all equipment and service locations.
- .3 Prepare dimensioned installation, interference and fabrication drawings, coordinated with the Contractors of other Divisions as required.
- .4 Provide sufficient details highlighting critical interferences of major equipment and services to ensure adequate accessibility.
- .5 Maintain specific dimensions for equipment location or access which are shown on the Consultant's Drawings.
- .6 Indicate sleeves, the size and locations of all openings required in concrete floor slabs, roof slabs/decks and walls for piping, ductwork and equipment, and stress points such as anchors, guides and inserts. Any additional cost incurred due to omitting to provide this information in advance of construction of these structural elements (the concrete is poured) shall be at the expense of this Contractor.
- .7 Prepare drawings of pump pits, equipment bases, anchors, inertia slabs, floor and roof curbs pertaining to the Mechanical Work. Base drawings upon reviewed Shop Drawings. Indicate all loads transferred to the structure.
- .8 Prepare installation drawings to maximum 1:50 scale for mechanical rooms showing plan and sections of the plant, services, bases, curbs, drains, motor terminals.
- .9 Prepare interference drawings for shafts, ceiling spaces, typical floors and wherever there is a possible conflict between the positioning of mechanical equipment, piping or ductwork, and architectural or structural features or the Work of Contractors of other Divisions
- .10 Before fabricating ductwork or piping for installation, make certain that such items can be installed as shown on the Drawings without interfering with the structure or the Work of Contractors of other Divisions. Problems that cannot be solved in agreement with the Contractors of other Divisions affected, shall be submitted for decision to the Consultant. If ductwork or piping is prefabricated prior to this investigation and reaching of a solution to possible interference problems, necessary changes to such prefabricated items shall be made at no additional cost to the Owner.
- .11 Indicate deviation in size and weight, and deviation in requirements for water, drainage, electric power or other service connection requirements for all equipment proposed, from the requirements show on the Contract Drawings.
- .12 The design of the structural framing of mechanical rooms, pipe spaces and major pipe run supports has been based on loads estimated using the pipe and equipment layout prepared by the Consultant. In advance of the construction of affected areas, prepare and

submit drawings for review by the Consultant showing the proposed layout and weights of actual selected mechanical equipment. Include details of concrete pads, concentrated pipe loads and point reactions of the equipment onto the structure.

- .13 Provide installation, interference and fabrication drawings to Contractors of other Divisions for coordination with their Work.
- .14 Update installation, interference and fabrication drawings as part of the record drawings, showing actual location of major equipment, services, access doors, shut-off valves.
- .15 The installation, interference and fabrication drawings are not to be submitted as shop drawings. Make them available for viewing at site when requested by the Consultant.

1.11 **REVIEW BEFORE PROCEEDING (HOLD)**

- .1 Where the word "HOLD" appears on Drawings and other Contract Documents, the Work is included in the Contract.
- .2 Execute such Work only after verification of dimensions, verification of materials and obtaining Consultant's written permission to proceed.

1.12 **MEASUREMENTS AND DEVIATIONS**

- .1 Where any part of the Mechanical Work is specifically located by dimensions on the Drawings, check and verify these dimensions on the Site prior to installation.
- .2 Where site conditions require minor deviations from indicated arrangements or locations, make such changes upon approval by the Consultant without additional cost to the Owner.
- .3 If a substantial interference or existing, unforeseen condition is encountered during the installation of the Mechanical Work that necessitates a major revision to the Mechanical Work or the Work of Contractors of other Divisions, notify the Consultant immediately and obtain written authorization before proceeding with the Work.

1.13 **PROVISION FOR FUTURE**

- .1 Where a space is indicated as reserved for future equipment or services, leave the identified space clear and install piping, ductwork and equipment in such manner that future connections can be made without dismantling the existing piping, ductwork and equipment, and without removing existing floors, walls and ceilings.

1.14 **EQUIPMENT NOT IN CONTRACT**

- .1 Supplied By Owner equipment:
 - .1 The Contractor of Division 01 will receive, check, store and be responsible for this equipment.
 - .2 The Contractor of Division 01 will unpack and assemble this equipment at its final location.
 - .3 Connect the required Mechanical services per the equipment manufacturer's installation instructions.
- .2 Existing Relocated equipment:
 - .1 Equipment shown as relocated on the Mechanical Drawings shall be relocated by the Mechanical Contractor unless otherwise noted.

- .2 Where equipment is shown as relocated under the Work performed by Contractors of other Divisions, disconnect and reconnect the associated Mechanical services to accommodate the new location for this equipment.

1.15 **SUBMITTALS**

- .1 Submit shop drawings in accordance with Section 01 33 00 – Submittal Procedures.
- .2 Assume responsibility for accuracy of equipment dimensions related to available space and accessibility for maintenance and service, and for compliance with code and inspection authority requirements.
- .3 Shop drawings showing more than one size or model will not be considered unless the exact model and options to be provided are clearly marked.
- .4 Shop drawings shall be certified by the manufacturers as ready for construction.
- .5 Identify equipment shop drawings with designations (tags) as shown on the Drawings or in the Specifications.
- .6 For all equipment, include the following:
 - .1 Manufacturer's name and model number.
 - .2 Equipment dimensions and weights.
 - .3 Itemized product description with optional items clearly marked as being included.
 - .4 Time required to fabricate and to deliver.
 - .5 All variations from Contract Documents.
 - .6 Field connection details
- .7 Clearly indicate the materials and/or equipment being supplied:
 - .1 Details of construction, finish, accurate dimensions, capacities and performance.
- .8 For electrically driven and fuel fired appliances, provide the following information:
 - .1 Electrical characteristics including voltage, phase, frequency and power rating. Provide maximum overcurrent protection requirement.
 - .2 For motors: NEMA rating, class and efficiency ratings. Indicate whether the motor is rated for use with variable frequency drives.
 - .3 Fuel input ratings, including flow rates and pressures.
 - .4 Equipment performance ratings, including flow rates, pressures, efficiencies, part load values and/or efficiencies (IPLVs), plotted flow characteristics (pump and fan curves) with operating points clearly marked.
- .9 For other equipment include the following information:
 - .1 Equipment performance ratings, including flow rates, pressures drops.
 - .2 Electrical control power requirements
- .10 Provide wiring shop drawings:
 - .1 Wiring diagrams and schematics for all equipment which has electrical controls or devices furnished with the equipment.

- .2 Wiring diagrams alone are not sufficient; schematic and interconnecting drawings, sequence of operation of equipment are also required for review.
 - .11 The Consultant's review shall not relieve the Contractor from responsibility for deviations from the Consultant's Drawings and Specifications, unless he has in writing, called the Consultant's attention to such deviations at the time of the submission. The Consultant's review shall be construed to only apply to general arrangement and shall not relieve the Contractor from the entire responsibility for correctness of details and dimensions. Any fabrication, erection, setting out or other work done in advance of the receipt of stamped shop drawings shall be done entirely at the Contractor's risk.
- 1.16 **'AS-BUILT' RECORD DRAWINGS**
- .1 Submit as-built drawings in printed and electronic (AutoCAD) format in accordance with Section 01 77 00 - Contract Closeout.
 - .2 Maintain a printed set of Contract Drawings on site and record all deviations from the Contract Documents. Recording shall be done on the same day a deviation was made.
 - .3 Prepare as-built drawings showing the following:
 - .1 Inverts of all services entering and leaving the building, and at property lines.
 - .2 Dimensions of underground services in relation to building lines at key points of every run.
 - .3 Elevations of underground services in relation to finished Ground floor level of the building.
 - .4 Dimensioned location of all services embedded in the structure.
 - .5 Dimensioned location of all services left for future Work.
 - .6 Diagram of interconnecting services between items of equipment including equipment supplied by Owner and under the scope of other Divisions.
 - .7 All Addendum changes.
 - .8 All changes to the Work due to Change Orders.
 - .9 All changes to the Work during construction.
 - .10 Location and designation of all electrically supervised valves, and smoke, fire/smoke and motorized dampers.
 - .11 Location and designation of all items requiring access or service in a hidden location.
 - .12 All changes to Specifications, details and equipment schedules.
 - .13 All duct traverse points and associated airflow rates as reported in final Air Balancing reports.
 - .4 Obtain one set of AutoCAD drawing files from the Consultant and transfer all as-built information from the printed set to the AutoCAD files at the completion of construction. Note that the Consultant's AutoCAD drawing files are copyrighted and may not be used for any other purpose other than that described above. The drawing files shall be provided solely to assist the Contractor in the preparation of as-built drawings. The Consultant assumes no liability for any errors, omissions, incomplete information, incorporation of latest changes, or other instructions. While the Consultant takes precautions to ensure that no computer virus is transmitted, scanning for viruses upon receipt is recommended.

- .5 Identify each as-built drawing as final for this purpose. Remove any reference to the Consultant such as Consultant's name, company logo and professional seal.

- .6 Prior to Testing, Adjusting and Balancing (TAB) and commissioning, provide printed copies of all current as-built drawings to the Contractors performing the Testing and Balancing Work (TAB Contractor) and to the Commissioning Agent.

1.17 **INSTALLATION AND START-UP INSTRUCTIONS**

- .1 Submit installation instructions and start-up instructions for all equipment in accordance with Section 01 33 00 – Submittal Procedures.

1.18 **OPERATING AND MAINTENANCE MANUALS**

- .1 Submit operating and maintenance manuals in accordance with Section 01 77 00 - Contract Closeout.

- .2 In addition, include the following in the manuals:

- .1 Non-dimensional layout showing location of all electrical devices on mechanical equipment.
- .2 Operating instructions, including start-up and shut-down procedure.
- .3 Lubricating instructions and recommended cycle of lubrication for each equipment, including various types of lubricants.
- .4 List of spare parts.
- .5 For refrigeration equipment:
 - .1 Operating instructions detailing the procedures to be followed for:
 - .1 Charging
 - .2 Changeover from one season to another
 - .3 Night operation
 - .4 Maintenance
 - .2 List of safety devices and instructions for their testing and adjusting.
 - .3 Control sequence with description of the sequences of operation.
 - .4 Detailed layout and sections indicating all maintenance, cleaning and lubrication points.
 - .5 List of parts (bill of material) indicating the catalogue number and manufacturer, complete with drawings indicating the location of each part in the complete assembly.
 - .6 Recommended chemical analysis of chilled water.
- .6 For heat exchangers and coils:
 - .1 Equipment layout (plans and section) giving all information on type of flanges, bolts, nuts, studs, tubes.
 - .2 Tube replacement instructions.
 - .3 Cleaning instructions.
- .7 For pumps and fans for each different type and size:
 - .1 List of parts indicating the catalogue number and manufacturer, complete

- with drawings indicating the location of each part in the complete assembly.
- .2 Performance curves.
- .8 For valves and fittings:
 - .1 Three (3) copies of framed valve charts for the project.
 - .2 A list of valves as per the valve chart indicating size, type, catalogue number, make of each valve, strainer and steam trap.
- .9 For instrumentation and control equipment:
 - .1 Complete instrument list for all gauges, thermometers, gauge glasses and other instruments.
 - .2 Sequence and description of operation for each control system.
 - .3 Control diagram for each system complete with equipment summary giving system designation and catalogue number for each component.
 - .4 Overall system electrical power supply schematic indicating source of electrical power for each system component. Indicate all battery backup provisions.
 - .5 Catalogue leaflet of each component used.
 - .6 Applications programming information and programmer's manual.
 - .7 Description of operating procedures, including required actions at each operator position, operation of computer peripherals, input and output formats and procedures, and emergency alarm and failure recovery procedures. Descriptions of system start-up, back-up equipment operation, and execution of all system functions and operating modes shall be provided.
 - .8 Description of manual override operation of all control points in system.
 - .9 Programming manual or set of manuals with description of programming language and of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
 - .10 Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
 - .11 Provide description of data communication, including data types and formats, data link components and interfaces, and operator test.
 - .12 Documentation of all programs created using custom programming language, including setpoints, tuning parameters, compilers and object database.
 - .13 Graphic files, programs, and database on electronic media.
 - .14 Complete original original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
 - .15 Instructions and schedules for inspections, cleaning, lubricating and calibration.

- .16 Lists of ordinary and special tools, operating materials supplies and test equipment recommended for operation and servicing.
- .10 For water treatment systems:
 - .1 Schematic drawings, data sheets for equipment, and step by step instructions for testing procedures, Material Safety Data Sheets for each chemical and testing reagent.
- .11 For medical gas and laboratory gas systems:
 - .1 Equipment list identifying components used in each system.
 - .2 Equipment manufacturer's names and addresses.
 - .3 Wiring diagrams of alarms and electrical components.
 - .4 Detailed drawings of equipment and components.
 - .5 Manufacturer's service manuals, including warranty for equipment.
 - .6 Valve schedule listing valves in system with location.
 - .7 Completed certification report forms.
 - .8 As-built drawings as reviewed by Consultant
 - .9 Canadian Registration Numbers (CRN) for components and fittings.
- .12 For other equipment:
 - .1 Description of start-up and activating procedures, commissioning procedures, as well as follow-up instructions to the Owner's operating staff to slowly break-in each unit.
 - .2 Maintenance instructions for all other equipment containing moving parts, requiring lubrication or chemical charging.
 - .3 Include a list of parts indicating catalogue number and manufacturer, complete with drawings indicating the location of each part in the complete assembly, and performance curves.
- .13 A list of all motors serving mechanical equipment. The list shall include:
 - .1 Location of motors.
 - .2 Name of unit served by each motor.
 - .3 Motor serial number, manufacturer.
 - .4 Power rating, voltage, full load current, service factor and rpm of motor (nameplate data), rating and catalogue number of motor starter thermal overload relays.
 - .5 Serial number, rpm, airflow, manufacturer, static pressure (or head) of fan or pump.
 - .6 Quantity, sizes and V-belt number of belts.
 - .7 Sizes and types of drives used.
 - .8 Type of oil or grease lubrication of gearbox, lubrication interval in hours of operation.
 - .9 Type of grease lubrication for driven equipment, lubrication interval in hours of operation.

- .14 A copy of the following:
 - .1 All reviewed sprinkler layouts and hydraulic calculations.
 - .2 Certificates from all equipment manufacturers, duct-cleaning specialist, pipe-cleaning specialist, chemical treatment specialist and local authorities having jurisdiction.
 - .3 All pipe and duct pressure test reports.
 - .4 Domestic water supply systems disinfection reports.
 - .5 Warranties and letters of guarantee from contractors and equipment manufacturers.
 - .6 Copies of permits, licenses and certificates.
 - .7 Start-up and activation and commissioning procedures and check sheets.
 - .3 All the above applies to component parts of equipment whether they are manufactured by the supplier of the equipment or are supplied as a component part of an equipment.
- 1.19 **CLEANING, TESTING AND APPROVAL RECORDS**
- .1 Maintain records of all pressure tests and flushing and sterilization tests, glycol/water concentrations, inspections and approvals by the Plumbing Inspector.
 - .2 Upon completion of each test and cleaning operation, forward a copy of each record to the Consultant for review.
 - .3 Forward the reviewed records to the Owner upon completion of the Work in accordance with Section 01 33 00 – Submittal Procedures.
- 1.20 **DIMENSIONS AND QUANTITIES**
- .1 Dimensions
 - .1 Dimensions shown on Drawings are approximate.
 - .2 Verify dimensions by reference to shop drawings and field measurement.
 - .2 Quantities
 - .1 Quantities or lengths indicated in any of the Contract Documents are approximate only and shall not be held to gauge or limit the Work.
- 1.21 **QUALIFICATIONS**
- .1 Tradesmen shall hold certification of applicable trades:
 - .1 Construction Millwright, O.Reg. 1048
 - .2 Electrician, O.Reg. 1051
 - .3 Plumber, O.Reg. 1073
 - .4 Refrigeration and air-conditioning mechanic, O.Reg. 75/05
 - .5 Sheet metal worker, O.Reg. 1077
 - .6 Sprinkler and fire protection installer, O.Reg. 1078
 - .7 Steamfitter, O.Reg. 1079

- .2 Requirements
 - .1 Trade workers shall have a Certificate of Qualification as Journeyman or Apprentice Registration for the province where the work is performed or an Interprovincial Certificate.
 - .2 Ratio of journeyman to apprentice shall not to exceed the defined ratio in the Apprenticeship Act of Ontario.
 - .3 On award of Contract, submit a list of trade journeyman and apprentices, together with their Certificate and Registration numbers.
 - .4 Certificates and Registration shall be provided to the Consultant on request.
 - .5 Maintain on-site an up-to-date record listing journeyman and apprentices working on site.
- .3 Technical Standards and Safety Authority Act 2000
 - .1 Manufacturers and installers of regulated pressure piping parts and systems regulated shall hold certificates of authorization under Boilers and Pressure Vessels O.Reg. 220/01, for:
 - .1 Pressure piping systems, CSA B51 Boiler, Pressure Vessel and Pressure Piping Code;
 - .2 Refrigeration piping systems, CSA B52 Mechanical Refrigeration Code.
 - .2 Installers shall hold certificates of authorization made under Fuel Industry Certificates O.Reg.215/01 for:
 - .1 Gaseous Fuels, O.Reg. 212/01;
 - .2 Propane Storage and Handling, O.Reg. 211/01;
 - .3 Fuel Oil, O.Reg. 213/01;
 - .4 Compressed Natural Gas, O.Reg. 214/01.

PART - 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- .1 Use new materials and equipment, free from defects impairing strength and durability, as specified or specified equivalent.
- .2 Material and equipment shall be of Canadian manufacture wherever possible, and labelled or listed as required by applicable Codes and/or have special approval of the inspection authority having jurisdiction for their respective functions and environments.
- .3 Provide products of same manufacture for similar applications unless noted otherwise.
- .4 Design of the mechanical systems is based on the listed supplier and/or model number/size stated on the equipment schedules and in the Specifications. Bear all costs due to physical or performance differences between stated equipment and proposed equipment. These differences may include but are not limited to physical size, layout, arrangement, connection size, location and/or quantity of connections, or performance differences such as noise, power requirements, flow, throw.

2.2 ALTERNATES AND SUBSTITUTIONS

- .1 Substitute products will only be considered when tendered products become unobtainable.

- .2 Provide detailed specifications and Shop Drawings with complete performance characteristics of the proposed alternate with the submission to the Consultant.
- .3 Assume responsibility and pay for any additional installation cost incurred by the Contractors of all other Divisions resulting from the substitution.

2.3 **EQUIPMENT AND STRUCTURE COORDINATION**

- .1 Locations and dimensions of curbs, roof and floor openings, where indicated on the Drawings, are based on the equipment used as basis for design.
- .2 Verify the actual size requirements for all curbs and openings. Notify the Consultant immediately if the dimensions of curbs and openings required for the unit supplied and for the connecting ductwork/piping differ from the dimensions given on the Drawings.
- .3 Bear all costs of required curb or floor/roof opening modifications resulting from a failure to notify the Consultant prior to fabrication or construction of curbs and framing.

2.4 **STANDARD SPECIFICATIONS**

- .1 Ensure that the chemical and physical properties, design, performance characteristics and methods of construction of all products provided comply with the latest issue of applicable Standard Specifications issued by the authorities having jurisdiction.
- .2 Do not apply such Standard Specifications to decrease the quality of workmanship, products and services required by the Contract Documents.

2.5 **MANUFACTURER'S NAMEPLATES**

- .1 Metal nameplates
 - .1 Provided with raised or recessed lettering, on each piece of equipment.
 - .2 Mechanically fasten nameplate on a metal stand-off bracket arranged to clear insulation.
 - .3 Mount on the same stand used for ULC and/or CSA registration plates.
- .2 Nameplate data to indicate:
 - .1 Size
 - .2 Capacity
 - .3 Equipment model
 - .4 Manufacturer's name
 - .5 Serial number
 - .6 Voltage
 - .7 Cycle
 - .8 Phase and power of motors

PART - 3 EXECUTION

3.1 **CONSTRUCTION REVIEW**

- .1 The construction review will include milestone and periodic reviews.

- .2 Milestone Reviews:
 - .1 Specific milestone reviews will be performed by the Consultant to ascertain reasonable conformity with the Contract Drawings and Specifications, and the applicable Municipal, Provincial and Federal Codes and Standards. Milestone reviews may include the following:
 - .1 Buried drainage
 - .2 Before installation of roofing membrane
 - .3 Before closure of service shafts and pipe chases
 - .4 Before closure of walls
 - .5 Before closure of ceilings
 - .6 Equipment Demonstration and Training
 - .7 Substantial Performance and Deficiency Review
 - .8 Total Performance
 - .2 Reviews will include portions of the Mechanical Work which may be concealed. If the Work is enclosed prior the Consultant reviewed the installation, the Consultant may direct the Contractor to expose the Work for it to be examined, at no additional cost to the Owner including rework affecting the Work of Contractors of other Divisions.
 - .3 If deficiencies are noted during any review related to Work that will be enclosed, correct noted deficiencies and have them reviewed by the Consultant prior to the Work being enclosed.
 - .4 Provide a minimum of seven (7) calendar days written notice to the Consultant when requesting a review date.
 - .5 The Consultant will provide a check-list to the Contractor of required milestone reviews which must be completed. Maintain this list on Site along with identified test reports, and make available for Consultant's review when requested. When completed, include this checklist form with the Test Reports forms specified in Section 20 05 83 - Start-Up and Performance Testing.
- .3 Periodic Reviews
 - .1 The Consultant will conduct periodic reviews as required for the project. These reviews are for the benefit of the Owner to describe the progress and workmanship of the Mechanical Work, and are not intended as any form of quality assurance for the Contractor. The Consultant is not responsible for quality control. The Contractor shall perform their own quality control and will be responsible for the execution of the Work in conformity with the Contract Documents and with the requirements of authorities.
 - .2 Deficiencies will generally not be reported as part of this review, as the work has not been reported by the Contractor as being complete. However, deficiencies may be reported where it may not be possible to correct the work at a later date, or without a great expense.
 - .3 The Contractor shall not rely on these periodic reviews to identify deficiencies during the progress of the Work.

.4 Deficiency Review

- .1 The Consultant will conduct a deficiency review only after the Contractor submits an application for Substantial Performance. As part of this application, the Contractor shall submit their own comprehensive deficiency list of incomplete or incorrect work. Failure by the Contractor to list any deficiency does not relieve the Contractor from correcting or completing the Work.
- .2 The Consultant shall review the Work and any deficiencies noted will be classified as Major or Minor.
 - .1 Major deficiencies are required to be corrected as part of obtaining Substantial Performance.
 - .2 Minor deficiencies, as long they are not related to life safety systems and do not affect the occupancy of the Site in any way, may be corrected after Substantial Performance.

.5 Final Review

- .1 The Consultant will conduct a final review only after the Contractor submits a declaration that all of the following has been completed:
 - .1 Noted deficiencies have been corrected,
 - .2 Final Record Drawings have been submitted to the Owner,
 - .3 Final Operating and Maintenance Manuals have been submitted to the Owner,
 - .4 All systems have been balanced, tested, commissioned and are operational,
 - .5 The Owner has been instructed in the operation and maintenance of all equipment,
 - .6 All tags and nameplates are in place and all data submitted and reviewed,
 - .7 Cleaning up is finished in all respects,
 - .8 All spare parts and replacement parts specified have been provided,
 - .9 Final test reports, including alternate season tests have been submitted to the Owner.
- .2 The Consultant will only review the deficiency list to confirm that these deficiencies have been corrected.

3.2 **ADJUSTMENT AND OPERATION OF SYSTEMS**

- .1 When the Work is complete, adjust equipment of the various systems for proper operation within the framework of the design intent and the operating characteristics as published by the equipment manufacturers.
- .2 The Consultant reserves the right to require the services of an authorized representative of manufacturers in the event any equipment is not adjusted properly.
 - .1 Arrange for such services and pay all costs thereof.
 - .2 After completion of adjustments, place systems in full operating condition and advise the Consultant that the Work is ready for acceptance.

3.3 **MANUFACTURER'S CERTIFICATION**

- .1 Submit letters from the manufacturers of all equipment certifying that their technical representatives have inspected and tested their equipment, and have approved the methods of installation and operation. Where existing systems are extended, provide letters covering both the new and existing equipment and connections.
- .2 These letters shall state the names of persons present at the inspection and testing, methods used and a list of functions performed with location and room numbers where applicable.
- .3 Refer to the respective equipment Specification Sections for specific requirements for these letters.

3.4 **ACCEPTANCE**

- .1 After all equipment has been installed, adjusted and all systems balanced:
 - .1 Conduct performance tests in the presence of the Consultant, the Commissioning Agent and the Owner.
 - .2 Arrange a time for these tests at the convenience of the Consultant, the Commissioning Agent and the Owner.
 - .3 Conduct tests under climatic conditions that will ensure a complete and comprehensive test for all systems involved, and in a manner and for duration as the Consultant may deem necessary.
- .2 During these tests:
 - .1 Demonstrate the correct performance of all equipment and of the systems they comprise.
 - .2 Should any system or equipment fail to function as required, make changes, adjustments or replacements necessary to meet the performance requirements.
 - .3 Repeat the tests until all requirements have been fully satisfied and all systems have been accepted by the Consultant.

3.5 **COORDINATION WITH TESTING, ADJUSTING AND BALANCING WORK**

- .1 Review with the Contractor performing the Testing, Adjusting and Balancing Work (TAB Contractor) prior to fabrication:
 - .1 Location of balancing devices
 - .2 Location of test connections
 - .3 Location of access openings
- .2 Report conditions which could affect optimum system performance.
- .3 Inspection:
 - .1 Ensure that all testing, balancing and metering devices are installed properly at the preselected locations, and are fully operational.
 - .2 Report any errors to the Consultant.
 - .3 Obtain the approval from the Contractor performing the TAB Work before relocating these devices due to field conditions.

- .4 Coordination with the TAB Contractor:
 - .1 The TAB Contractor will give adequate prior notification in case the services of any tradesmen is requested.
 - .2 Coordinate efforts so that items requiring replacement or having longer delivery time (sheaves, motors) are tested as early as possible.
 - .3 Schedule sufficient time so that the initial TAB Work can be completed before occupancy begins and coordinate with all Subcontractors involved.
 - .4 Keep the TAB Contractor informed of any major change made during the construction and provide the TAB Contractor with a set of Record Drawings and reviewed Shop Drawings.
 - .5 Provide balancing devices, test connections access openings, balancing probe inlets and plugs.
 - .6 Clean and pre-run all equipment, change filters, and place all heating, ventilating and air conditioning systems into full operation for each working day of the TAB Work.
 - .7 Provide immediate labour from pertinent mechanical Subcontractors, and all tools, equipment and materials to make required equipment and system alterations and adjustments as the TAB Work progresses, including control adjustments.
 - .8 Make available all equipment data (Shop Drawing performance data and Operating Instructions) to the TAB Contractor.
 - .9 As part of the coordination effort, be fully responsible for all Mechanical systems constructed, installed and adjusted to provide optimum performance as required by the design intent. Any re-adjusting required as the result of spot checks by the Consultant shall be done at no increase to the Contract Price.
 - .10 No Work assigned in this Article voids the responsibility of the Mechanical Contractor for the Mechanical systems constructed, installed and adjusted to achieve the design intent.

3.6 **INSTRUCTION TO OWNER**

- .1 Instruct the Owner's personnel in all aspects of the operation of systems and equipment. Refer to requirements for demonstration in the respective equipment sections.
- .2 Arrange and pay for the services of equipment manufacturers' technical representatives required for the instruction on specialized portions of the installation.
- .3 Submit to the Consultant at the time of final inspection a complete list of systems, stating for each system:
 - .1 Date when instructions were given to the Owner's personnel;
 - .2 Duration of instruction;
 - .3 Names of personnel instructed;
 - .4 Other parties present (manufacturers' representatives, Consultant);
 - .5 Signatures of the Owner's personnel stating that they properly understood the system installation, operation and maintenance requirements.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
 - .2 Articles that are of a general nature, applicable to each Section of Divisions 20, 21, 22, and 23.
- .2 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.
 - .3 Installation of access doors on walls and ceilings: Section 09 21 16 - Gypsum Board Assemblies
 - .4 Concrete curbs: Section 03 30 00 – Cast-in-place Concrete
 - .5 Duct access doors: Section 23 33 00 – Duct Accessories

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 – Submittal Procedures.
 - .2 Submit product data for all products described in this Section of the Specification. Submittal shall include dimensions, weights, capacities, ratings, electrical characteristics, metal gauges, finishes of materials, and construction details.
 - .3 Submit detailed and coordinated drawings showing location and type of all access doors.
 - .4 Submit fire stopping shop drawings, including ULC/cUL listing number, installation drawings for each type of penetration and description of installation materials.
 - .5 Submit results of electromagnetic scans and x-rays.
 - .6 Submit link seal schedule showing location, service, inside diameter of wall opening, sleeve length and pipe outside diameter for each instance.
 - .7 Submit shop drawings for steel work prepared by a licensed Professional Engineers.

1.3 MATERIALS AND EQUIPMENT

- .1 Use only new materials and equipment of manufacture as specified or shown on the Drawings. Ensure that equipment and materials for similar applications are of the same manufacturer.
- .2 If the Contractor wishes to substitute materials of manufacturers other than those listed for specific products, the name of the alternate manufacturer and a complete description of the materials to be substituted shall be listed in the Contractor's Tender submission, along with the amount representing the adjustment to the Bid price.

- .3 Ensure that materials not specified to a specific manufacture are of high commercial standard and quality.

1.4 **REFERENCE STANDARDS**

- .1 ASTM A53/A53M - Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
- .2 ASTM A269 - Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
- .3 ASTM A307 - Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
- .4 ASTM A780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
- .5 ASTM E84 / UL 723 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- .6 CAN/CSA-G40.20/G40.21 - General Requirements for Rolled or Welded Structural Quality Steel.
- .7 CAN/CSA-G164 - Hot Dip Galvanizing of Irregularly Shaped Articles.
- .8 CAN/CSA-S16.1 - Limit States Design of Steel Structures.
- .9 CSA W59 - Welded Steel Construction (Metal Arc Welding).
- .10 CAN/ULC-S115 - Fire Tests of Fire stop Systems

PART - 2 PRODUCTS

2.1 **ACCESS DOORS AND PANELS**

- .1 General service access doors shall be constructed of steel, prime coated as follows:
 - .1 Minimum sizes:
 - .1 600 mm x 600 mm for personnel entry.
 - .2 300 mm x 450 mm for hand entry.
 - .3 Sized to suit equipment maintenance access requirements.
 - .2 In plaster, gypsum board, tiled or masonry walls for exposed flush installation, 1.6 mm access door with 1.2 mm mounting frame, continuous concealed hinge.
 - .3 In plaster or tiled walls for recessed installation, 1.6 mm access door recessed by 25mm with 2.1 mm mounting frame, concealed pivoting rod type hinge.
 - .4 In areas not accessible by public, 1.6 mm access door recessed by 25mm with 2.1 mm mounting frame with drywall taping bead on all sides, concealed pivoting rod type hinge, and flush-to-surface screwdriver operated stainless steel cam latch.
 - .5 In areas finished with tile or marble surfaces provide doors constructed of stainless steel.
 - .6 In damp and high humidity areas provide doors constructed of stainless steel with neoprene gasket.
 - .7 Access doors shall be fitted with screwdriver operated stainless steel latches, except in areas subject to security risks (public corridors, psychiatric patient areas,

public washrooms). In these areas doors shall be fitted with keyed cylinder locks with similar keys.

- .8 For fire rated walls, provide 1.6 mm rated access door, ULC listed "B" label for 1-1/2 or 2 hours. Door shall be complete with 1.6 mm mounting frame, concealed hinge, spring closer, and knurled knob operated universal self-latching bolt.

- .9 Standard of Acceptance

- .1 Acudor
- .2 Mifab
- .3 Nystrom
- .4 Cendrex
- .5 Milcor
- .6 Williams Brothers

- .2 In gypsum board surfaces in public areas, provide architectural access door with concealed hardware and gypsum board inlay. Standard features shall include cam latch flush with surface, aluminum frame and glass fibre-reinforced nylon hardware, fully hinged removable door panel and integrated safety catches, perimeter gasket installed onsite. Size access doors as required based on service and use.

- .1 Standard of Acceptance

- .1 Access Panel Solutions, bauco plus series

2.2 DRAIN VALVES

- .1 Drain valves shall be 20 mm for piping up to and including 75mm, and minimum 50mm for larger piping; straight pattern bronze with hose end male thread, cap and chain.

2.3 V-BELT DRIVES

- .1 Provide a V-belt drive for each motor driven device which is not direct connected, designed for at least 130 percent of the motor nameplate power rating. Keep overhung loads on prime mover shafts within manufacturer's design guidelines. Belt drives to be at least 95 percent efficient. Select belts to suit starting torque for driver. Use single belt drives only for motors 1.5 kW and smaller.
- .2 Sheaves shall be cast iron construction with machined grooves. Sheaves 75 mm size and larger diameter shall have taper lock bushings. Use matched sets on multi-belt drives. Statically and dynamically balance all sheaves as an operating unit.
- .3 Sheaves for motors up to 7.5 kW with not more than two belts shall be:
 - .1 Cast iron or steel, secured to shafts with removable keys;
 - .2 Adjustable pitch type on motor, fixed pitch type on driven device, giving plus or minus 10% speed range;
 - .3 Selected to meet specified operating condition at mid position in pitch adjustment.
- .4 Sheaves for motors over 7.5 kW or drives with three or more belts shall be:
 - .1 Cast iron or steel with split tapered bushing and keyway;
 - .2 Fixed pitch.

- .5 Belts shall be:
 - .1 Matched sets of 'b' section, selected for service factor of 2.0 based on installed motor horsepower;
 - .2 Capable of carrying load with one belt broken.
- .6 Motor slide rails shall include:
 - .1 Adjustment plates for centre line alignment
 - .2 Belt tension adjusting screws.

2.4 **DRIVE AND COUPLING GUARDS**

- .1 Provide guards to protect belt drives, flywheels, rotating couplings on equipment and fan inlet and outlets. Guards to meet OSHA requirements.
- .2 Build guards of all welded construction on exposed rotating parts or elements and on all drives including the following:
 - .1 V-belt drives
 - .2 Flexible couplings
 - .3 Gear drives
- .3 Guards shall be:
 - .1 Removable for servicing;
 - .2 Arranged to permit lubrication with guards in place.
- .4 Construction (except fan drives):
 - .1 Total enclosure type fabricated of minimum 1.3 mm black sheet steel.
 - .2 Hinged side to allow access for lubrication, inspection or removal of the drive parts.
 - .3 Maximum clearance of openings in guards to rotating parts not to exceed 13mm.
 - .4 Make provision for slide rail adjustment.
- .5 Construction for fan drives:
 - .1 V-belt drives: total enclosure type as specified above.
 - .2 Enclosure sides: 13mm mesh, 2.7mm wire screening.
 - .3 Tachometer holes at shaft centres, reinforced as required to maintain rigidity of guard.
- .6 Flexible drive coupling guards:
 - .1 Location: between motor and driven equipment
 - .2 Minimum 1.3mm black sheet steel, securely fastened to the equipment baseplate and readily removable.
 - .3 Leave a clearance of approx. 13 to 25 mm between the guard and the coupling.
 - .4 Extend the guard to within 13mm of both motor and driven equipment housing.
- .7 Guards on unprotected fan inlets and outlets shall be minimum 20 mm galvanized wire mesh or expanded metal screen with net free area of guard not less than 80% of fan opening.

2.5 SLEEVES

.1 General

- .1 Provide sleeves for pipes, ducts and conduits passing through masonry walls, concrete floors, and where required by STC rated ceilings and partitions.
- .2 Maintain fire rating integrity where pipes and ducts pass through fire rated walls, floors and partitions.

.2 Floor and wall sleeves

- .1 Sleeves in fire separations shall be:
 - .1 Sized to suit fire stopping methods employed for bare pipes, conduits, insulated pipes, bare and insulated ducts without fire dampers, and
 - .2 Sized to suit conditions of approval given in manufacturer's installation instructions for fire and smoke dampers.
- .2 Sleeves in other construction shall be:
 - .1 Sized to clear insulated pipes and ducts by 13 mm all around, and
 - .2 Sized to clear conduits, bare pipes, and bare ducts by 6 mm all around.
- .3 Sleeves for pipes, conduits and ducts smaller than 0.4 m² through solid walls and floors shall be Schedule 40 steel pipe or 1 mm (minimum) sheet metal, lapped and spot welded.
- .4 Sleeves for pipes, conduits and ducts smaller than 0.4 m² through gypsum board partitions shall be 1 mm minimum sheet metal, lapped and spot welded with 20 mm lip flange at one end.
- .5 Sleeves for ducts 0.4 m² and larger through walls and floors shall be 1.6 mm minimum sheet metal, lapped and spot welded with 20 mm lip flange at one end.

.3 Waterproof sleeves

- .1 Applications:
 - .1 Where pipes and ducts pass through floors in areas subject to water, in mechanical rooms, in kitchens, in washing areas, in janitor's closets and in slabs over electric and telephone rooms.
- .2 Waterproof sleeves for pipes and conduits:
 - .1 Schedule 10 pipe, with 25 mm wide annular fin continuously welded at midpoint, with a heavy coat of zinc rich paint applied after fabrication, or
 - .2 Pre-fabricated PVC sleeve, or
 - .3 Copper DWV sleeve up to and including 150mm sleeve size, and rolled 32 ounce copper sleeves for larger than 150mm sleeve size.
- .3 Waterproof sleeves for ducts less than 0.4 m²:
 - .1 1 mm galvanized steel, with 40 mm flange at midpoint.
- .4 Waterproof sleeves for ducts 0.4 m² and larger and openings with multiple ducts:
 - .1 1.6 mm galvanized steel, with 40 mm flange at midpoint, or;
 - .2 Form opening with wood (removed after concrete is set) and trim opening with welded steel angle frame 75 mm high , bolted to slab and caulked, or;

- .3 Trim opening with 75 mm x 75 mm continuous concrete curb doveled to slab.
 - .4 Modifications for existing construction:
 - .1 Annular fins and flanges attached to sleeve at point equivalent to surrounding floor level or curb.
- 2.6 **FIRE STOPPING AND SMOKE SEALS**
 - .1 Fire stopping and smoke seal assemblies shall be approved in accordance with CAN/ULC-S115, ULC/cUL listed with rating to suit the fire resistance rating of the wall or floor assembly they are applied to.
 - .2 Standard of Acceptance:
 - .1 Nelson Firestop Products
 - .2 Royal Quickstop
 - .3 3M
 - .4 A/D Fire Protection System
 - .5 Hilti
- 2.7 **SMOKE AND ACOUSTICAL SEALANT**
 - .1 Smoke and acoustical sealant to be paintable water-based caulking material with low shrinkage after curing, white colour. Application temperature range 5°C - 40°C. Allowable movement +/-12.5% (ISO 11600). Temperature resistance rating -20°C – 80°C. Flame spread rating of 10, smoke development rating of 10 per UL 723 (ASTM E84).
 - .2 Standard of Acceptance
 - .1 Hilti
 - .2 3M
 - .3 Tremco
 - .4 Dow Corning
 - .5 Johns Manville
- 2.8 **WALL AND FLOOR PLATES**
 - .1 Fit pipes passing through walls, floors and ceilings in finished areas with escutcheon, wall or floor plates.
 - .2 Supply plates:
 - .1 At floor chrome plated two piece split type with hinge.
 - .2 At walls and ceilings similar to floor plate but with set screw to fasten plate to pipe.
- 2.9 **LINK SEALS**
 - .1 Link seals shall be:
 - .1 Manufactured from modular synthetic rubber links with stainless steel hardware.
 - .2 Loosely assembled with bolts to form a continuous rubber belt around pipes, with a pressure plate under each bolt head and nut.

- .3 Constructed to provide electrical insulation between pipes and sleeves.
 - .2 Standard of Acceptance
 - .1 Thunderline
 - .2 GPT Industries
 - .3 Proline Global
 - .4 Trumbull
- 2.10 **PLATFORMS, LADDERS AND COVERS**
 - .1 Fabricate platforms, gratings, ladders, trench and pit covers, from steel.
 - .2 Work to be done by firms specializing in this field.
 - .3 Platforms, ladders, and gratings
 - .1 Vertical ladders
 - .1 Fabricated with steel sides, 50 mm x 10 mm and 350 mm apart with 20 mm round bars 300 mm on centres secured to sides.
 - .2 Designed to carry a live load of 7.5 kPa uniformly distributed.
 - .2 Platforms
 - .1 Supported from building structure.
 - .2 Fitted with toe angle carried around the outside of the platform and extending at least 100 mm above the top of the platform.
 - .3 Covered with open steel floorway grating with pressed diagonal spacing bars. Bars to be 32 mm x 3 mm.
 - .3 Gratings
 - .1 Made up in convenient lengths and arranged so that sections may be removed.
 - .2 Full width as shown on Drawings.
 - .3 Fitted with toe angle carried around the outside of the grating, and extending at least 100 mm above the top of the grating.
 - .4 Hot dipped galvanized after fabrication.
 - .4 Steel pipe railing
 - .1 1070 mm high, with intermediate rail at 535 mm height, around platforms on both side, except where the platform is within 150 mm of the building wall.
 - .2 Made of 40 mm standard steel pipe with pipe rail fittings and vertical pipe supports secured to the platform structure less than 2 m apart.
 - .5 Sleeves through grating
 - .1 Mild steel pipe sleeves of sufficient size for pipe and insulation.
 - .2 Welded to adjacent bars of the platform so that platform strength is maintained.
 - .3 Extend up at least 75 mm above the top of the grating.

- .6 Equipment openings through gratings
 - .1 Fitted with toe angles around equipment, framed to support grating and extending up at least 75 mm above the top of the grating.
 - .7 Stairs
 - .1 Bolted to floor construction and masonry walls, or to the steel framing of the landing.
 - .2 Treads of same grating as the platforms.
 - .3 Maximum rise of 190 mm, minimum run of 230 mm.
 - .4 Supported on steel carrier angles at stringers, with reinforcing and carrier angles not less than 32 mm x 32 mm x 5 mm.
 - .5 Continuous steel channel stringers around the landing and secured to the masonry.
 - .8 Finish - Outdoor
 - .1 Hot-dipped galvanized after fabrication for outdoor installations.
 - .9 Finish - Indoor
 - .1 Apply one shop coat of primer to metal items, with the exception of galvanized or concrete encased items.
 - .2 Use primer unadulterated, as prepared by the manufacturer.
 - .3 Paint on dry surfaces, free from rust, scale, grease.
 - .4 Do not paint when temperature is lower than 7°C.
 - .5 Clean surfaces to be field welded; do not paint.
 - .4 Roof platform system
 - .1 Prefabricated, supported from roof without penetrations or flashings, made up from:
 - .1 High density polypropylene roof bases,
 - .2 2.5 mm formed channel structure,
 - .3 1.9 mm supplementary support, and
 - .4 Galvanized steel, traction grip grating.
 - .5 Trench covers and pit covers
 - .1 Fabricated with:
 - .1 75 mm x 75 mm x 9.5 mm welded angle frame with anchor bars,
 - .2 25 mm x 9.5 mm trim bar to fit concrete pit, and with matching chequer plate cover,
 - .3 Hot dip galvanized after fabrication.
- 2.11 **DRIP PANS**
- .1 Construct drip pans of min. 1.0mm galvanized steel sheet with sealed connections. Provide drain line from drip pans to nearest hub drain, funnel floor drain, janitor's sink, or appropriate location as shown on the Drawings.

PART - 3 EXECUTION

3.1 GENERAL

- .1 Execute the Work in accordance with requirements specified in the various Sections of Divisions 20, 21, 22, 23 and 25.
- .2 Lay out Work of each mechanical trade Contractor so that it does not interfere with Work of other Divisions' Contractors.
- .3 Make good any damage to Owner's property or other Contractor's Work caused by improperly locating or carrying out Work.
- .4 Location of pipes, ductwork, raceways and equipment may be altered without extra cost provided the alteration is made before installation.

3.2 WORKMANSHIP

- .1 The Consultant's Drawings and instructions govern the general location of all items.
- .2 Install ducts and pipes parallel and perpendicular to the building planes and concealed in chases, behind furring or above ceiling, except in unfinished areas. Install all exposed systems neatly and grouped together, to present a neat appearance. No exposed piping or ductwork shall be installed in areas with dropped ceiling unless specifically reviewed and accepted by the Consultant. No piping shall be concealed within outside walls. Installation shall permit free use of space and maximum headroom.
- .3 Install all equipment and apparatus requiring maintenance, adjustment, or replacement with sufficient clearance for servicing.
- .4 Do not use explosive activated tools.
- .5 Install all ceiling mounted components (diffusers, grilles, sprinklers) in accordance with reflected ceiling drawings reviewed by the Consultant. Layout of each device in finished areas is critical in terms of symmetry and location.
- .6 Leave space clear and install all Work to accommodate future materials and/or equipment as indicated and to accommodate equipment and/or material supplied under the scope of another Division of Work. Verify space requirements in which Work is to be installed. Install all pipe and duct runs to maintain headroom and clearances, and to conserve space in shafts and ceiling spaces.
- .7 Confirm on Site the exact location of outlets and fixtures.
- .8 Vent pipes, exhaust hoods and other mechanical equipment mounted on the roof, or housing for such equipment shall not be closer to the edge of the roof than a distance equal to the height of the pipe, hood or equipment, unless specifically reviewed and accepted by the Consultant.
- .9 The location and size of existing services shown on the Drawings are based on the best available information. The actual location of existing services shall be verified on Site before work is commenced. Particular attention shall be paid to buried services.
- .10 Adequate space and provision shall be left for removal of coils and servicing of equipment, with minimum inconvenience to the operation of systems.
- .11 Cap off and seal all open ends of installed ductwork, piping and conduits to prevent entrance of foreign matter.

- .12 Do not install piping in a location or manner which might result in freezing.
- .13 Equipment Installation
 - .1 Align, level and adjust equipment as required for satisfactory operation.
 - .2 Install equipment in such a manner that connecting and disconnecting of piping and accessories can be made readily, and that all parts are easily accessible for inspection, operation, maintenance and repair.
 - .3 Install and start up items of equipment in accordance with the manufacturer's printed installation and operating instructions.
- .14 Noise and Vibration
 - .1 Noise and vibration levels of equipment and systems shall be within design intent.
 - .2 If noise or vibration levels created by any mechanical equipment and systems, transmitted to occupied portions of building or other mechanical work are over the allowable noise levels set out for this Project, make all necessary changes and additions as approved by the Consultant without additional cost.
- .15 Lubrication
 - .1 Lubricate all equipment prior to start up in accordance with the manufacturer's printed instructions.
 - .2 Supply all lubrication including sufficient quantity for drainage and refilling of oil sumps when required by manufacturer's instructions.

3.3 **ACCESS DOORS AND PANELS**

- .1 Access doors in ductwork are provided under the work of Section 23 33 00 – Duct Accessories.
- .2 Supply access doors in walls and ceilings where access is required for the operation and/or maintenance of concealed mechanical equipment. Access doors to be installed under the work of Section 09 21 16 - Gypsum Board Assemblies.
- .3 Install systems and components to result in a minimum number of access panels. Indicate access panel locations on Record Drawings.
- .4 Size and locate access doors in applied tile, block or glazed or unglazed structural tile to suit joint patterns.
- .5 Access doors in ceilings, where acoustic tile is applied to plaster or gypsum board, to be recessed type designed to receive tile insert.
- .6 Access doors are not required in removable ceilings. Provide coloured marking devices after completion of ceilings, at four corners of each panel below point requiring access. Colour code markers to show service or device above.
- .7 Access doors installed in fire separations, fire-rated walls and ceilings to have the appropriate fire rating.
- .8 At time of Owner's training, hand over and obtain signed receipt for 4 sets of each type of key used to lock access doors in secure areas.

3.4 **DIELECTRIC COUPLINGS**

- .1 Provide dielectric isolation between pipes of dissimilar metals with suitable couplings, insulating dielectric unions, insulating flanges, or insulating gaskets between flanges.
 - .1 Place dielectric isolation between steel piping, and bronze or brass valves.
 - .2 Do not use bronze or brass valves as dielectric fittings.
- .2 Dielectric coupling shall consist of:
 - .1 Insulating unions for pipe sizes 50mm and under
 - .2 Insulating flanges for pipes sizes 65mm up to 100mm
 - .3 Insulating gaskets for pipe sizes 150mm and over:
 - .1 Compatible with pressure and temperature service;
 - .2 Flange bolts placed in insulating sleeves with insulating washers under nuts.

3.5 **DRAIN VALVES**

- .1 Provide drain points for piping systems with drain valves at low points and at section isolating valves.

3.6 **V-BELT DRIVES**

- .1 Tension belts to manufacturer's recommendations before start-up and after first 100 hr of operation using calibrated belt tensioning gauge.
- .2 Provide replacement pulleys and belts during start-up and balancing to suit field operating conditions at no additional cost to the Contract.

3.7 **DRIVE AND COUPLING GUARDS**

- .1 Install belt guards to accommodate movement of motors for belt tension adjustment.
- .2 Where equipment is installed on resiliently mounted base frame or pad, attach belt guard to this base.
- .3 Belt guards and fan inlet guards may be omitted where fan and motor are installed in a plenum less than 1.2 m high and the disconnect for the fan motor is mounted adjacent to and outside the access door to the plenum.
- .4 Fan inlet guards may be omitted where the fan is fitted with inlet guide vanes.
- .5 Rework any substandard guards supplied with mechanical equipment to conform to the specified requirements.

3.8 **SLEEVES**

- .1 Place and secure sleeves in concrete form work.
- .2 Supply sleeves to be set in concrete and masonry walls with installation detail drawings.
- .3 Regular sleeves:
 - .1 Terminate flush with surfaces of concrete and masonry walls.
 - .2 Through exterior walls above grade use Schedule 10 steel pipes, machine cut, flush with finished structure inside and to suit flashing on outside.

- .3 Through exterior walls below grade and other waterproof walls use extra heavy weight cast iron or PVC sleeves, machine cut. Check flashing details for further information.
- .4 Waterproof sleeves in new construction:
 - .1 Extend 75 mm above finished floor in mechanical spaces.
 - .2 Cut sleeves flush with the underside of floor.
 - .3 With flange embedded within concrete floor.
- .5 Sleeves in existing concrete and masonry walls and floors:
 - .1 Installed in neatly cut or drilled holes in existing construction.
 - .2 Cutting and drilling of structural elements, such as floors, slabs, walls, columns, or beams to be carried out in accordance with the procedure set out in Article "Cutting and Patching" included in this Section.
 - .3 Terminate sleeves flush with surfaces of concrete and masonry walls.
 - .4 Extend waterproof sleeves 75 mm above finished floor in mechanical spaces with flange, countersunk, and bolted down flush into floor surface.
- .6 Coordinate filling of future-use sleeves with weak concrete, gypsum plaster or similar material with Division 03 - Concrete.
- .7 Pipes and ducts passing through waterproof floors except where furred in or enclosed in a shaft shall be furnished around by a watertight concrete curb, 100mm high by 100mm wide with 19mm chamfered edges, provided under the Work of Division 03 – Concrete. Coordinate with Section 03 30 00 – Cast-in-place Concrete Contractor. Extend sleeves where used to be flush with the top of the curb.
- .8 Coat exposed exterior surfaces of plain finish ferrous sleeves with heavy application of zinc rich paint in compliance with ASTM A780.
- .9 At fire separations and smoke separations, pack and seal void between sleeve and pipe, duct without fire damper, conduit, or insulation as set out in Article "Fire Stopping and Smoke Seals" included in this Section.
- .10 At other locations, pack void between sleeve and pipe, conduit, duct or insulation for full depth of sleeve, with mineral wool and seal with silicone-free caulking compound.
- .11 Install fire dampers in accordance with conditions of approval given in manufacturer's instructions.
- .12 Brace duct sleeves and box-outs to retain their position and shape during the pouring of concrete and other work.
- .13 Provide bracing for each duct at each passing through structure to prevent sagging.
- .14 Cover exposed duct sleeves and openings in exposed areas only. Use 1.3mm galvanized steel escutcheons in form of a duct collar. Over curbs extend the collar 25mm down the side of the curb, similar to counter flashing. Fix collar in position with cadmium plated screws.
- .15 Provide escutcheons at all penetrations of exposed piping into finished areas; at insulated pipes make the escutcheons large enough to fit around the insulation.

3.9 **FIRE STOPPING AND SMOKE SEALS**

- .1 Install fire dampers and intumescent pipe sleeves.
- .2 Seal space between piping, ductwork, conduit, miscellaneous support steel penetrating fire separations, and sleeve or opening with firestop and smoke sealing system. Materials shall be supplied, worker training shall be arranged and installation shall be supervised by a specialist firm with an established reputation in this field.
- .3 Fire stopping for the Mechanical services shall be provided by the Contractor performing the Work of Section 07 84 00 – Fire Stopping and Smoke Seals, carried out under the supervision of the Division 20, 21, 22, 23 and 25 Contractors.
- .4 Be responsible for any additional cost incurred as a result of oversizing of openings during cutting operation.
- .5 Install fire stopping and smoke seal in accordance with manufacturer's instructions and ULC listing requirements.
- .6 Select thickness and arrangement of back-up materials to suit size of service, length of sleeve and anticipated movement.
- .7 Select fire stopping system to allow insulation and vapour barrier to pass un-broken through assembly.
- .8 Surfaces shall be clean, dry and free from dust, oil, grease, loose or flaking paint and foreign materials at time of application of materials.
- .9 Do not apply fire stopping materials to fire or smoke dampers.
- .10 Provide a written report on completion of the fire stopping and smoke seal, by area or floor if necessary, indicating the work has been completed and ready for inspection. Do not cover over fire stopping and smoke seal, including installation of walls and ceilings, until work has been inspected.

3.10 **WALL AND FLOOR PLATES**

- .1 Size plates to cover sleeves.
- .2 Secure plates tight against finished surfaces and fit to cover sleeve extensions where sleeves extend above finished floor.

3.11 **CUTTING AND PATCHING**

- .1 Do not cut, remove or burn structural parts or sections of the building, whether they are steel, concrete or masonry without the written authorization of the Consultant.
- .2 Should cutting, repairing, and patching of previously finished work of other trades be required to allow installation of mechanical work, pay all costs for the trade concerned to perform the work.
- .3 Layout cutting of structural elements, such as floors slabs, walls, columns or beams and obtain approval before starting work. Conduct an electromagnetic scan of reinforcing rods and submit results to the Structural Engineer's review. Based on these results, arrange and pay for supplemental x-ray examination as necessary, to locate concrete reinforcement and embeds. X-rays shall be performed by a qualified technician, in a safe manner and in accordance with all applicable regulations governing this activity. Submit x-rays and obtain approval prior to starting any work. Make adjustments to location of openings as required to minimize cutting of rebar and completely avoid electrical conduits.

- .4 Neatly cut or drill holes in existing construction to accommodate piping, ductwork or conduits. Cut holes through slabs only. Do not cut holes through beams.
- .5 Holes to be cut shall be 200 mm (diameter) or smaller only.
- .6 Maintain at least 100 mm clearance from beam faces. Spacing shall be at least 3 hole diameters on centre.
- .7 Repair cut or damaged surfaces with materials and finishes to match existing.
- .8 Refer to Section 01 73 29 – Cutting and Patching for additional requirements.

3.12 **LINK SEALS**

- .1 Fit each pipe passing through exterior foundation walls below grade, where internally accessible, with link seal between sleeve and bare pipe.
- .2 Determine inside diameter of each wall opening or sleeve before ordering seal.
- .3 Position seal in sleeve around pipe and tighten bolts to expand rubber links until watertight seal is obtained.

3.13 **FLASHINGS**

- .1 Flash and counter-flash flue vent stacks passing through roof using pre-fabricated flashing equivalent to Thaler Model MEF.
- .2 For safety vents, plumbing vents and other pipes passing through roofs, stack flashings will be supplied and installed by roofing trade, unless otherwise shown on the Drawings. Provide counter-flashing over flashing. The use of pitch pockets is not acceptable.

3.14 **PLATFORMS, LADDERS AND COVERS**

- .1 Locate supporting steel to permit removal of parts for service or repair, and to allow clear access to valves, fittings, and equipment.
- .2 Erect metalwork square, plumb, straight, and true, accurately fitted, with tight joints and intersections.
- .3 Provide anchorage, dowels, anchor clips, bar anchors, expansion bolts and shields, and toggles.
- .4 Make field connections with bolts to CAN/CSA-S16.1, or weld.
- .5 Supply items for casting into concrete or building into masonry to appropriate trades together with setting templates.
- .6 Touch-up field welds, bolts and burnt or scratched surfaces after completion of erection with primer.
- .7 Where gratings or trench covers are cut in field or damaged, touch up with zinc rich paint.

3.15 **DRIP PANS**

- .1 Provide drip pans at the following locations:
 - .1 Beneath all gravity drain pipes passing through operating rooms, recovery rooms, delivery rooms, nurseries, food preparation areas, food serving areas, food storage areas, electrical rooms, battery rooms, UPS rooms, elevator machine rooms, diesel

generator rooms, and telephone rooms, over horizontal runs of bus ducts, and in locations as indicated on the Drawings.

3.16 **SPARE PARTS**

- .1 Furnish the following spare parts:
 - .1 One set of packing glands for each size of pump gland;
 - .2 One casing joint gasket for each size pump;
 - .3 One head gasket for each heat exchanger;
 - .4 One glass for each gauge glass;
 - .5 One set of V-belts for each drive;
 - .6 One filter cartridge or set of filter media for each filter or filter bank installed.

3.17 **PROTECTION**

- .1 Protect work and materials before, during and after erection from weather and other hazards, and keep workplace in a clean and orderly manner.
- .2 Protect pipe ends, valves and parts of equipment left unconnected to prevent damage or intrusion of foreign matter. Provide pipe caps for threaded male connections and plugs for threaded female connections.
- .3 Protect plumbing fixtures or mechanical equipment having a baked enamel finish by covering with polyethylene sheet securely held in place.

3.18 **PAINTING**

- .1 With the exception of prime painting of miscellaneous steel or any other specific requirements as specified under the respective Sections of Divisions 20, 21, 22, 23 and 25, or equipment otherwise factory painted, all painting will be provided under Section 09 91 00 - Painting.
- .2 Factory applied finish painting:
 - .1 Pumps, air handling units, uninsulated pressure vessels, unit ventilators, convectors and bare metal equipment items in boiler, mechanical and fan rooms shall be supplied with factory prime and final coats applied.
 - .2 Use heat resistant paint where conditions require.
 - .3 Protect factory finished equipment during construction and clean at completion of work.
- .3 Factory applied prime painting:
 - .1 Factory prime paint other equipment fabricated from iron or steel including access doors, grilles, diffusers, dampers, metal radiation enclosures, and fire hose cabinets.
 - .2 In occupied areas of the building, touch up any damage to prime coat resulting from shipping or installation and leave ready for final painting under Division 09 - Finishes.

3.19 **MAINTENANCE OF BEARINGS**

- .1 During construction turn-over rotating equipment at least once a month after delivery.

- .2 Run-in sleeve type bearings in accordance with manufacturer's recommendations.
- .3 Drain, flush out and refill with new charge of oil or grease.
- .4 Protect bearings, shafts and sheaves against damage, corrosion and dust accumulation.
- .5 Provide extended grease nipples for bearing lubrication.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

.1 Section includes:

.1 Labour, products, equipment and services necessary for installation within the confines of an existing building.

.2 Related Requirements:

.1 Comply with Conditions of the Contract and Division 01 - General Requirements.

.2 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.

1.2 CO-ORDINATION BETWEEN NEW AND EXISTING INSTALLATION

.1 Check and co-ordinate all systems in the new building addition which are extended to or from existing systems to ensure their proper operation.

.2 Provide interfacing components between new and existing systems as necessary for proper performance and operation.

.3 Route pipes, ducts, conduits and other services to avoid interference with existing installation.

.4 Relocate existing services and equipment to suit installation of new Work without any adjustment to the Bid Price.

.5 Provide temporary dust screens, barriers, warning signs in locations where renovation and alteration Work is performed adjacent to areas that are operational during the time the Work is performed.

.6 Arrange Work to minimize interruption of physical access to the building.

1.3 PENETRATIONS THROUGH EXISTING STRUCTURE

.1 Do all cutting and core drilling for the Work of Divisions 20, 21, 22, 23 and 25. Obtain Consultant's approval before proceeding.

.2 Provide sleeves and follow Consultant's instructions where necessary to completely penetrate existing floors, walls, ceiling, roof or structural members.

.3 Refer to Section 20 00 19 – Basic Materials and Methods for general requirements of cutting and patching Work.

.4 If any fire proofing material or insulation on building structure is damaged where mechanical equipment has been removed or added, Contractor to repair at this Division's expense.

.5 Provide fire stopping as required by code at each location where existing penetration through fire rated wall or floor assembly remains due to removal of existing piping, ductwork or other mechanical service.

1.4 USE OF EXISTING MATERIAL AND EQUIPMENT

.1 Test existing equipment which is to remain in areas being renovated for proper operation. Identify required repairs in written report to the Consultant.

- .2 Clean, test for proper operation and repair existing equipment to be relocated before being put back into service. Identify required repairs in written report to the Consultant.
- .3 Repair or replace, without any adjustment to the Bid Price, all existing equipment, which is damaged in the process of relocation.
- .4 Unless noted otherwise provide additional equipment of the same type and manufacture where required to supplement existing equipment.
- .5 Review existing equipment on site to determine operating conditions prior to Bid Submission.

1.5 **SALVAGE MATERIALS**

- .1 Remove from the site all material in renovated areas of the existing building which are not to remain or be reused, unless noted as remaining the property of the Owner.

1.6 **EXISTING SERVICES**

- .1 Disconnect and remove all existing products which are abandoned.
- .2 Remove all piping which is abandoned, except inaccessible piping in furred-in space. Cut and cap piping below finished surfaces so that finished Work presents a neat and clean appearance.
- .3 Plug and cap all abandoned drain and vent points in systems which are being reused. Plug and cap to the approval of local authorities.
- .4 Allow for all work necessary to complete the alterations, rerouting and/or repositioning of existing services and equipment, and all interconnections of new and existing systems.
- .5 Verify the location and size of all existing services before proceeding with the Work.
- .6 Maintain heating and cooling in the building as required to protect the building and equipment and to provide comfort conditions for the occupants.
- .7 Protect all existing systems, indicated to remain, and finished new work from damage. Should any existing mechanical or electrical service, fire proofing or insulation on the building structure be damaged or interrupted by the Work carried out under the scope of Divisions 20, 21, 22, 23 or 25, make all required repair at no expense to the Owner. Notify the Owner immediately whenever an existing service was damaged.

1.7 **INTERRUPTION OF SERVICES**

- .1 Maintain all mechanical services to all parts of the building which are in use. Provide temporary services as necessary.
- .2 Notify the Owner in writing minimum one (1) week in advance of any planned system shutdown, or as set out in the Owner's base building construction manual. Shutdowns of any portion of an existing base building system shall be performed by the Owner's operations staff and/or coordinated with the Owner in regards to time and duration. Arrange for all necessary signage to be posted. Perform shutdown of major services outside of regular working hours at the Owner's request.

1.8 **PREMIUM TIME**

- .1 Include the cost of premium time in Bid Price for work during nights, weekends or other time outside normal working hours necessary to maintain all mechanical services in operation.

1.9 **FIRE PROTECTION**

- .1 Maintain fire protection and life safety systems operational at all times in accordance with the governing authorities' rules and regulations.

PART - 2 PRODUCTS (NOT USED)

PART - 3 EXECUTION (NOT USED)

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section for the following:
 - .1 Provide single phase and three-phase low-voltage induction motors, from fractional horsepower (143T Frame) to 200 horsepower (449T Frame) for all mechanical equipment supplied and installed under the scope of Divisions 21, 22, 23 and 25.
 - .2 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.

1.2 RELATED WORK

- .1 The following work is provided under other Sections or Divisions of the Work:
 - .1 Motor starters and motor control centres, except variable frequency drives and soft-start starters specified under the Mechanical Work: Division 26 – Electrical.
 - .2 Fused or unfused disconnects, except where specified as an integral component of the Mechanical equipment: Division 26 – Electrical.

1.3 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Include electrical ratings, efficiency, bearing data, power factor, frame size, dimensions, mounting details, materials, motor size, voltage, phase, speed (RPM), enclosure, starting characteristics, torque characteristics, code letter, full load and locked rotor current, service factor, insulation rating and lubrication method.

1.4 REFERENCE STANDARDS

- .1 Ontario Electrical Safety Code
- .2 CSA C22.1 - Canadian Electrical Code
- .3 ASHRAE 90.1 – Energy Standard for Buildings
- .4 National Energy Code of Canada for Buildings
- .5 CSA 390 - Test Methods, Marking Requirements, and Energy Efficiency Levels for Three-Phase Induction Motors
- .6 IEEE 85 - Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery
- .7 IEEE 112 - Standard Test Procedure for Polyphase Induction Motors and Generators

- .8 IEEE 114 - Standard Test Procedure for Single-Phase Induction Motors
- .9 NEMA MG-1 - Motors and Generators

PART - 2 PRODUCTS

2.1 GENERAL

- .1 Motor performance including efficiency shall meet or exceed the requirements of ASHRAE 90.1 or NECB, as applicable, when tested to CSA 390, IEEE 112 or IEEE 114.
- .2 Select motor sizes so that the motors do not operate into the service factor at maximum required loads on the driven equipment. Motors on pumps and fans with variable speed control shall be sized for non-overloading at all points on the performance curves.
- .3 Motor nameplate rating:
 - .1 Not less than input brake horsepower of driven equipment plus 5%, at specified operating conditions, and;
 - .2 Not less than the scheduled minimum horsepower.
 - .3 Premium efficiency.
 - .4 Selected for chemical duty or explosion proof where scheduled.
 - .5 Service factor: 1.15 minimum for three phase motors.
- .4 Standard of Acceptance:
 - .1 TECO – Westinghouse
 - .2 Reliance - Baldor
 - .3 WEG
 - .4 Siemens
 - .5 LEESON
 - .6 US Motors

2.2 ENCLOSURE, ALL MOTORS

- .1 Construction:
 - .1 Cast iron, aluminum, or rolled steel construction;
 - .2 Drain openings;
 - .3 Shouldered lifting eye bolts;
 - .4 Bi-directional, spark-proof, abrasion and corrosive resistant fan keyed to shaft;
 - .5 Compression type grounding lug or double ended cap screw of silicon bronze, mounted in conduit box by drilling and tapping into motor frame.
- .2 Motor nameplate:
 - .1 Type 316 stainless steel;
 - .2 Mounted on enclosure with stainless steel fastening pins;
 - .3 Information as described in NEMA Standard MG-1;
 - .4 Motor bearing part numbers and motor wiring diagram indicated.

- .3 Protective coating:
 - .1 Primer and 4-5 mils epoxy overcoat on external surfaces, and corrosion resistant coating of epoxy paint on internal surfaces, shaft, rotor, stator iron, and end bells.
 - .2 Shaft extension protected with rust preventive strippable coating capable of being peeled off or unwrapped.
- .4 Motor termination boxes/leads:
 - .1 Cast iron diagonally split, pipe tapped for conduit;
 - .2 Attached to motor frame with cadmium plated hex head cap screws;
 - .3 Arranged for conduit entry from either side or bottom;
 - .4 Gaskets between box and motor frame and between halves of box;
 - .5 Cover secured with cadmium plated hex head cap screws;
 - .6 Box assembled to motor;
 - .7 Motor leads in conduit box;
 - .1 Identified in accordance with CSA C22.1;
 - .2 With same insulation class as windings;
 - .3 Sized in accordance with CSA C22.1 recommended minimum ampacity values.
 - .8 Motor leads between motor frame and termination box to pass through tight fitting neoprene rubber seal.

2.3 **SINGLE PHASE MOTORS**

- .1 Continuous duty, resilient mount.
 - .1 Motor rating: less than 375W
 - .2 Voltage, frequency and RPM as scheduled.

2.4 **THREE PHASE MOTORS, 350W TO 525W**

- .1 EEMAC, Class B, Type F insulation, squirrel cage induction, continuous duty, ball bearing.
 - .1 Voltage, frequency and RPM as scheduled.
 - .2 Motor type: TEFC with 80°C temperature rise unless otherwise scheduled.
 - .3 1800 RPM or as scheduled.

2.5 **THREE PHASE MOTORS, 750W AND LARGER**

- .1 EEMAC, T-Frame, Class B, Type F insulation, squirrel cage induction, continuous duty, ball or sleeve bearing.
 - .1 Voltage, and frequency as scheduled.
 - .2 Motor type: TEFC with 80°C temperature rise.
 - .3 1800 RPM or as scheduled.

- 2.6 **THREE PHASE MOTORS, 750W AND LARGER, VARIABLE FREQUENCY DRIVE APPLICATIONS**
 - .1 EEMAC, T-Frame, Class B, Type F triple build, form wound insulation, squirrel cage induction, continuous duty, ball bearing, 40°C temperature rise.
 - .1 Inverter duty rated.
 - .2 Maximum speed turndown: 25%
 - .3 Voltage, and frequency as scheduled.
 - .4 Motor type: ODP for variable torque applications, TEFC for constant torque applications.
 - .5 1800 RPM or as scheduled
- 2.7 **MULTIPLE SPEED MOTORS**
 - .1 For 2:1 speed ratios: single winding consequent pole (two winding)
 - .2 For all other speed ratios: two winding
- 2.8 **GROUNDING LUG**
 - .1 Motors less than 15kW:
 - .1 Ground lug on motor terminal box.
 - .2 Motors 15kW and larger:
 - .1 Directly bolted to motor frame
 - .2 Located inside terminal box on motor.
- 2.9 **WINDING TEMPERATURE SENSORS - RTD'S**
 - .1 Where required:
 - .1 Motors greater than 224kW
 - .2 Inverter Duty Motors greater than 112kW
 - .2 Type:
 - .1 RTD sensor in each winding, wired to separate terminal box on side of motor.
 - .2 RTD relay/control circuit by others.
- 2.10 **WINDING TEMPERATURE SENSOR PROTECTION**
 - .1 Where required:
 - .1 Motors 37kW up to 225kW
 - .2 Motors 18.6kW up to 30kW located in air ducts, plenum chambers or in air stream inside air conditioning equipment.
 - .2 Type:
 - .1 Winding temperature sensor wired to disconnect motor on high temperature
 - .2 120 V control transformer
 - .3 "Push-to-Test" red pilot light (high winding temp)

- .4 Reset button
- .5 Supply control unit to the Contractor performing the Work of Division 26 – Electrical for installation in motor starter.

2.11 **WINDING TEMPERATURE THERMOSTAT**

- .1 Where required:
 - .1 Single phase, and three phase motors up to 15kW located in air ducts, plenum chambers or in air stream inside air conditioning equipment.
- .2 Type:
 - .1 Motor winding thermostats equivalent to Klaxon

2.12 **PERMISSIBLE VIBRATION**

- .1 Vibration velocity to be not more than 0.05 inches/second measured at bearing housing.

2.13 **SOUND PRESSURE LEVEL**

- .1 Not more than 85dbA, measured at 3 metres in accordance with IEEE 85.
- .2 Motor manufacturer to ensure that motor is compatible with type of adjustable frequency generation to be supplied, and that system will be capable of providing rated torque over frequency range from 15 to 60 Hz while operating within motor temperature rise specification.
- .3 Motor to be capable of operating between 60 Hz and 90 Hz with torque reducing at drive frequency above 60 Hz.

PART - 3 EXECUTION

3.1 **INSTALLATION**

- .1 Install motors in accordance with manufacturer's recommendations, with the requirements of the OESC, CEC and NEMA, as shown on the Drawings and as required by other Sections of these Specifications.
- .2 Motor and equipment control
 - .1 Motor control centre, starters and/or disconnect switches for each motor or electrically connected item: provided under the Work of Division 26 - Electrical.
 - .1 Exception:
 - .1 Starters and disconnects which are specified as part of the equipment.
 - .2 Variable frequency drives and soft starters

3.2 **TESTING**

- .1 Test motors in accordance with IEEE 112 or IEEE 114 as applicable, to conform to the requirements of NEMA MG-1.

- .2 Additional tests may be performed on a random sampling of motors supplied for the Project at the discretion of the Consultant as follows:
 - .1 Insulation test to establish capability to withstand continuous phase-to-ground rms voltage of 1000 Volts minimum for 30 minutes.
 - .2 Winding to withstand 2500 Volt AC phase-to-ground for one second.
 - .3 Surge comparison test using 3000 Volts AC phase-to-phase with submission of detailed comparison wave forms.
 - .4 Shaft runout tests with results taken after motor is completely assembled.
 - .5 Measurement of full load amperes, watts, power factor, RPM, and locked rotor current at rated voltage.
 - .6 Verification of vibration status through velocity readings in inches/second taken at both ends of motor.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .2 Scope of Work:
 - .1 The Contractor performing the Work of Division 26 – Electrical will provide power wiring for all mechanical equipment supplied and installed under the scope of the Division 21, 22 and 23 Contract. Refer to the Division 26 – Electrical Drawings for the extent of the Electrical Work. Provide all additional power wiring and interlock wiring required for fully operational systems and equipment.
- .3 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.

1.2 RELATED WORK

- .1 The following work is provided under other Sections or Divisions of the Work:
 - .1 Field control wiring of local control and monitoring systems for packaged equipment: will be provided under the work of the respective Division under which the equipment is supplied unless otherwise specified.
 - .2 Centralized control and monitoring of Mechanical systems and equipment: Division 25 – Building Automation.
 - .3 Power supply to Mechanical equipment and to associated control equipment: Division 26 – Electrical.
 - .4 Motor starters and motor control centres, except variable frequency drives and soft-start starters specified under the Mechanical Work: Division 26 – Electrical.
 - .5 Fused or unfused disconnects, except where specified as an integral component of the Mechanical equipment: Division 26 – Electrical.

1.3 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for all components including technical specification data sheets for each system component, sequence of operation, wiring diagrams, control device arrangements, control device locations on floor plans to scale.

1.4 REFERENCE STANDARDS

- .1 Ontario Electrical Safety Code

1.5 **QUALITY ASSURANCE**

- .1 Provide electrical and electronic equipment which is CSA approved where such approval is required by the authorities having jurisdiction.
- .2 Conduit and wiring materials and methods shall be in strict accordance with the requirements of Division 26 – Electrical and the applicable provincial and federal electrical codes and standards.

PART - 2 PRODUCTS

2.1 **WIRING AND CONDUIT**

- .1 Conduit and wiring materials shall be in strict accordance with the requirements of Division 26 – Electrical and the applicable provincial and federal electrical codes and standards. Consider this Specification as minimum requirements.
- .2 Wire
 - .1 RW-90 X-link type, 1000V insulation for 600 Volt systems and 600V insulation for 120/208 Volt systems, installed in conduit, sized to carry 125% of full load running current in accordance with the applicable Electrical Code.
 - .2 Minimum No. 12 AWG for power
 - .3 Colour coded No. 14 AWG for control power, 120VAC and lower
 - .4 Individually identify conductors on each end with slip-on, plastic wire markers. Identification to match wiring diagrams.
- .3 Conduit
 - .1 Electrical metallic tubing (EMT):
 - .1 Up to 32mm size in ceilings, furred spaces, in hollow walls and partitions and where not exposed to mechanical injury.
 - .2 Rigid galvanized steel:
 - .1 38mm size and larger.
 - .2 Sized to suit service where located in poured concrete.
 - .3 For inverter duty:
 - .1 Liquid tight, flexible metal conduit and cable specifically manufactured for this duty;
 - .2 Voltage rating: nominal 1000 V, and voltage spikes to 2000 V;
 - .3 Three (3) phase and three (3) ground conductors.
 - .4 Standard of Acceptance
 - .1 NEXANS
 - .2 LAPP USA
 - .3 ShowCor – Shawflex
 - .4 Rockbestos-Suprenant Cable

- .4 Grounding:
 - .1 Provide insulated green bonding conductor in each power and control conduit sized per the applicable Electrical code. Minimum bonding conductor size #12AWG copper.
- .5 Mineral Insulated Copper Cable (MICC):
 - .1 ULC listed 2 hour fire rating;
 - .2 Shipped with ends temporarily sealed and stored under dry conditions;
 - .3 Terminated using suitable terminating hardware;
 - .4 VC jackets for embedded cables.
 - .5 Standard of Acceptance
 - .1 Pyrotenax

2.2 **CORROSION PROTECTION ANODES**

- .1 High grade electrolytic zinc, 99.99% pure to ASTM B-418 Type II.
- .2 Supplied with 5mm diameter minimum steel core with #8 TWH stranded connecting wire or bolt-on strap connection where required.

PART - 3 EXECUTION

3.1 **GENERAL**

- .1 Electrical materials, equipment and installation procedures shall conform to the requirements of the applicable Electrical code.
- .2 Wiring methods and standards shall conform to those specified under the Division 26 - Electrical Specifications.

3.2 **POWER CONDUIT AND WIRE**

- .1 Provided under the scope of the Mechanical Work:
 - .1 Line voltage thermostats, and wiring from thermostat to fan coil units, unit heaters and cabinet unit heaters.
 - .2 Hardwire interlock wiring between control devices (pressure switches, temperature switches, limit switches) and motor starters.
 - .3 Between junction box provided by Division 26 - Electrical, to switch and equipment service lights.
- .2 Provided under the scope of Division 26 - Electrical:
 - .1 Power wiring to motors and packaged equipment.
 - .2 To junction box on adjacent wall, column or ceiling for equipment service lights (marine lights).

3.3 **CONTROL CONDUIT AND WIRE**

- .1 Provided under the scope of the Mechanical Work:
 - .1 Control wiring, conduit and relays to interlock starters and connect safety and operating controls.

- .2 Provided under the scope of Division 26 - Electrical:
 - .1 Fan shut-down and start-up relays and wiring for operation by the Fire Alarm System
 - .2 Thermostats and wiring for electric heaters
- 3.4 **GROUNDING**
 - .1 Ground electrical equipment and wiring in accordance with the local authority's rules and regulations.
- 3.5 **CORROSION PROTECTION ANODES**
 - .1 Provide external corrosion protection anodes for:
 - .1 Buried ductile iron water mains, fittings, and hydrants;
 - .2 Metallic services as shown.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
 - .2 Provide contactors and control devices for packaged equipment supplied under the scope of Divisions 21, 22 and 23.
- .2 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for contactors and control devices.

1.3 QUALITY ASSURANCE

- .1 Read together with the Division 26 – Electrical Specification and adhere to its requirements. Supply and install all electrical apparatus that is required for a complete installation of the Mechanical Work and is not covered under the Work of the Division 26 – Electrical Contractor.

PART - 2 PRODUCTS

2.1 NOT APPLICABLE.

PART - 3 EXECUTION

3.1 CONTACTORS AND CONTROL DEVICES

- .1 Install all automatic devices such as thermostats, controlling electrical equipment, supplied under the scope of the Division 21, 22 and 23 Contracts.
- .2 Disconnect switches, starters, push button stations, cable lugs, pilot lights, and control circuit transformers shall be supplied and installed under the scope of the Division 26 – Electrical Contractor, except as detailed in the diverse Sections of the Division 21, 22 and 23 Specifications, and as noted below.
 - .1 The Contractors performing the Work of Divisions 21, 22 and 23 shall provide all starters, contactors, fuses, and equipment-mount pre-wired non-fused service switches as part of packaged equipment such as chillers, boilers, domestic hot water heaters, rooftop heating and air conditioning units, electric heating coils, computer room air conditioning units, as specified under their respective Sections. The Division 26 – Electrical Contractor will provide fused, remote disconnect

switches for these equipment as required by the applicable provincial and federal electrical code.

- .2 Provide the Division 26 – Electrical Contractor certified shop drawings for all motors and other equipment requiring line voltage power connection, supplied as part of the Mechanical Work, in support of selection of overload protection and sizing of power wiring.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
 - .2 Provide flexible connections and expansion joints for the Mechanical Work performed under the scope of Divisions 22 and 23 as required.
- .2 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.

1.2 RELATED WORK

- .1 The following Work is provided under other Sections or Divisions of the Work:
 - .1 Anchors, guides: Section 20 05 29 - Bases, Hangers and Supports.

1.3 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for expansion compensation equipment. Shop drawing shall include the following information:
 - .1 Catalogue cuts and data sheets on specific compensators to be utilized showing compliance with the Specifications.
 - .2 Drawings showing methods of suspension, support guides for piping and ductwork. Submittals shall include the initial load, initial deflection, change in deflection, final load and change in load at all spring and anchor support locations, as well as guide spacing. Calculations shall include pipe stress at end conditions and branch off locations. Include installation instructions.
 - .3 Submittal must be stamped and signed by a professional engineer licensed in the project location jurisdiction, either in the employ of the expansion compensation vendor, or specialized to the field of expansion compensation system design, for at least 5 years; for the following systems:
 - .1 Any piping system using manufactured expansion joints;
 - .2 Hot water heating, maximum 93°C: 200mm and over;
 - .3 Steam, low pressure (< 100 kPa): 200mm and over;
 - .4 Submit certificate for the factory pressure testing of expansion compensators.

1.4 REFERENCE STANDARDS

- .1 ASTM A53 / A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

- .2 ASTM A240 / A240M - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
- .3 ASTM F1120 - Standard Specification for Circular Metallic Bellows Type Expansion Joints for Piping Applications
- .4 ASTM F2934 - Standard Specification for Circular Metallic Bellows Type Expansion Joint for HVAC Piping Applications
- .5 ASME B31.1 – Power Piping
- .6 ASME B31.9 – Building Services Piping
- .7 NSF/ANSI 61 - Drinking Water System Components

1.5 **QUALITY ASSURANCE**

- .1 Select flexible connectors and expansion joints for the maximum system working and test pressures to which they are exposed but to not less than 1034 kPa, with adequate cyclic life to last through 25 years of normal operation.
- .2 Select joints to compensate for the thermal expansion in piping between anchors with not less than 25% safety margin, calculating expansion based on the following operating temperatures:
 - .1 Hot piping: from 4.4°C to maximum operating temperature;
 - .2 Steam piping: from 4.4°C to maximum saturation temperature;
 - .3 Cold piping: from 26.6°C to minimum operating temperature.
- .3 Products used in potable water systems shall be ANSI classified in accordance with NSF-61.
- .4 All grooved joint couplings and specialties shall be the products of a single manufacturer.

PART - 2 PRODUCTS

2.1 **SLIP TYPE EXPANSION JOINTS**

- .1 Application
 - .1 For axial pipe movement.
 - .2 Travel: 100 mm to 300 mm single unit, 200 mm to 600 mm for double units.
 - .3 Size: 40mm to 600mm.
 - .4 Maximum operating pressure: 1030 kPa saturated steam.
 - .5 Factory tested to 1.5 times the maximum operating pressure.
- .2 Construction
 - .1 Body and packing housings: Class 150 or Class 300 carbon steel pipe to ASTM A53, Grade B.
 - .2 Wall thickness to match service pipe with flanges or weld ends to match service pipe jointing specification.
 - .3 Adjustable packing gland or fixed packing gland arrangement with a packing injection assembly, arranged for repacking under full line pressure.

- .4 Slip pipe of carbon steel pipe to ASTM A 53, Grade B, hard chrome plated.
- .5 Anchor base constructed of steel welded to body on double units.
- .6 Internal and external guides in packing housing with concentric alignment of slip pipe.
- .7 Extension limit stop of stainless steel, with accessible and removable pins.
- .8 Not less than six packing rings of Teflon or graphite impregnated material.
- .9 Lubricating fittings with grease nipple, pet cocks, lubricant gun with hose assembly or plunger body of heavy wall carbon steel, and plunger of carbon steel with hex head for use with socket wrench.
- .10 Lubricant to manufacturer's recommendations.
- .11 Drip connection coupling with drain plug.
- .3 Standard of Acceptance
 - .1 Flexonics
 - .2 Adsko
 - .3 Hyspan
 - .4 Advanced Thermal System
 - .5 Flexpression
 - .6 FlexTech Industries
 - .7 Mason

2.2 **CONTROLLED FLEXING EXPANSION JOINTS**

- .1 Application
 - .1 For axial and lateral movements.
 - .2 Travel: up to 190 mm axial and 8 mm lateral depending on size.
 - .3 Size: 75mm to 450mm.
 - .4 Maximum operating pressure: 1030 kPa at up to 425°C.
 - .5 Factory tested to 1.5 times the maximum operating pressure.
- .2 Construction
 - .1 Bellows hydraulically formed, type 304 stainless steel for specified fluid.
 - .2 Two piece nickel iron reinforcing or control rings.
 - .3 Flanges or weld ends to match service pipe jointing specification.
 - .4 Austenitic stainless steel liner oriented with direction of flow.
 - .5 Carbon steel tie rods.
 - .6 Carbon steel painted shroud.
- .3 Standard of Acceptance
 - .1 Flexonics
 - .2 Adsko

- .3 Metraflex
- .4 Hyspan
- .5 Badger
- .6 Flex-Hose Co.
- .7 Flexpression
- .8 FlexTech Industries
- .9 Mason

2.3 **EXTERNALLY PRESSURIZED EXPANSION JOINTS**

.1 Application

- .1 For axial movements.
- .2 Travel: 100 mm to 200 mm single unit, 200 mm to 400 mm double unit.
- .3 Size: 50mm to 300mm.
- .4 Maximum operating pressure: 2070 kPa at up to 425°C.
- .5 Factory tested to 1.5 times the maximum working pressure.

.2 Construction

- .1 External pressurized design.
- .2 Housing: ASME A53 Gr B carbon steel.
- .3 Connections: ASME/ANSI B16.5 flanges, weld ends to ASME/ANSI B16.9, or grooved ends as applicable.
- .4 Bellows: hydraulically formed, three ply laminated, T321 stainless steel to ASTM A240 for the specified fluid.
- .5 Internal steel liner.
- .6 Internal and external guides.

.3 Standard of Acceptance

- .1 Flexonics
- .2 Adsco
- .3 Hyspan
- .4 Metraflex
- .5 Flex-Hose Co.
- .6 FlexTech Industries
- .7 Mason

2.4 **EXPANSION COMPENSATORS (BELLOWS TYPE)**

.1 Application

- .1 For axial movements.
- .2 Travel: 50 mm to 75 mm carbon steel, 50 mm for copper.
- .3 Size: 20mm to 100mm for carbon steel, 20mm to 75mm for copper.

- .4 Maximum operating pressure: 2070 kPa at up to 400°C.
- .5 Factory tested to 1.5 times the maximum working pressure.
- .2 Construction
 - .1 External pressurized design.
 - .2 Pipe: Schedule 40 ASME A53 Gr B carbon steel.
 - .3 Bellows: hydraulically formed, three ply laminated, T321 stainless steel to ASTM A240 for specified fluid,
 - .4 Connections: S
 - .1 Steel pipe: ASME/ANSI B16.5 flanges with floating flange as required, weld ends to ASME/ANSI B16.9, or grooved ends as applicable.
 - .2 Copper tubing: female copper solder type ends for copper pipe.
 - .5 Flow liner: T304 stainless steel to ASTM A240.
- .3 Standard of Acceptance
 - .1 Flexonics
 - .2 Adsco
 - .3 Hyspan
 - .4 Metraflex
 - .5 Flex-Hose Co.
 - .6 FlexTech Industries
 - .7 Mason

2.5 **BELLOWS PUMP CONNECTORS**

- .1 Application
 - .1 For axial and lateral movements, vibration isolation at pumps.
 - .2 Travel: 25 mm compression, 9.5 mm extension, and 3 mm to 7.5 mm lateral, depending on size.
 - .3 Size: 50mm to 350mm.
 - .4 Maximum operating pressure: 1450 kPa at up to 121°C.
 - .5 Factory tested to 1.5 times the maximum operating pressure.
- .2 Construction
 - .1 Pipe: Schedule 40 ASME A53 Gr B carbon steel,
 - .2 Bellows: hydraulically formed, three ply laminated, T304 stainless steel to ASTM A240.
 - .3 Flange plate: to ASTM A36 carbon steel, ASME/ANSI B16.5 class 300.
 - .4 Flow liner: T304 stainless steel to ASTM A240.
 - .5 Restraint/limit rods.
- .3 Standard of Acceptance
 - .1 Flexonics

- .2 Hyspan
- .3 Metraflex
- .4 Flex-Hose Co.
- .5 FlexTech Industries
- .6 Mason

2.6 **BRAIDED EQUIPMENT CONNECTOR**

- .1 Application
 - .1 For axial and lateral movements, vibration isolation at pumps and equipment.
 - .2 Size: 50mm to 250mm.
 - .3 Maximum operating pressure: 1100 kPa at up to 121°C.
 - .4 Factory tested to 1.5 times the maximum operating pressure.
- .2 Construction
 - .1 Type 304 stainless steel corrugate internal liner with braided stainless steel cover.
 - .2 Flanges: carbon steel to ASTM A36, ASME/ANSI B16.5 class 150.
- .3 Standard of Acceptance
 - .1 Flexonics
 - .2 Hyspan
 - .3 Metraflex
 - .4 Flex-Hose Co.
 - .5 FlexTech Industries
 - .6 Mason

2.7 **FLEXIBLE RUBBER JOINTS**

- .1 Application
 - .1 For axial, lateral and angular movements.
 - .2 Travel:
 - .1 Axial: up to 55 mm for double arch, and 19 mm for single arch.
 - .2 Lateral: up to 35 mm for double arch, and 9.5 mm for single arch.
 - .3 Angular: 35° for double arch, and 15° for single arch.
 - .3 Size: 40mm to 300mm for double arch, 350mm to 600mm for single arch.
 - .4 Maximum operating pressure: 1450 kPa at up to 37°C.
 - .5 Factory tested to 1.5 times maximum operating pressure.
- .2 Construction
 - .1 Spool type, reinforced EPDM inner liner and outer cover, with wire reinforced flange collars.
 - .2 40mm to 300mm: two filled arches with stabilizing ring.

- .3 350mm to 600mm: one filled arch.
 - .4 Tie rod control units with vibration isolation washers.
 - .5 Retaining rings.
 - .6 Neoprene covers.
 - .3 Standard of Acceptance
 - .1 Flexonics
 - .2 Garlock Canada Ltd
 - .3 Metraflex
 - .4 Proco
 - .5 Flex-Hose Co.
 - .6 FlexTech Industries
 - .7 Mason
- 2.8 **FLEXIBLE METAL HOSE CONNECTIONS**
 - .1 Construction
 - .1 Inner hose: corrugated T304 stainless steel.
 - .2 Outer jacket: braided T304 stainless steel wire mesh.
 - .3 Threaded or female soldered end connections up to 50mm, flanged 65mm and over.
 - .4 Selected for 1034 kPa maximum operating pressure and 93°C maximum operating temperature.
 - .2 Standard of Acceptance
 - .1 Flexonics
 - .2 Metraflex
 - .3 Flex-Hose Co.
 - .4 Flexpression
 - .5 US Hose
 - .6 FlexTech Industries
 - .7 Mason
- 2.9 **FLEXIBLE TEFLON HOSE CONNECTIONS**
 - .1 Application
 - .1 Alternative to flexible metal hose connections specified above.
 - .2 May only be used for connections to reheat coils.
 - .2 Construction
 - .1 PTFE "Teflon" inner tube, static dissipating conductive.
 - .2 304 stainless steel braided wire mesh outer jacket.

- .3 Threaded male, and threaded swivel female connections up to 50mm, flanged 65mm and over.
 - .4 Selected for 1034 kPa maximum operating pressure and 150°C maximum operating temperature.
 - .5 Designed to absorb 150 mm transverse movement.
 - .6 Flexible length not less than 450 mm.
 - .3 Standard of Acceptance
 - .1 Eaton
 - .2 Flexpression
 - .3 FlexTech Industries
 - .4 Hyspan
 - .5 US Hose
- 2.10 **GROOVED END EXPANSION JOINTS**
 - .1 Slip type expansion joints
 - .1 Application
 - .1 For axial movement.
 - .2 Travel: up to 80 mm.
 - .3 Size: 50mm to 150mm.
 - .4 Maximum operating pressure: 2400 kPa at up to 110°C.
 - .2 Construction
 - .1 Housing: ductile iron to ASTM A-536, grade 65-45-12.
 - .2 Housing coating: enamel.
 - .3 Body / end: carbon steel, Schedule 40 to ASTM A-53, Type E or S, Grade B.
 - .4 Slide: Schedule 40, cold drawn seamless tubing, to AISI 1015 or 1018.
 - .5 Body / end coating: black enamel.
 - .6 Slide coating: polyphenylene sulfide modified with polytetrafluorethylene (PPS/PTFE).
 - .7 Gasket grade: EPDM (green color code) for cold and hot water service for temperatures -34°C to 110°C, dilute acids, oil-free air and chemical services. ANSI/NSF 61 for cold and hot potable water service.
 - .3 Standard of Acceptance
 - .1 Victaulic Style 150
 - .2 As an alternative, for pipe sizes 20mm to 300mm provide a joint consisting of a series of grooved end pipe spools joined in tandem with flexible couplings. The number of nipples/couplings is dependent on the amount of movement required.
 - .1 Standard of Acceptance
 - .1 Victaulic Style 155

PART - 3 EXECUTION

3.1 GENERAL

- .1 Install joints and hoses in accordance with manufacturer's written instructions. Joints shall not cause any change in position of equipment or piping resulting in piping stresses or misalignment.
- .2 Provide expansion loops or swing joints in preference to expansion joints, where space permits.
- .3 Application of expansion joints and flexible connections:
 - .1 Flexible hoses
 - .1 On suction and discharge connections of domestic water booster pumps.
 - .2 On suction and discharge connections of base mounted double suction pumps.
 - .3 On discharge connections of sump and sewage pumps.
 - .4 In steam, hot water, chilled water, or glycol piping connections to coils and to humidifiers in air handling units where units, or sections of units to which piping is connected are supported or suspended by means of springs or isolation pads.
 - .5 On piping connections to domestic hot water tanks.
 - .6 Cooling tower supply and return connections at the towers.
 - .2 Swing joint or braided hose
 - .1 Branch piping to hydronic terminals and to booster coils
 - .3 Flexible rubber expansion joint
 - .1 Cooling tower supply and return piping connections at pumps.
 - .2 Above ground drainage piping where shown on the Drawings.
 - .4 Expansion compensators
 - .1 Domestic hot water supply and recirculation piping up to 75mm.
 - .2 Heating and chilled water system piping up to 50mm.
 - .3 Compressed air, maximum 860 kPa.
 - .5 Expansion joints
 - .1 Domestic hot water and recirculating water piping 100mm and over.
 - .2 Heating and chilled water system piping 65mm and over.
 - .6 Slip joints
 - .1 High temperature hot water over 100°C;
 - .2 High pressure steam piping over 100 kPa.

3.2 EXPANSION JOINTS INSTALLATION

- .1 Support and guide piping adjacent to expansion joints:
 - .1 Support piping on each side of the expansion joint;
 - .2 Support the expansion joint when provided with mounting supports;

- .3 Do not rely on pipe guides to support piping and the expansion joint.

3.3 **PUMP CONNECTORS**

- .1 Install pump connectors at:
 - .1 For vertical-in-line pumps, in vertical portion of piping or in adjacent horizontal piping as shown on typical pump installation detail. Do not install connectors between valves and pump.
 - .2 For base mount pumps, install connectors at pump inlet and outlet flanges.
 - .3 Inlet and discharge side for all other pumps.
- .2 Support and guide piping adjacent to pump connector to eliminate lateral misalignment. Support piping independently from the connector.

3.4 **EQUIPMENT CONNECTORS**

- .1 Install equipment connectors on piping connections to equipment as required. Connector and hose sizing:
 - .1 Nominal diameter: same size as pipe.
 - .2 Length: selected at not less than manufacturer's catalogued minimum active length for the configuration, and not more than 1.5 times this minimum recommended length.
- .2 Support or guide piping firmly adjacent to equipment connectors to prevent pipes from swaying.
- .3 For steam coils, locate connectors:
 - .1 Between control valve and coil on steam supply side, and
 - .2 After steam trap on the condensate line.
- .4 For chilled and hot water coils, locate connectors:
 - .1 Between strainer and coil on the supply side, and
 - .2 Between coil and control valve on return side.
- .5 At reheat coils installed in terminal boxes or in ductwork, arrange equipment connectors so that there are no bends or axial offsets greater than the OD of the connector, measured from the centreline of the connector.

3.5 **INSPECTION OF ANCHOR AND GUIDE INSTALLATION**

- .1 The expansion joint manufacturer's field representative shall review the anchors and guides around expansion joints on:
 - .1 Steam piping;
 - .2 Domestic hot water and recirculating water piping 150mm size and over;
 - .3 Heating system and chilled water piping 150mm size and over.

3.6 **START-UP AND TESTING**

- .1 Install steel spools instead of flexible connections until all pressure and leakage tests have been completed.

- .2 Prior to placing expansion joints in service, apply match-marks to joint flanges/connectors to record axial, lateral, rotation and angular movement of joint connections. After the systems are at operating temperature, inspect match-marks and record displacement of joint connections compared to pre-start conditions. Submit report including photos of displaced match-marks.

3.7 **PROJECT CLOSE-OUT**

- .1 Submit a letter from the manufacturer certifying that the expansion compensation equipment, anchors and guides have been installed in accordance with their recommendations and the Contract Documents, and that the equipment operates to their satisfaction.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
 - .2 Provide meters and gauges for the Mechanical Work provided under the respective Sections' scope of Divisions 21, 22, 23 and 25.
- .2 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.

1.2 RELATED WORK

- .1 The following work is provided under other Sections or Divisions of the Work:
 - .1 Air flow measuring devices: Section 25 35 00.
 - .2 Natural gas piping: Section 23 11 23.
 - .3 Electrical power monitoring: Section 28 46 00.

1.3 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for meters, gauges and all related accessories specified in this Section. Submit a schedule showing service, location, range, make, and catalogue number for each meter and gauge type.

1.4 REFERENCE STANDARDS

- .1 ASME B40.200 - Thermometers, Direct Reading and Remote Reading
- .2 ASME B40.100 - Pressure Gauges and Gauge Attachments
- .3 ASME B1.20.1 - Pipe Threads, General Purpose
- .4 CAN/CSA B-149.1 – Natural Gas and Propane Installation Code
- .5 CAN/CSA C22.2 - Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use

PART - 2 PRODUCTS

2.1 GENERAL

- .1 Sensor Elements
 - .1 Selected for thermowells designed for 50mm insulation.

2.2 THERMOMETERS

- .1 Select all thermometers to suit the expected range of temperatures of the medium and ensure that normal working temperature occurs approximately at mid-scale. If the range of working temperatures is undetermined, use the following ranges for the different services:
 - .1 Domestic Hot Water: 0 to 100°C with 2 scale divisions.
 - .2 Domestic Cold Water: -18 to 55°C with 2 scale divisions.
- .2 Thermometers shall have a 5-year manufacturer's warranty.
- .3 Straight thermometers
 - .1 Thermometers shall be 225mm high, straight shank, immersion type, dual scale (°F and °C), with a tapered cast aluminium graphite filled bulb chamber. The tube shall have magnifying properties, and have a green or red organic fill fluid. Provide a 150mm long extension neck socket for insulated pipes. Thermometers with plastic case are not acceptable.
 - .2 The stem shall be 150mm in length with a 32mm adjustable swivel nut and a separable 20mm NPT threaded brass or lead free brass thermowell. Thermowells to be stamped by the manufacturer with a batch code. Lead Free thermowells to be stamped LF where applicable.
 - .3 Thermometer shall be fully adjustable and provide a full 360-degree positioning on a vertical axis and lock in any position along its arc.
 - .4 The scale shall be constructed of white painted aluminum with permanently painted black markings. The scale shall be non-reflective and the lens is to be glass.
 - .5 Accuracy shall be $\pm 1\%$ of full scale.
 - .6 Thermometers shall have a reservoir top to allow not less than 25% temperature over scale without damage.
 - .7 The thermometer enclosure rating shall be IP54.
- .4 Bi-metal dial thermometers
 - .1 Direct mounted, bimetal type with adjustable angle feature for 360° rotation and 180° angle adjustment.
 - .2 Hermetically sealed, 125mm diameter case of welded stainless steel construction with external adjustment.
 - .3 Thermometer shall have a bimetal coil, plastic window, white dial with black markings.
 - .4 Stem length of 150mm, or adjust length to be minimum 75mm from insulation, 12mm NPT stem connection.
- .5 Remote thermometers
 - .1 63mm diameter aluminum dial, painted white with black, dual scale markings.
 - .2 Stainless steel front flange and U-clamp case.
 - .3 Black aluminum pointer.
 - .4 Vapour actuated.
 - .5 Nickel plated brass bulb
 - .6 Armoured extension capillary, 2.7m long.

- .7 The thermometer enclosure rating shall be IP52.
- .6 Thermometer wells
 - .1 Brass threaded thermometer wells for all piping systems, pressure rated to match piping system design pressure
 - .2 50mm extension for insulated piping
 - .3 Threaded cap nut (material to match well material) with chain permanently fastened to well and cap.
- .7 Standard of Acceptance:
 - .1 Trerice
 - .2 Taylor
 - .3 Ashcroft
 - .4 Winters
 - .5 Weksler
 - .6 WIKA

2.3 **GAUGE GLASSES**

- .1 Gauge glasses shall be fail-safe type with shut off valve, ball check, flushing facilities, and white enamelled brass back plate, suitable for the intended service.

2.4 **MANOMETERS**

- .1 Manometers shall be inclined tube differential type (equipped with vent valves for zeroing), of solid acrylic plastic construction with built-in level vial. Manometers shall have an adjustable mirror-polished scale, and be furnished complete with two 1.5m lengths 6mm tubing, two static pressure tips, mounting hardware, additional bottle of red gage fluid and instructions.
- .2 Range and graduation shall be with metric and imperial scale, and match the expected maximum pressure differential across the filter bank it serves.
- .3 Standard of Acceptance:
 - .1 Dwyer
 - .2 Meriam
 - .3 Kimo

2.5 **PRESSURE GAUGES**

- .1 Pressure gauges shall have a 100mm dial. Case and ring shall be constructed of 304 stainless steel. The dial shall be a white aluminum dial with black and red markings. The socket shall be made of brass, the bourdon tube of phosphor bronze and brass movement with under and overload stops. The process connection shall be 6mm NPT bottom or lower back mount with a removable restrictor screw in the orifice. The lens shall be polycarbonate and the pointer micrometer adjustable and made of anodized black aluminum. The gauge shall have a Buna-N fill plug and a blowout back plug. Pressure gauge accuracy shall be $\pm 1\%$ of full scale value (Grade 1A). The enclosure rating shall be IP66. Manufacturer's series or model number shall be marked on each dial and the socket shall be stamped with the manufacturer's batch code.

- .2 Gauges installed in fire standpipe and sprinkler systems shall be a 90mm dial and be constructed of a black plastic. The dial shall be white aluminum with black and red markings. The wetted parts shall be made of a brass socket, silver alloy welds and a phosphor bronze bourdon tube. The movement shall be made of brass. The process connection shall be 6mm NPT bottom mount. The lens shall be a threaded polycarbonate and the pointer made of black aluminum. The gauge shall have an internal pointer and over-stop to guard against overpressure. Pressure gauge accuracy shall be $\pm 3-2-3\%$ of full scale (ASME grade B). The gauge shall be UL/cUL listed and FM approved with respective logos on the dial. The ambient or process temperature tolerance of the gauge shall be -40°F to 150°F (-40°C to 65°C) and the enclosure rating shall be IP52. The gauge shall come in 0/80/retard/250 psi (psi/kPa) range for air or 0/300 psi (psi/kPa) range for air and water. Manufacturer's series or model number shall be marked on the dial and the socket shall be stamped with the manufacturer's batch code. A blank installation date label shall be provided with each gauge, but not attached to it.
- .3 Select gauges to suit fluid working pressure and, if possible, test pressure. If test pressure falls outside safe instrument range, attach a note to this effect on the installation instructions. Ensure that the normal working pressure occurs approximately at mid-scale.
- .4 Pressure gauges shall have a 5-year manufacturer's warranty.
- .5 Standard of Acceptance:
 - .1 Terice
 - .2 Taylor
 - .3 Ashcroft
 - .4 Winters
 - .5 Dwyer

2.6 **FLOW INDICATORS**

- .1 Liquids
 - .1 Construction:
 - .1 Visual flow indication.
 - .2 Equipped with a dual flow scale L/s-USGPM.
 - .3 Protected against accidental breakage of the glass indicator.
 - .4 In-line type for pipe sizes up to 40mm dia.
 - .5 By-pass type with isolating valves for larger sizes.
 - .2 Standard of Acceptance:
 - .1 Xylem / Bell & Gossett
 - .2 Hedland
 - .3 Jogler

2.7 **VOLUME FLOW MEASUREMENT**

- .1 Turbine Type
 - .1 Operating Medium:
 - .1 Water

- .2 Condensate
 - .3 Make-up Softened Water
 - .2 Primary Flow Element:
 - .1 Bidirectional turbine flow meter
 - .3 Flow Transmitter:
 - .1 Measuring transmitter with 0-10 VDC pulse output
 - .2 Pulse output: 0.06 L/s / 0.6 L/s / 6.0 L/s
 - .3 Digital register (dual) L/s (USGPM)
 - .4 Maximum pressure drop 7 kPa at full flow
 - .5 Maximum operating temperature: 95°C
 - .6 Square root extractors
 - .7 Additional contacts for remote monitoring and/or initiation of system chemical feed pumps after each 200 litres
 - .8 Accuracy: $\pm 1\%$ of full range
 - .9 Repeatability: $\pm 0.1\%$
 - .10 Power supply: 120VAC
 - .4 Standard of Acceptance:
 - .1 Neptune
 - .2 Kent
 - .3 Elster
 - .4 Badger
- .2 Oscillating Piston Type
 - .1 Operating Medium:
 - .1 (No. 1) (No. 2) (No. 6) (Diesel) oil
 - .2 Primary Flow Element:
 - .1 Brass body, oscillating anodized aluminum piston
 - .2 Maximum operating pressure: 1550 kPa
 - .3 Mounting position: horizontal or vertical
 - .4 Type 316 stainless steel safety filter
 - .3 Flow Transmitter:
 - .1 Accuracy: $\pm 1\%$ over entire operating range
 - .2 Calibrated to No. 2 fuel oil at 21°C
 - .3 Register reading: 0.1 litres
 - .4 Inductive pulser for remote flow rate monitoring
 - .5 2 wire, 5-15 VDC output

- .4 Standard of Acceptance:
 - .1 ABB Industrial
 - .2 Badger
 - .3 Elster
 - .4 Kent
- .3 Rotary Type
 - .1 Operating Medium:
 - .1 Natural Gas
 - .2 Primary Flow Element:
 - .1 Rotary positive displacement
 - .2 Line mounting body style
 - .3 Contra-rotating impeller
 - .4 Splash lubricated ball bearing design
 - .3 Flow Transmitter
 - .1 Microprocessor based flow meter
 - .2 Alkaline battery operation
 - .3 Magnetic shaft sensors
 - .4 Single point temperature calibration/compensation
 - .5 Liquid crystal display in cubic metres
 - .6 Four isolated, adjustable output points
 - .7 Accuracy: $\pm 0.3^{\circ}\text{C}$
 - .8 Temperature resolution: 0.1°C
 - .9 Pulse outputs: 1 non-compensated, 2 compensated, 1 alarm
 - .10 Pulse output range: refer to drawings for each meter
 - .11 NEMA 4X enclosure
 - .4 Standard of Acceptance:
 - .1 Roots-Dresser
 - .2 Sage
 - .3 Norgas
 - .4 Eldridge Products
- .4 Differential Pressure Type
 - .1 Operating Medium:
 - .1 Water
 - .2 Steam
 - .3 Natural Gas

- .2 Primary Flow Element:
 - .1 Insertion bar or orifice differential pressure type
 - .2 Integral 3 valve manifold
 - .3 Pipe size: NPS 2 to NPS 20
 - .4 Material: Type 316SS
 - .5 Designed for "Hot-Tap" installation on existing piping)
- .3 Flow Rate Transmitter:
 - .1 Simultaneous calibration of flow element and transmitter
 - .2 Keypad entry and display of information including span and zero
 - .3 Accuracy: $\pm 1\%$ of reading over a minimum of 10:1 turndown
 - .4 Repeatability: $\pm 0.1\%$
 - .5 Output: 4-20 mA flowrate transmitter with a three valve manifold for isolation and testing
 - .6 Square root extractors
 - .7 Remote mounted for systems operating at 93°C and over
 - .8 NEMA 4 housing
 - .9 Power supply: 120 VAC
 - .10 HART communication module, overlaid on 4-20 mA wiring)
- .4 Standard of Acceptance:
 - .1 Annubar
 - .2 Elsag Bailey
 - .3 Rosemount
 - .4 Foxboro

2.8 **MASS FLOW**

- .1 Differential Pressure Type
 - .1 Operating Medium:
 - .1 Steam
 - .2 Natural Gas
 - .2 Primary Flow Element:
 - .1 Insertion bar or orifice differential pressure type
 - .2 Integral 3 valve manifold
 - .3 Pipe size: 50mm to 500mm
 - .4 Material: Type 316SS and Inconel
 - .5 Designed for "Hot-Tap" installation on existing piping)
 - .3 Flow Rate Transmitter:
 - .1 Simultaneous calibration of flow element and transmitter

- .2 Keypad entry and display of information including span and zero
- .3 Accuracy: $\pm 1\%$ of reading over a minimum of 10:1 turndown
- .4 Repeatability: $\pm 0.1\%$
- .5 Output: 4-20 mA flowrate transmitter with a three valve manifold for isolation and testing
- .6 Square root extractors
- .7 Remote mounted for systems operating at 93°C and over
- .8 NEMA 4 housing
- .9 Power supply: 120 VAC
- .4 Pressure Transmitter
 - .1 Piezo-electric silicon chip sensor
 - .2 Rangeability: 5:1 turndown
 - .3 Type 316SS body and drain valves
 - .4 Electronics housing: NEMA 4
 - .5 Output: 4-20 mA
 - .6 Power supply: 120 VAC
- .5 Temperature Sensor:
 - .1 Three wire, 100 OHM platinum RTD
 - .2 4-20 mA output
 - .3 Accuracy: 0.2% of calibrated span
 - .4 Aluminum housing
 - .5 Power supply: 24 VDC
- .6 Mass Flow Rate Computer:
 - .1 Calculates Reynolds numbers, flow profiles, and mass flow rate compensated for temperature and pressure
 - .2 Adjustable digital flow averaging
 - .3 Menu-driven software entered through face mounted keypad
 - .4 2 line x 20 character LCD display
 - .5 Output: RS-422 serial communication, dry contact, 2x 4-20 mA configurable
 - .6 Lithium battery back-up
 - .7 NEMA 4X enclosure
 - .8 Power supply: 120 VAC
- .7 Standard of Acceptance:
 - .1 Annubar
 - .2 Elsas Bailey
 - .3 Rosemount

.4 Foxboro

2.9 **AUXILIARY EQUIPMENT**

.1 Chart Recorders

- .1 (Wall mounted) (Free standing) flow meter:
 - .1 Single pen recorder for measuring volume flow for water
 - .2 Two pen recorder for measuring mass flow and pressure for steam and natural gas
 - .3 Electronic (7) day (circular) (or) (strip) chart
 - .4 One year supply of charts and ink
- .2 Standard of Acceptance:
 - .1 Elsag Bailey Controls Limited
 - .2 Fisher Controls
 - .3 Dietrich Standard

PART - 3 EXECUTION

3.1 **GENERAL**

- .1 Locate thermometers and pressure gauges that they can be easily read from a level of 1.5m above finished floor level.
- .2 Install thermometer wells in piping tee where thermometers are indicated, in vertical position. Fill well with oil or graphite and secure cap.
- .3 Thermometer wells installed in domestic water systems shall be lead-free.
- .4 Where direct reading instruments cannot be satisfactorily located use a remote instrument.
- .5 Locate remote instruments next to the point of reading, on wall or structure.
- .6 Each remote or panel mounted instrument shall have an engraved lamacoid nameplate identifying the system and service.
- .7 Insert pipeline thermometer into tanks, equipment tappings or in pipeline using screwed tees or forged steel couplings, welded into the lines.
- .8 Duct thermometers shall be attached to duct using sheet metal screws through thermometer flange.
- .9 Insert pressure gauges into equipment tappings or in pipelines using screwed tees or forged steel couplings welded into the lines.
- .10 When a common supply header or duct provides the same temperature water/air to many zones, provide a thermometer on the common header or duct only, rather than a thermometer on each branch.
- .11 For control valves with by-pass locate the thermometer in the common pipe to allow for manual temperature control.

3.2 THERMOMETERS

- .1 Thermometers to be installed with thermal paste to ensure accurate reading.
- .2 Install thermometers in the following locations, and where shown or specified:
 - .1 Entering and leaving side of each chilled and hot water coil, except individual reheat coils mounted in ductwork or in air terminal units.
 - .2 Return lines of main branches of heating, chilled, and condenser water systems.
 - .3 Entering and leaving sides of mixing valves.
 - .4 Supply and return lines at hot water boilers.
 - .5 Supply and return lines on primary heating water loops.
 - .6 Entering and leaving lines of liquid-to-liquid heat exchangers.
 - .7 On each branch of 3-port control valves, excluding valves serving hydronic terminal units such as fan coil and induction units, and individual reheat coils.
 - .8 Individual supply and return lines at each boiler, chiller evaporator and condenser.
 - .9 Heating and chilled water storage tanks.
 - .10 Domestic hot water storage tanks.
 - .11 In ducts, upstream and downstream from each coil, spray or humidifier, except individual reheat coils in ductwork.
 - .12 On each of the three ducts or plenums connected to mixing sections.
 - .13 On return air main ducts from each air handling zone.
 - .14 On outside air ducts connected to air handling units.
 - .15 Where shown on Drawings.

3.3 GAUGE GLASSES

- .1 Provide gauge glasses on all liquid reservoirs, normally not completely filled such as fire water storage and expansion tank, and where shown. Gauge glasses shall be along the full height of each tank. Individual gauge glasses shall be maximum 450 mm high. Where more than one gauge glass is required to give full coverage on any tank, glasses shall overlap by a minimum of 150 mm.
- .2 Provide shut-off valves on all connections to gauge glasses.

3.4 MANOMETERS

- .1 Install a manometer at each bank of filters to show the resistance to air flow through the filters. Where prefilters and final filters are mounted in a common frame it is only necessary to provide a single manometer to show the resistance across the total filter assembly. Where filters are separately mounted in individual frames provide a manometer for each set of filters.

3.5 PRESSURE GAUGES

- .1 Install each gauge complete with a 6mm needle valve, rated for 150°C and 41,368 kPa. Provide pressure snubber on all pump services and coil syphon for steam, air, gas service. Install pressure gauges as noted.

- .2 Install pressure gauges in the following locations, and where shown or specified.
 - .1 Individual supply and return lines at each boiler, water heater, chiller evaporator and condenser.
 - .2 Cooling tower headers.
 - .3 Entering and leaving side of heat exchangers in non-potable hydronic systems.
 - .4 Suction and discharge sides of all pumps and circulators (potable and non-potable hydronic, fire service).
 - .5 High and low sides of all pressure reducing or regulating stations (water, steam, air).
 - .6 Entering domestic water service.
 - .7 At the top of fire protection pipe risers.
 - .8 Expansion tanks.
 - .9 Entering and leaving side of pressure reducing valves.
 - .10 At each water supply connection to the fire suppression piping.
 - .11 At the highest point of each standpipe riser.
 - .12 On each fire storage tank.
 - .13 Where shown on Drawings.
- .3 Provide valved and capped gauge connection at:
 - .1 Entering and leaving side of heating water and chilled water coils in air supply units.
 - .2 Entering and leaving side of strainers.
 - .3 At the top and bottom of each supply and return riser (excluding perimeter risers).
 - .4 Entering and leaving side of heat exchangers in potable water systems.
 - .5 Where shown on Drawings.
- .4 Cap gauge connections after balancing of systems.

3.6 **METERING DEVICES**

- .1 Install flow measuring devices in horizontal straight pipe runs, free of valves and fittings.
- .2 Provide isolating valve at each connection to transmitter.
- .3 Length of straight pipe before and after metering elements.
 - .1 Not less than 1 m before and 1 m after or,
 - .2 As recommended by manufacturer.
- .4 Mount meters and provide piping and wiring between measuring elements and meters.

3.7 **REMOTE MEASURING ELEMENTS**

- .1 Where measuring element is located more than 1.8m above floor level, or is not otherwise readily accessible, locate transmitter at 1.2m above floor in accessible location.

- .2 Run signal lines in Schedule 40 threaded steel pipe, except final connections to transmitter can be in type L copper with silver solder joints. Bronze quarter turn isolating valve may be used in place of a dielectric union to separate the copper and steel pipe.
- .3 Provide isolating valve at each connection to transmitter, and provide valved and capped drains at bottom of signal risers.
- .4 For remote transmitters on steam service, provide inverted loop from top of flow measuring element, and provide colour dyed water in the drop leg to transmitter.

3.8 **CALIBRATION**

- .1 Provide services of manufacturer's service representative to calibrate and commission the equipment.
- .2 Make calibration checks on flow measuring instruments before attempting system balancing.
- .3 Return instrument systems failing to meet accuracy and repeatability criteria to the manufacturer for re-calibration and/or repair.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
 - .2 Provide bases, hangers and support for mechanical equipment and piping, all installed under the respective Sections' scope of Divisions 20, 21, 22, 23 and 25.
- .2 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.

1.2 RELATED WORK

- .1 The following work is provided under other Sections or Divisions of the Work:
 - .1 Spring hangers: Section 20 05 16 – Expansion Control
 - .2 Seismic restraint: Section 20 05 49 - Seismic Control
 - .3 Ductwork hangers: Section 23 31 00 - Ducts and Casings

1.3 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Hangers, supports, anchors, guides, and restraints shall be selected to withstand all static and dynamic loading conditions which act upon the piping system and associated equipment.
 - .3 Submit layout drawings showing types and placement of manufactured, pre-fabricated roof support systems. Submit details for roofing pad anchoring to roof structure.
 - .4 Submit a detailed design for anchors, guides, and their proposed connection to the structure, including reaction forces and loads imposed on structure prepared in conjunction with the expansion joint manufacturer. All drawings must be sealed by a professional engineer licensed in the project location jurisdiction.
 - .5 Submit design drawings for custom fabricated trapeze hangers, sealed by a professional engineer licensed in the project location jurisdiction. Include the following information:
 - .1 Construction detail drawing for each loading condition
 - .2 Span deflection calculations
 - .3 Building attachment load calculations and types
 - .6 Provide the services of the professional engineer who sealed the custom trapeze hanger shop drawings to conduct a general review of the completed installation on site. Engineer to submit a report summarizing their findings to the Consultant.

1.4 **REFERENCE STANDARDS**

- .1 ASME B31.1 – Power Piping
- .2 ASME B31.9 – Building Services Piping
- .3 ANSI/MSS SP 58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.
- .4 ASTM A780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
- .5 AWS D1.1 – Structural Welding Code, Steel
- .6 CAN/CSA-S16.1 - Limit States Design of Steel Structures.
- .7 CAN/CSA-G40.20/G40.21 - General Requirements for Rolled or Welded Structural Quality Steel.
- .8 CSA W47.1 - Certification of companies for fusion welding of steel.
- .9 CSA W48.1 - Filler metals and allied materials for metal arc welding.
- .10 CSA W59 - Welded Steel Construction (Metal Arc Welding).
- .11 CSA W117.2 - Safety in welding, cutting, and allied processes.
- .12 NFPA 13 - Installation of Sprinkler Systems

PART - 2 PRODUCTS

2.1 **GENERAL**

- .1 Hangers, supports, sway braces, to be made up from stock or production parts, manufactured and fabricated in accordance with ASME B31.1, ASME B31.9 and ANSI/MSS SP-58.
- .2 Select elements of pipe support systems to provide adequate factors of safety under loads applied by gravity, by temperature induced expansion and contraction, by internal pressure in mechanically jointed plain end pipe, and by change of momentum in fluid flow.

2.2 **QUALITY CONTROL**

- .1 Pipe support products shall be selected from manufacturers' standard product line.
- .2 Model designations from the manufacturers' catalogues noted in this Section are used to establish the quality standard and construction details permitting assessment of products from other manufacturers.
- .3 Standard of Acceptance
 - .1 Hangers:
 - .1 Anvil
 - .2 Myatt
 - .3 Taylor
 - .4 Carpenter & Paterson

- .5 Pentair/Erico
- .6 Eaton B-Line
- .2 Insulation shields:
 - .1 Anvil
 - .2 Myatt
 - .3 Taylor
 - .4 Pipe Shields Inc.

2.3 **HANGERS**

- .1 Horizontal pipe support – suspended
 - .1 Hot or cold suspended piping, including conduits, where horizontal movement is 25 mm or less and the hanger rod is longer than 300 mm.
 - .1 Clevis hanger – steel pipe
 - .1 Standard weight carbon steel clevis hanger with level adjustment and locknut (double bottom locknut), manufactured to ANSI/MSS SP 58 Type 1, equivalent to Anvil Figures 260 and 300. For Figure 260, provide clevis bolt spacer on insulated piping. Size hanger to include insulation thickness.
 - .2 For uninsulated fire suppression piping use standard weight galvanized carbon steel swivel ring hanger manufactured to ANSI/MSS SP 58 Type 10, ULC and FM approved, equivalent to Anvil Figure 69.
 - .2 Clevis hanger – copper pipe and tubing
 - .1 Light weight carbon steel epoxy-coated clevis hanger, with level adjustment and locknut (double bottom locknut), up to and including 100mm pipe dia. manufactured to ANSI/MSS SP 58 Type 12, equivalent to Anvil Figure CT-65.
 - .2 For copper tubing up to and including 25mm dia. use light weight carbon steel epoxy-coated swivel ring hanger manufactured to ANSI/MSS SP 58 Type 10, equivalent to Anvil Figure 97C.
 - .2 Suspended hot steel or copper piping having horizontal movement in excess of 25 mm or hot steel piping with hanger rod 300 mm or less.
 - .1 Roller hanger
 - .1 Shall be adjustable trapeze or yoke style roller type, 2-rod hanger with locknuts manufactured to ANSI/MSS SP 58 Type 41, equivalent to Anvil Figure 177 or 171 as applicable.
 - .2 Rollers of sufficient width to clear the outside diameter of the insulation on the piping.
 - .3 Support rollers at both ends, either by a yoke, swivel type hanger or by two adjustable rods with locknuts (double locknuts).
 - .4 On trapeze hangers and where pipe is supported from below, use adjustable pipe roller stand manufactured to ANSI/MSS SP 58 Type 46, equivalent to Anvil Figure 275.

- .3 Glass drainage piping.
 - .1 PVC coated, padded, carbon steel adjustable swivel ring hanger manufactured to ANSI/MSS SP 58 Type 10, equivalent to Anvil Figure CT-69.
 - .2 Galvanized, felt lined carbon steel, adjustable swivel ring hanger manufactured to ANSI/MSS SP 58 Type 10, equivalent to Anvil Figure 69F.
- .2 Horizontal pipe support – bottom supported
 - .1 Hot and cold, steel and copper piping.
 - .1 Adjustable pipe roller stand manufactured to ANSI/MSS SP 58 Type 44, equivalent to Anvil Figure 271.
- .3 Hanger rod
 - .1 Carbon steel, machine threaded rods
 - .1 Galvanized finish in mechanical rooms and in areas exposed to outdoors.
 - .2 Black steel finish in all other areas.
 - .2 For vertical adjustment of hanger rods, use forged steel turnbuckle manufactured to ANSI/MSS SP 58 Type 13, equivalent to Anvil Figure 230.
- .4 Upper Attachments
 - .1 Beam clamps
 - .1 For pipes 12mm to 50mm, bottom side attachment to standard I, M or W beams where thickness does not exceed 19mm, use malleable iron C-Clamp manufactured to ANSI/MSS SP 58 Type 23, ULC listed, equivalent to Anvil Figure 86. Maximum load 180 kg.
 - .2 For pipes 12mm to 50mm, top side attachment to standard I, M or W beams where thickness does not exceed 15mm, use malleable iron C-Clamp with zinc plated retaining clip manufactured to ANSI/MSS SP 58 Type 23, ULC listed, equivalent to Anvil Figure 86/89X. Maximum load 180 kg.
 - .3 For pipes 65mm to 200mm (to 100mm for FM approved applications), attach hanger rod centered under beam flanges using malleable beam clamp with steel tie rod and nuts manufactured to ANSI/MSS SP 58 Type 30, ULC listed, equivalent to Anvil Figure 218. Maximum beam width 178mm, maximum flange thickness 15mm. For FM approved application, use in combination with Figure 157 extension piece. Maximum load 619 kg.
 - .4 For pipes 65mm to 200mm, for centered support under beam flanges with beam width in excess of 178mm, and for pipes 150mm to 200mm in FM approved applications, use heavy duty carbon steel beam clamp with spacer, bolt and nuts manufactured to ANSI/MSS SP 58 Type 21, ULC listed and FM approved, equivalent to Anvil Figure 134. Maximum load 1,360 kg.
 - .5 For pipes 250mm and larger, provide supplementary steel members supported from structural steel.
 - .6 For cold pipes NPS 2 and under, supported from steel joists use carbon steel washer plates with double locking nuts, equivalent to Anvil Figure 60.

- .7 For cold pipes NPS 2-1/2 and larger and for hot pipes, supported from steel joists use carbon steel washer plates with double locking nut, carbon steel clevis and malleable iron socket.
- .2 Concrete inserts (new construction)
 - .1 For single or double pipe runs up to and including NPS 12, use universal concrete insert with galvanized malleable iron body and nut, universal nut style, manufactured to ANSI/MSS SP 58 Type 18, ULC listed and FM approved, equivalent to Anvil Figure 282.
 - .2 For pipe runs of three or more pipes use multiple inserts, spaced to suit the smallest pipe in group.
 - .1 Alternatively, use continuous hanger insert, cold formed hot dipped galvanized strip steel with end caps, 25mm x 41mm, equivalent to Power-Strut PS 449.
 - .3 For pipe runs 350mm and over, use special inserts.
- .3 Concrete clevis plates (existing concrete)
 - .1 Carbon steel plate with clevis and malleable iron socket and expansion case and bolt with minimum of two expansion cases and bolts for each hanger, equivalent to Anvil Figure 49. Used in conjunction with forged steel weldless eye nut manufactured to ANSI/MSS SP 58 Type 17, equivalent to Anvil Figure 290, or with carbon steel welded eye rod, equivalent to Anvil Figure 278.
 - .2 Do not use explosive driven anchors.
- .4 Self-drilling expansion type concrete inserts
 - .1 To secure miscellaneous equipment and materials to masonry or concrete construction already in place.
 - .2 Of sufficient number and size to prevent concrete from breaking away.
 - .3 Standard of Acceptance
 - .1 ITW
 - .2 Tapcon
 - .3 Hilti
- .5 Welding Studs
 - .1 Maximum size: 10mm for attaching miscellaneous materials and equipment to building steel.
 - .2 If the weight of materials or equipment requires bolts or studs larger than 10mm diameter, use steel clips or brackets, secured to building steel by welding or bolting, as approved by the Consultant.
 - .3 Standard of Acceptance
 - .1 Graham
 - .2 Omark
 - .3 Nelson

- .5 Trapeze hangers
 - .1 Performance
 - .1 Manufactured to product load listings, or
 - .2 Custom fabricated to maximum deflection between supports of 1/250 (0.4%) of span and for a minimum factor of safety of 5 times load to ultimate tensile or compressive strength.
 - .2 Construction
 - .1 Carbon steel shapes, to suit load application consisting of hollow steel section (equivalent to Anvil Figure 46), equal leg angle sections (equivalent to Anvil Figure 50), or double C channel "strong-back" with welded clips (equivalent to Anvil Figure 45).
 - .2 Assembly to include minimum two support hanger rods, selected for minimum factor of safety of 5 times the load to ultimate tensile or compressive strength of rod.
 - .3 Pipe restraint
 - .1 Restrain pipes from lateral movement using bolt-on angle brackets or pipe U-bolts manufactured to ANSI/MSS SP 58 Type 24 (equivalent to Anvil Figure 137), for manufactured hangers and welded-on angles for fabricated hangers, except where roller type hanger is indicated on the Drawings or in the Specification.
 - .4 Finish
 - .1 Galvanized finish in mechanical rooms and in areas exposed to outdoors.
 - .2 Black steel finish in all other areas.
- .6 Insulation Protection
 - .1 Insulation saddle, to be welded to pipe.
 - .1 Manufactured to ANSI/MSS SP 58 Type 39A and 39B, equivalent to Anvil Figure 160-165 as applicable.
 - .2 Insulation shields.
 - .1 Shop fabricated or manufactured plates of size required to properly fit the outside diameter of the pipe insulation, manufactured to ANSI/MSS SP 58 Type 40.
 - .2 Equivalent to Anvil figure 167, modified with holes at each end to suit 12mm wide stainless steel band clamps.
 - .3 Shop fabricate bearing plates conforming to the following table for various pipe sizes:

Pipe Size mm	Length of Plate mm	Thickness of Plate mm
12 to 50	300	1.2
75 to 100	300	1.52
150	450	1.52
200 and over	600	1.9

- .4 Form the bearing plates to the O.D. of the adjoining pipe insulation and extend the plate up to the horizontal centre line of the pipe.

2.4 PIPE SUPPORT

- .1 Vertical pipe support
 - .1 Steel or cast iron pipe
 - .1 Floor supported carbon steel riser clamp manufactured to ANSI/MSS SP-58 Type 8, ULC listed, field-welded pipe lugs, equivalent to Anvil Figure 261.
 - .2 Suspended carbon steel riser clamp manufactured to ANSI/MSS SP-58 Type 42, ULC listed, 4- or 6-bolt construction, field-welded pipe lugs, equivalent to Anvil Figure 40.
 - .2 Copper pipe
 - .1 Carbon steel, copper plated riser clamp manufactured to ANSI/MSS SP-58 Type 8, equivalent to Anvil Figure CT-121.
 - .3 Glass drainage piping
 - .1 Galvanized felt lined carbon steel riser clamps manufactured to ANSI/MSS SP-58 Type 4.
- .2 Pipe Guides
 - .1 Outer hinged housing with sliding spider clamp, carbon steel, equivalent to Anvil Figure 256.
- .3 Rooftop Support System
 - .1 Prefabricated pipe, duct and equipment support system
 - .1 Base: injection moulded plastic, structurally reinforced, or UV-resistant recycled rubber.
 - .2 Framing: hot dipped galvanized steel to ASTM A570 Grade 33 (stainless steel Type 304 to ASTM A 167), roll formed 2.7mm thick tubular sections. Tubing perforated with nominal 14mm diameter holes on nominal 50mm centres on 3 sides.
 - .3 Hangers: Carbon steel, machine threaded rods, galvanized finish.
 - .4 Clamps, bolts, nuts and washers to suit installation, same material as framing members.
 - .5 Roof pads to suit roof construction.
 - .2 Standard of Acceptance
 - .1 Portable Pipe Hangers
 - .2 Miro Industries
 - .3 Anvil
 - .4 Taylor
 - .5 Big Foot
 - .6 Advanced Support Products

2.5 EQUIPMENT SUPPORT

- .1 Concrete bases for housekeeping pads shall be:
 - .1 Constructed using plywood form work and 20 MPa concrete,
 - .2 Doweled to concrete floor slab with not less than 13 mm diameter steel rods.
 - .3 Plan dimensions:
 - .1 75 mm larger all around than base of apparatus for non-seismic applications;
 - .2 200 mm larger all around than base of apparatus for seismically restrained equipment;
 - .3 Finished to make smooth, neat surfaces with corners chamfered 25 mm.
 - .4 Minimum height conforming to the following table:

Equipment Description	Floor Type	Vibration Isolation	Pad Thickness mm
Stationary, not motorized	All	All	100
Motorized, up to 7.5 kW	All	-	100 150 (for fans)
Motorized, 11 to 19 kW	Slab on grade	No	250
	Slab on grade	Yes	150
	Suspended slab	Yes	150
Motorized, greater than 19 kW	Slab on grade	No	300
	Slab on grade	Yes	150
	Suspended slab	Yes	150

- .5 Unless otherwise noted, for air handling equipment, the height of the housekeeping pad shall be set to accommodate the full depth of condensate traps above the finished floor level.

PART - 3 EXECUTION

3.1 GENERAL

- .1 Provide supports required for the erection and support of the mechanical Work. Construct supports of steel, masonry or concrete, as noted or required. Ensure that steel supports in contact with water or high humidity are galvanized, with members bolted together using cadmium plated bolts, and all other support is made of primed steel.
- .2 Support suspended equipment from the bottom. Support tanks and other equipment with cast or welded steel saddles having proper curvature and inherent beam strength. Support plenums and sheet metal type air-handling units from auxiliary frames or beams under equipment. Support fans from structural steel frames with steel base plate. Cut, drill, and fit miscellaneous metal fabrications for pipe anchors and equipment supports. Comply with AWS D1.1 for procedures of manual shielded metal-arc welding, appearance and quality of welds made, methods used in correcting welding work. Grind smooth welds at exposed

connections so that no roughness shows after finishing, and so that contours of welded surfaces match adjacent contours. Read Division 05 – Metals, for further information.

- .3 Provide supports and suspended bases having ample strength to safely carry the load under all operating conditions and during testing. Submit support and base details to the Consultant for review. Design supports except springs with a minimum factor of safety of five (5) based on ultimate tensile strength at operating temperature.
- .4 Ensure that the load onto structures does not exceed the maximum loading as shown on structural Drawings or as directed by the Consultant.
- .5 Support or suspend piping with necessary hangers, structural supports and/or brackets, to prevent sagging, warping and vibration and to allow for movement due to expansion and contraction.
- .6 Install building attachments within concrete or to structural steel. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping.
- .7 In steel framed construction, support piping from structural members. Where structural members are not suitably located for upper hanger attachments and inserts of adequate capacity cannot be installed in floor slabs over, provide supplementary steel framing members fabricated as specified for trapeze hangers, mechanically fastened to structural steel. The use of diagonal hangers which will induce lateral stresses in the chord members of the joist is not permitted.
- .8 Do not allow loads of any nature to be transmitted through the piping connections to equipment not specifically designed for such loads.
 - .1 Where flexible connections are not called for at connections to equipment, support the pipe by stands attached to both pipe and supporting structure so that force in any direction is not transmitted to the equipment.
- .9 Use trapeze type hangers where pipes are grouped together, unless specifically indicated otherwise on the Drawings.
 - .1 Suspend horizontal member by adjustable rods with locking feature for maintaining level and slope.
 - .2 Space trapeze type hangers based on the closest interval required by any pipe supported thereon.
 - .3 Provide any auxiliary steel required to support trapeze between building steel.
- .10 Do not use explosive drive pins in any section of the Work without obtaining prior approval from the Consultant.

3.2 **HANGER INSTALLATION**

- .1 Support hangers directly from the structure only. Do not support pipes or equipment from other pipes, ducts, equipment, suspended ceiling, unless specifically shown on the Drawings.
- .2 Suspend hanger rods generally from certified inserts in concrete or by beam clamps. Before welding to steel structure members obtain prior permission of welding method from the Consultant and ensure that loads do not exceed the limit set by the Consultant. Ensure that hanging from floors and roofs made from pre-cast concrete members is from inserts originally cast into the members and provided by the Division 21, 22 or 23 Contractor, or by rods passing between the members connected to a steel plate resting on the upper

surface. To prevent raising of the hanger rod, install a lock nut and a minimum 50mm dia. flat washer tight against the under surface of the precast material.

- .3 Sliding guides must have sliding surfaces cleaned of all dirt, paint or corrosion and, except for Teflon, have coating of graphite paste added during erection. Adjust guides to allow for free sliding at operating conditions. After assembly, provide these guides with temporary protective cover or wrapping added to keep them free of debris during extent of construction work. When piping is ready to be put into service, remove this protective covering, blow out guides clean of all debris and add paste where applicable. Care must be taken that ample clearance is provided so as not to obstruct free sliding of guide.
- .4 Install copper, brass, and stainless steel pipes with 3mm thickness of di-electric packing between the pipe and the pipe attachment or use special pipe attachments specific for that service.
- .5 Install guides on pipes with expansion movement next to expansion joints. Consult with the expansion joint manufacturer and follow his instructions for number and spacing of guides. Use a minimum of two guides on each side of expansion joints.
- .6 Set hanger rods on steel and copper lines with expansion movement out of plumb in ambient temperature position, a distance equal to one-half pipe movement calculated from anchor point. Base movement on 25mm expansion per 30m of pipe length and 37°C temperature difference. Use toggle type insert for beam clamp for such locations.
- .7 Use roller type hanger only where shown on the Drawings or as described in this Specification.
- .8 Install all hangers close to points where pipes change direction or where branch piping drops or rises from main.
- .9 Install vertical riser suitably anchored and guided with manufactured or fabricated guides to maintain accurate vertical position. Protect insulated pipes with 2.2mm galvanized steel jacket at guides. Guide pipes with expansion movement and definite anchor points up to and including 100mm sizes, at every floor or 3m. Guide larger pipes and vertical cast iron pipes at every second floor or 7.5m.
- .10 For horizontal cast iron, glass, or polypropylene pipes where packed or friction type mechanical joints are used, provide a support at every joint in straight runs with maximum 1.5m between supports. Where fittings are joined together (elbows, wyes, etc.) provide a separate support for a minimum of every second fitting.
- .11 For horizontal cast iron, pipes where screwed or bolted type joints are used, the spacing or supports may be increased not to exceed 2.4m between supports, but provide a support for every joint and every second fitting as described above.
- .12 Use lockwasher with single nut on all bolted connections for pipe supports, anchors, guides and support steel, or use double nuts. Adhere fastening nuts, including top and bottom load nuts, and clevis bolt nuts, to threaded rods or fittings with Loctite 242.
- .13 During hydrostatic test on all air and vapour piping supported by springs or counterweights, install temporary rigid supports, blocking, or lock the spring against movement to prevent excessive strain on piping or equipment.
- .14 Place hangers and supports close to fittings, elbows, valves and/or other heavy parts.
- .15 Place suitably dampened spring hangers at the first three supports from the equipment connection on piping subject to excessive movement or shock from any source, thermal expansion and contraction.

- .1 Where it is evident that no undue loads will be transmitted to the equipment by the system concerned, i.e. small bore connections to comparatively large equipment, cold service piping not subject to shock, etc., then spring hangers may be omitted and standard hangers used.
- .16 Use spring hangers where vertical movement of the horizontal pipes may occur due to expansion or contraction. Refer to Sections 20 05 16 – Expansion Control and 20 05 48 – Vibration Control for further information.

3.3 HANGER SELECTION

- .1 Select lower attachment and insulation protection based on the following, unless otherwise shown on drawings:

Pipe Size NPS	Operating Temperature		
	Less than 21°C	Between 21°C and 43°C	Greater than 43°C
	Insulated	Non-insulated	Insulated
2 and less, steel	Clevis and Shield	Clevis only	Clevis
2-½ to 6, steel	Clevis and Shield	Clevis only	Roller and Saddle
8 and over, steel	Clevis and Shield	Roller only	Roller and Saddle
½ to 4, copper	Clevis and Shield	Clevis	Clevis and Shield, or Roller and Shield

- .2 Install temporary spacers between the insulation shield and the pipe equal to the thickness of insulation specified. Refer to Section 20 07 19 – Piping Insulation.
- .3 Do not use pipe hooks, chains, or perforated straps.

3.4 SADDLES AND ROLLER SUPPORTS

- .1 Place saddles at roller supports for steel pipes as specified above.
- .2 Weld saddles to black or galvanized steel piping.
- .3 Refinish galvanized surfaces destroyed by the welding with a zinc rich paint equivalent to W.R. Meadows "Galvafrid", Kerry Industries "ZRC" or Niagara Paint Inc. "PL052898".

3.5 INSULATION SHIELDS

- .1 Place insulation shields at pipe supports as specified above.
- .2 Field or factory punch a hole at each end of the shield to allow a 12mm stainless steel band clamp to pass through opening.
- .3 Secure shields with two 12mm stainless steel band clamps per shield.

3.6 HANGER SPACING

- .1 Horizontal runs of plumbing and drainage piping shall be supported as per the hanger spacing requirements described in the Ontario Building Code.
- .2 Place additional hangers in locations where there are concentrated loads such as valves, specialties, etc.

.3 Hanger spacing - black steel and galvanized pipe

- .1 For horizontal runs of black or galvanized steel pipe, other than for plumbing service, the maximum distances between supports and with minimum diameter rods shall be as follows. Exception: fuel oil, natural gas, propane, and medical gas piping.

Pipe Size mm	Rod Size mm	Spacing	
		Water Service m	Steam or Air m
12	10	1.5	1.5
20	10	1.8	2.1
25	10	2.1	2.7
32	10	2.1	2.7
40	10	2.7	3.6
50	10	3.0	3.9
65	12	3.0	4.2
75	12	3.6	4.5
100	16	4.2	5.0
150	19	5.0	6.4
200	22	5.7	7.3
250	22	5.7	7.3
300	22	7.0	7.9
350	25	7.6	9.7
400	25	8.2	10.6
450	25	8.5	11.2
500	32	9.0	11.8
600	32	9.7	12.8
750	5	10.0	13.4
900	5	13.7	18.0

.4 Hanger spacing - copper and stainless steel tubing

- .1 For horizontal runs of copper and stainless steel tubing for services other than plumbing, the maximum distances between supports and with minimum diameter rods shall be as follows. Exception: fuel oil, natural gas, propane, and medical gas piping.

Pipe Size mm	Rod Size mm	Spacing	
		Water Service m	Steam or Air m
Up to 20	10	1.5	1.8
25	10	1.8	2.4
32	10	2.0	2.7
40	10	2.4	3.0
50	10	2.4	3.3
65	12	2.7	3.9
75	12	3.0	4.2
100	16	3.6	4.8

.5 Hanger spacing - PVC or CPVC pipe

- .1 For horizontal runs of PVC or CPVC pipe for services other than plumbing, the maximum distances between supports and with minimum rods sizes for un-insulated pipe shall be as follows.

Pipe Size mm	Rod Size mm	Pipe Schedule			
		PVC 40 m	CPVC 40 m	PVC 80 m	CPVC 80 m
12	6	1.2	1.2	1.2	1.2
20	6	1.2	1.2	1.2	1.5
25	6	1.2	1.5	1.5	1.8
32	6	1.2	1.5	1.5	1.8
40	6	1.5	1.8	1.8	1.8
50	6	1.5	1.8	1.8	2.0
65	6	1.8	2.0	1.8	2.4
75	6	1.8	2.0	2.0	2.4
100	6	2.0	2.4	2.4	2.7
150	6	2.4	2.4	2.7	3.0
200	10	2.7	2.7	3.0	3.0
250	10	2.7	-	3.3	-
300	12	3.0	-	3.6	-

- .2 For insulated pipe, reduce spacing by 30%.

.6 Hanger spacing – cast iron pipe

- .1 Horizontal cast iron piping shall be supported with the following maximum horizontal spacing and minimum hanger rod diameters:

Pipe Size mm	Rod Size mm	Spacing m
40	10	1.5
50	10	1.5
65	12	1.5
75	12	1.5
100	16	1.5
150	19	1.5
200	19	1.5
250	22	1.5
300	22	1.5

- .2 Provide hangers within 450 mm of each joint, at each change of direction, and within 450 mm of the terminal end of each pipe run.
- .7 Refer to Section 22 63 00 - Gas Systems for Laboratory and Healthcare Facilities for special hanger requirements and spacing for Medical Gas Piping.
- .8 Refer to Section 23 11 13 - Fuel Oil Piping for hanger spacing for Fuel Oil Piping.
- .9 Refer to Section 23 11 23 - Natural-Gas Piping for hanger spacing for Natural Gas and Propane Piping.
- .10 Hanger spacing and hanger rod diameter for steel or copper flexible joint roll groove pipe to be as shown in the tables above for appropriate pipe material with not less than one hanger between joints, and with anchors and guides located to maintain piping true to line and grade.
- .11 Glass, plastic, and other special piping to be supported, anchored and guided to the pipe manufacturer's requirements.
- .12 Do not restrain axial movement.
- .13 Spacing shown is based on fluids with specific gravity of 1.0 and 26°C. For other conditions, use other published data approved by the Consultant.
- .14 For all drain pipe installed under structural slab on disturbed soil (up fill), suspend piping via galvanized clevis hangers embedded in the structural slab. Hanger spacing shall be per pipe manufacturer recommendations, maximum 1.5 m, with minimum of two (2) hangers per pipe length.

3.7 **TRAPEZE HANGERS**

- .1 Shim pipes on common trapeze hangers to slope each pipe in required direction.

- .2 Mechanical fasten shim plates to hanger. Shim plates and pipe lateral restraints may be fastened as one unit.

3.8 **VERTICAL PIPING SUPPORT**

- .1 Support vertical plumbing and drainage piping to meet the requirements of the Ontario Building Code, unless more stringent requirements are specified herein.
- .2 Vertical support spacing:
 - .1 Cast iron soil pipes: at every floor with riser clamps, or maximum at every 3m.
 - .2 PVC and CPVC pipes: at every 1.2m.
 - .3 Other piping: at every floor with riser clamps or maximum at every 3.6m, unless otherwise required by expansion conditions or otherwise specified.
- .3 Support bottom of risers with base fitting set on concrete pier or by hanger located at top of riser pipe as close to riser as possible.
- .4 Install riser clamps bolted securely to pipes. Rest ends of clamp on the pipe sleeve or on the floor. Weld shear lugs to steel pipe to transfer load to riser clamp. Solder cut segments of copper tubing to the copper pipe to prevent slippage of riser through the copper riser clamps.
- .5 Stabilize vertical piping laterally by fabricated brackets or malleable iron, extension type split hangers.
- .6 Run vertical piping at columns in the column webs, on either or both sides of the column, unless otherwise directed by the Consultant.

3.9 **ANCHORS AND GUIDES**

- .1 Use anchors where shown on the Drawings and/or as required to maintain permanent location of pipe lines.
- .2 Take special care in locating anchors to avoid introduction of undue reaction forces into the structure of the building, to flanges of pumps and equipment, to expansion joints and to the pipe.
- .3 Construct anchors for steel or galvanized pipe of approved steel straps and/or rods.
- .4 For anchoring copper lines, use copper plated anchors, or use insulation bands between tubing and clamps if steel straps or rods are used.
- .5 Provide minimum two (2) pipe guides on each side of an expansion joint or expansion compensator. Maintain 1200mm between each guide, and not more than 900mm between the last guide and the start of expansion joint or expansion compensator.
- .6 For special expansion joint/compensator or for special applications, where more than two guides on each side are required, follow manufacturer's recommendations for the location of guides.
- .7 Where guides are installed on cold piping, provide thermal break to prevent sweating.
- .8 Do not proceed with the installation of guides and anchors until after receipt of reviewed shop drawings.

3.10 **INSERTS**

- .1 Install inserts required for the attachment of hangers for suspensions of piping, ductwork or equipment. Size and space inserts for the loads to be supported.
- .2 Set inserts for pipes and equipment hangers onto formwork prior to pouring of concrete. Provide a 200mm length of rebar and wire through insert. Secure inserts firmly to formwork before concrete is poured.
- .3 In mechanical rooms, and other areas of multiple pipe runs:
 - .1 Provide continuous type insert channels at 1800mm intervals along the route of piping.
 - .2 Provide a 200mm length of rebar and wire through insert.
- .4 Supply inserts and location drawings for precast concrete to the precast supplier for casting into the material. Otherwise, include the cost of having the precast concrete supplier install the inserts at the Site in the Contract price.
- .5 For piping or equipment supported from existing concrete construction or from masonry drill and install threaded or expansion type inserts.
- .6 Do not install inserts into metal pan floor slab decking.

3.11 **THRUST RESTRAINTS**

- .1 Provide thrust restraint on plain end cast iron drain waste and vent pipe mechanical joints where required to accommodate axial thrust. Install bell clamps and rodding at each joint, at each T-branch and at each cleanout. Scope of bracing shall include but not be limited to all joints at the base of all vertical sanitary drains serving more than 10 storeys, including cleanouts, and all joints in suspended horizontal piping at the lowest level which drains by gravity to the street services.

3.12 **DOUBLE NUT REQUIREMENTS**

- .1 Upper Attachment
 - .1 Beam clamp: provide a double nut on end of beam clamp tie rod.
 - .2 C-clamp with retaining clip: not applicable.
 - .3 Supplemental steel: double nut all mechanical fasteners fixing supplemental steel to building structural steel.
- .2 Middle Attachment
 - .1 Upper load bearing point, to beam clamp or C-clamp: not applicable.
 - .2 Upper load bearing point, to supplemental steel: double nut on top of load bearing point, single nut on underside of bearing point.
 - .3 Lower load bearing point, all: double nut on underside of bearing point.
- .3 Lower attachment
 - .1 Clevis hanger: double nut on horizontal clevis bolt.
 - .2 Saddle hanger: refer to middle attachment requirements above.
 - .3 Trapeze hanger: refer to middle attachment requirements above.
 - .4 Apply Loctite 266 to the second nut (and match mark both nuts).

- .4 Upper Attachments - Structural Steel
 - .1 For pipe size NPS 10 and larger supported from structural steel:
 - .1 Provide supplementary structural steel and weld or bolt to structural steel.
 - .2 Submit plan drawings and details to the structural engineer for review.

3.13 **ROOF MOUNTED SUPPORT**

- .1 Manufacturer site responsibilities:
 - .1 Provide on-site assistance and inspection as required for installation.
 - .2 Provide layout drawing, located positions of each hanger.
- .2 Hanger system installation:
 - .1 Remove roofing ballast and debris from areas of base.
 - .2 Adhere roofing pad to roof membrane with adhesion system as recommended by manufacturer.
 - .3 Adhere base to roofing pad with adhesion system as recommended by manufacturer.
 - .4 Set frame legs in to bases and assemble hangers.
 - .5 Remove excess adhesive from frame, bases and pads.
 - .6 Replace roof ballast up to edge of base.

3.14 **EQUIPMENT SUPPORT**

- .1 Verify size of bases shown on structural Drawings with actual requirements and advise the Consultant and the respective trades if change in size or shape of the pad is required.
- .2 Place all suspended equipment on welded steel base of up to 150mm profile steel, stiffened with 3mm checkered steel plate (shall be provided under the scope of Division 05 – Metals).
- .3 Set equipment on supporting frames and brackets; install hangers, anchor bolts, vibration mountings and snubbers.
- .4 Set equipment base plates on housekeeping pads on minimum 13 mm (2 in) epoxy grout and fill hollow portion of base with concrete. Grout dowels in place. Bond pads and bases to floor. (Pad and concrete fill shall be provided under the scope of Division 03 – Concrete.)
- .5 Upon approval by the Consultant, concrete pads of 150mm maximum thickness may be poured under equipment after equipment is set in place, with concrete fully vibrated into place under the equipment base plate.
- .6 Install anchor bolts, vibration mountings and snubbers between equipment and housekeeping pad, or inertia pad and housekeeping pad.
- .7 Equipment subject to thermal expansion
 - .1 Applicable to hot equipment which is not supported on spring vibration isolators, including but not limited to:
 - .1 Boilers, hot water heaters,
 - .2 Heat exchangers,

- .3 Expansion tanks,
 - .4 Deaerator and condensate tanks, diesel exhaust SCR emission control units.
- .2 Fasten equipment to building structure to accommodate thermal expansion in accordance with manufacturer's instructions. In the absence of such instruction, fasten equipment support legs as follows unless otherwise shown:
 - .1 Rigidly fasten one support point which is closest to the piping connections;
 - .2 For supports located on the same transverse or longitudinal axis, provide guides with vertical restraint tabs, aligned in the direction of fixed support point;
 - .3 For other support points, do not fasten or guide.
 - .4 Provide 3mm thick PTFE (teflon) glide pads beneath each support leg.
- .8 Setting and alignment of rotating equipment (fans, pumps):
 - .1 Use millwrights to set and align to lines established using an engineer's level.
 - .2 Shim equipment using standard brass or bronze shim stock of suitable thickness to provide proper level and alignment.
 - .3 Have the Consultant approve equipment settings for equipment mounted on concrete pads or foundations prior to grouting.
 - .4 Re-check alignment prior to start-up of equipment.

3.15 **MISCELLANEOUS STEEL**

- .1 Hang or support equipment, piping, ductwork with miscellaneous structural supports, platforms, braces as may be required unless Drawings or other Sections of the Specification state otherwise.
- .2 Construction:
 - .1 Welded construction wherever practicable.
 - .2 Chip welds to remove slag, and grind smooth.
 - .3 Bolted joints allowed for field assembly using high strength steel bolts.
- .3 Painting and cleaning
 - .1 Clean steel to Steel Structures Painting Council SSPC-SP6, Commercial Blast Cleaning requirements.
 - .2 Apply one coat of oil alkyd primer conforming to CISC/CPMA 2-75 - Quick-drying Primer for Use on Structural Steel, to all miscellaneous steel.
 - .3 In the field, touch up all bolt heads and nuts, previously unpainted connections and surfaces damaged during erection with primer as hereinbefore specified.
 - .4 Apply two coats of primer to all surfaces which will be inaccessible after erection.
 - .5 Thoroughly remove all foreign matter from steelwork on completion of installation.

3.16 **SET-UP AFTER INSTALLATION**

- .1 Adjust hangers to equalize hanger loads, to support piping true to line and grade, and to minimize loads transferred through connections to equipment and outlets.

3.17 **COMPLETION**

- .1 Immediately after erection of anchors and supports, clean welds and paint exposed areas with a rust inhibitive paint.
- .2 Apply paint by brush to provide a minimum dry film thickness of 2.0 mils.
- .3 For galvanized surfaces clean welds, bolted connections and abraded areas; apply galvanizing repair paint to comply with ASTM A780.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

.1 Section includes:

- .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .2 Supply the Contractor performing the Work of Division 26 – Electrical with a complete motor list, including nominal power, voltage, phase, application, starter type and control interlocks of all motors provided under the scope of the Division 21, 22, and 23 Contracts. All motor control centres (MCCs) and loose motor starters will be provided under the scope of Division 26 – Electrical.

.2 Related Requirements:

- .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
- .2 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.

PART - 2 PRODUCTS

2.1 **NOT APPLICABLE.**

PART - 3 EXECUTION

3.1 **NOT APPLICABLE.**

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
 - .2 Provide vibration isolation for motor driven equipment, and restraints for isolated equipment to limit movement during start-up and normal operation.
- .2 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for vibration isolation equipment. Shop drawing shall include but not be limited to:
 - .1 Catalogue cuts and data sheets on specific vibration isolators to be utilized showing compliance with the specifications.
 - .2 An itemized list showing the items of equipment or piping to be isolated, the isolator type of model number selected, isolator loading and deflection, and reference to specific drawings showing base and construction where applicable.
 - .3 Grooved joint couplings and fittings shall be shown on drawings and product submittals, and shall be specifically identified with the applicable style or series designation.
 - .4 Written approval of the base design to be used, obtained from the equipment manufacturer.
 - .5 Drawings showing equipment base constructions for each machine, including dimensions, structural member sizes and support point locations.
 - .6 Drawings showing methods for isolation of pipes and ductwork piercing walls and slabs.
 - .7 Load calculations for selection of isolators, including supplemental bases, based on lowest operating speed of equipment supported.

1.3 RELATED WORK

- .1 The following Work is provided under other Sections or Divisions of the Work:
 - .1 Seismic restraints: Section 20 05 49 - Seismic Control
 - .2 Pipe movement control: Section 20 05 16 - Expansion Control
 - .3 Piping constant load supports: Section 20 05 29 - Bases, Hangers and Supports

1.4 **QUALITY ASSURANCE**

- .1 The objective of this Specification is to provide the necessary design for the control of noise and vibration in the Building due to the operation of machinery or equipment, and/or due to interconnected piping, ductwork, or conduit. The installation of all vibration isolation units, and associated hangers and bases, shall be under the direct supervision of the vibration isolation manufacturer's representative.
- .2 All vibration isolators shall have either known undeflected heights or calibration markings so that, after adjustment, when carrying their load, the deflection under load can be verified, thus determining that the load is within the proper range of the device and that the correct degree of vibration isolation is being provided according to the design.
- .3 All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves shall be furnished by the manufacturer and must be linear over a deflection range of not less than 50% above the design deflection.
- .4 The theoretical vertical natural frequency for each support point, based upon load per isolator and isolator stiffness, shall not differ from the design objectives for the equipment as a whole by more than 10%.
- .5 All neoprene mountings shall have a Shore hardness of 30 to 60, after minimum aging of 20 days or corresponding oven-aging.
- .6 All vibration isolation devices shall be the product of a single manufacturer.
- .7 Standard of Acceptance
 - .1 Kinetics
 - .2 BVA / Vibro-Acoustics
 - .3 Mason Industries
 - .4 Tecoustics

PART - 2 PRODUCTS

2.1 **GENERAL**

- .1 Designation for isolators and bases follow the designation set out in "Sound and Vibration Control" Chapter of the current ASHRAE HVAC Applications Handbook.

2.2 **TYPE 1A PAD TYPE ELASTOMETER MOUNT**

- .1 Elastomer pad shall have the following features:
 - .1 20mm minimum thickness per layer of pad.
 - .2 Suitable top bearing plate provided to uniformly distribute load.
 - .3 Ribbed or waffled design.
 - .4 15% deflection.
 - .5 Standard neoprene with moderate oil-resistance, compounded to hardness no greater than 70 durometer.
 - .6 1.6mm galvanized steel plate between multiple layers of pad thickness.
 - .7 Bolts through equipment and pad shall be oversized and provided with resilient washers and bushings.

2.3 TYPE 1B PAD TYPE ELASTOMETER MOUNT

- .1 Elastomer pad shall have the following features:
 - .1 High quality bridge bearing neoprene.
 - .2 3mm deflection.
 - .3 Maximum loading 6,895 kPa.
 - .4 Suitable bearing plate to distribute load.
 - .5 Minimum thickness 25mm.

2.4 TYPE 2A ELASTOMETER MOUNT

- .1 Neoprene mount shall have a minimum static deflection of 9mm. All metal surfaces shall be oil-resistant neoprene covered and have friction pads both top and bottom. Bolt holes shall be provided on the bottom and a tapped hole and cap screw on top. Steel rails shall be used above the mountings under equipment such as small vent sets to compensate for the overhang.
- .2 Neoprene shall be compounded to hardness no greater than 70 durometer.
- .3 Mount shall have straight line deflection curve.

2.5 TYPE 2B ELASTOMETER HANGER ROD ISOLATOR

- .1 Isolator shall incorporate a moulded unit type neoprene element and steel retainer box encasing the neoprene mounting.
- .2 Neoprene shall be compounded to hardness no greater than 70 durometer.
- .3 Isolator shall have sufficient clearance between mounting hanger rod and steel retainer box.

2.6 TYPE 3A SPRING ISOLATOR

- .1 Spring isolator shall be free standing and laterally stable without any housing and complete with a moulded neoprene cup or 6mm neoprene acoustical friction pad between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Installed and operating heights shall be equal. The ratio of the spring diameter divided by the compressed spring height shall be no less than 0.8. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection.
- .2 Isolator exposed to corrosive/outdoor environment shall be of corrosion resistant construction with neoprene coated springs, cadmium plated hardware and all other metal parts hot dip galvanized.
- .3 Springs shall be selected to be non-resonant with equipment forcing frequencies or support structure natural frequencies.

2.7 TYPE 3B SPRING HANGER ROD ISOLATOR

- .1 Isolator shall be manufactured with minimum characteristics as the Type 3A spring isolator, but without the neoprene element.
- .2 Springs shall be seated in a steel washer reinforced neoprene cup that has a neoprene bushing projecting through the bottom hole to prevent rod to hanger contact.

- .3 Spring diameters and the lower hole sizes shall be large enough to allow the hanger rod to swing through a 30° arc from side to side before contacting the cup bushing.
- .4 If ducts are suspended by flat strap iron, the hanger assembly shall be modified by the manufacturer with an eye on top of the box and on the bottom of the spring hanger rod to allow for bolting to the hanger straps.
- .5 Submittals on either of the above hangers shall include a scaled drawing of the hanger showing the 30° capability.
- .6 Where operating weight differs from installed weight, provide built-in adjustable limit stops to prevent equipment rising when weight is removed. Stops shall not be in contact during normal operation.

2.8 **TYPE 3C COMBINATION SPRING/ELASTOMETER HANGER ROD ISOLATOR**

- .1 Isolator shall consist of rigid steel frames containing minimum 32mm thick neoprene elements at the top and a steel spring with general characteristics as described in Type 3B, seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. In order to maintain stability the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc from side to side before contacting the cup bushing and short circuiting the spring.
- .2 Neoprene shall be compounded to hardness no greater than 70 durometer.

2.9 **TYPE 4 RESTRAINED SPRING ISOLATOR**

- .1 Isolator shall be the same as Type 3A, including built-in resilient vertical limit stops.
- .2 All restraining bolts shall have large rubber grommets to provide cushioning in the vertical as well as horizontal modes. The hole through the bushing shall be a minimum of 20mm larger in diameter than the restraining bolt. Horizontal clearance on the sides between the spring assembly and the housing shall be a minimum of 12mm to avoid bumping and interfering with the spring action. Vertical limit stops shall be out of contact during normal operation.
- .3 Top plate shall include tapped holes for bolting to equipment.
- .4 Isolator shall be capable of supporting equipment at a fixed elevation during equipment erection.
- .5 Housing and springs shall be powder coated and hardware electro-galvanized.

2.10 **DIRECT ISOLATION, TYPE A**

- .1 No base, isolator directly attached to equipment.

2.11 **INTEGRAL STRUCTURAL STEEL BASE, TYPE B**

- .1 Base to be reinforced as required to prevent base flexure at start-up and misalignment of drive and driven units. Rectangular bases are preferred for all equipment. Centrifugal refrigeration machines and pump bases may be T or L shaped. Pump bases for split case pumps shall be large enough to support suction and discharge elbows. Centrifugal fan bases shall be complete with motor slide rails, drilled for drive and driven unit mounting template.

- .2 All perimeter members shall be steel beams with a minimum depth equal to 1/10 of the longest dimension of the base. Base depth need not exceed 350mm provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Height saving brackets shall be employed in all mounting locations to provide a base clearance of 25mm.

2.12 **CONCRETE INERTIA BASE, TYPE C**

- .1 Concrete inertia base shall be formed in a structural steel perimeter base, reinforced as required to prevent flexure, misalignment of drive and driven unit or stress transfer into equipment.
- .2 The base shall be complete with motor slide rails, pump base elbow supports, and complete with equipment bolting provisions and isolators. Base shall be a minimum of 1/12 of the longest dimension of the base but not less than 150mm. The base depth need not exceed 300mm unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include minimum concrete reinforcing consisting of 12mm bars welded in place on 150mm centers running both ways in a layer 40mm above the bottom. Forms shall be furnished with steel templates to hold the anchor bolt sleeves and anchor bolts while concrete is being poured. Height saving brackets shall be employed in all mounting locations to maintain a 25mm minimum clearance between base and housekeeping pad. Wooden formed bases leaving a concrete rather than a steel finish are not acceptable.
- .3 Minimum thickness of the inertia base shall be according to the following tabulation:

Concrete Inertia Base	
Motor size kW	Min. thickness mm
up to 11	150
15-37	200
45-55	250
75-185	300
225-375	400

2.13 **SPRING ISOLATED ROOF CURB, TYPE D**

- .1 Structural roof curb assembly shall have a top and bottom frame resiliently connected by spring isolator complying with specification Type 3A.
- .2 The lower member shall consist of a sheet metal Z section containing adjustable and removable steel springs that support the upper floating section. The upper frame shall provide continuous support for the equipment and shall be captive so as to resiliently resist wind forces. All directional neoprene snubber bushings shall be a minimum of 6mm thick. Steel springs shall be laterally stable and rest on 6mm thick neoprene acoustical pads. Hardware shall be plated and the springs shall be provided with a rust resistant finish. The curb's waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curb's waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 50mm of insulation.

2.14 **MOUNTING TYPES AND STATIC DEFLECTION SCHEDULE**

Equipment				Slab on Grade			Suspended Slabs		
Type	Category	hp or other	RPM	Base Type	Isolator Type	Min. Defl. mm	Base Type	Isolator Type	Min. Defl. mm
Refrigeration Machines and Chillers	Reciprocating	All	All	A	2A	6	A	4	38
	Centrifugal scroll	All	All	A	1A	6	A	4	38
	Screw	All	All	A	1A	25	A	4	64
	Absorption	All	All	A	1A	6	A	4	38
	Air-cooled recip, scroll	All	All	A	2A	6	A	4	38
	Air-cooled screw	All	All	A	4	25	B	4	64
Air Compressors and Vacuum Pumps	Tank-mtd horiz.	≤10	All	A	3A	19	A	3A	38
		≥15	All	C	3A	19	C	3A	38
	Tank-mtd vert.	All	All	C	3A	19	C	3A	38
	Base-mtd	All	All	C	3A	19	C	3A	38
	Large recip	All	All	C	3A	19	C	3A	38
Pumps	Close coupled	≤7.5	All	B	2A	6	C	3A	19
		≥10	All	C	3A	19	C	3A	38
	Inline	5 to 25	All	A	3A	19	A	3A	38
		≥30	All	A	3A	38	A	3A	38
	End suction,	≤40	All	C	3A	19	C	3A	38
	double suction	50 to 125	All	C	3A	19	C	3A	38
	split case	≥150	All	C	3A	19	C	3A	64
	Packaged pump	All	All	A	3A	19	C	3A	38
Cooling towers	All	All	≤300	A	1B	6	A	4	89
			301to500	A	1B	6	A	4	64
			≥501	A	1B	6	A	4	19
Boilers	Fire-tube	All	All	A	1A	6	B	4	38
	Water-tube	All	All	A	1A	3	A	1A	3
	Steam	All	All	A	1A	6	B	4	38
Fans: axial, plenum, cabinet, inline	≤ 550mm dia.	All	All	A	2A	6	C	3A	19
	≥ 600mm dia.	≤500Pa	≤300	B	3A	64	C	3A	89
		static	301to500	B	3A	19	C	3A	64
		press.	≥501	B	3A	19	B	3A	38
		>≤500Pa	≤300	C	3A	64	C	3A	89
		static	301to500	C	3A	38	C	3A	64
		press.	≥501	C	3A	19	C	3A	38
Centrifugal fans	≤ 550mm dia.	All	All	B	2A	6	B	3A	19
	≥ 600mm dia.	≤40	≤300	B	3A	64	B	3A	89
			301to500	B	3A	38	B	3A	64
			≥501	B	3A	19	B	3A	19
		≥50	≤300	C	3A	64	C	3A	89
			301to500	C	3A	38	C	3A	64
			≥501	C	3A	25	C	3A	38
Propeller fans	Wall-mounted	All	All	A	1A	6	A	1A	6
	Roof-exhauster	All	All	A	1A	6	D	4	38

Equipment				Slab on Grade			Suspended Slabs		
Type	Category	hp or other	RPM	Base Type	Isolator Type	Min. Defl. mm	Base Type	Isolator Type	Min. Defl. mm
Heat pumps, fan coils, CRAC units	All	All	All	A	3A	19	A	3A	19
Condensing units	All	All	All	A	1A	6	A	4	38
AHUs, AC, heating and ventilation units	All	≤10	All	A	3A	19	A	3A	19
	All	≤15,	≤300	A	3A	19	B	3A	89
		≤1 kPa	301to500	A	3A	19	A	3A	64
		static pr.	≥501	A	3A	19	A	3A	38
		>15,	≤300	B	3A	19	B	3A	89
		>1 kPa	301to500	B	3A	19	B	3A	64
		static pr.	≥501	B	3A	19	B	3A	38
Packaged RTUs	All	All	All	A	1B	6	D	3A	19
Ducted rotating equipment	Small fans, fan powered boxes	≤600 cfm		A	3A	13	A	3A	13
		>600 cfm		A	3A	19	A	3A	19
Heat exchangers, tanks	Plate and frame			See spec	1A	3	See spec	1A	3
Piping (see specs)	Floor supported			-	4	25	-	4	25
	Suspended						-	3C	32

PART - 3 EXECUTION

3.1 GENERAL

- .1 Install all products in accordance with manufacturer's written instructions. Vibration isolators must not cause any change or position of equipment or piping resulting in piping stresses or misalignment.
- .2 Provide through the manufacturer all vibration isolation equipment work and measures to prevent the transmission of objectionable vibration to the building structure and from one area to another area. Provide all necessary drawings indicating isolator locations and base dimensions. Have the installation directed and supervised by the manufacturer. Supply to the manufacturer the necessary copies of all drawings of equipment to be isolated.
- .3 Consider the areas classified as follows for selection of vibration control devices:
 - .1 Mechanical rooms or equipment locations in basement or sub-basement areas only and not bordering areas regularly occupied are 'non-critical'.
 - .2 Mechanical rooms or equipment locations bordering habitable suites, boardrooms, conference rooms, private offices are 'ultra-critical'. This shall include all mechanical penthouses and all mechanical compartment rooms.

- .4 Vibration isolation is not required for the following systems between equipment and building, but provide isolated connection to these for pipes and ducts:
 - .1 Fire pumps;
 - .2 Sump pumps, sewage pumps;
 - .3 Dedicated smoke venting and smoke control fans.
- .5 All piping and ductwork required to be isolated shall freely pass through walls and floors without rigid connections. Penetration points shall be sleeved using acoustical sleeves, or otherwise formed to allow passage of piping or ductwork, and maintain a 20mm to 32mm clearance around the outside surfaces. This clearance space shall be tightly packed with fiberglass, and caulked airtight after installation of piping or ductwork.
- .6 No rigid connections between equipment and building structure shall be made that degrades the noise and vibration isolation system herein specified.
- .7 Electrical conduit connections to isolated equipment shall be flexible to allow free motion of isolated equipment.
- .8 Do not install any equipment, piping, or conduit, which makes rigid contact with the building unless permitted in this Specification. Building includes, but is not limited to: slabs, beams, columns, studs, and walls.
- .9 Coordinate Work with other Contractor's Work to avoid rigid contact with the building. Inform other Contractors following the Mechanical Work, such as plastering or electrical, to avoid any contact which would reduce the vibration isolation.
- .10 Bring to the Consultant's attention prior to installation any conflicts with the Work of other Contractors, which will result in unavoidable rigid contact with equipment or piping as described herein, due to inadequate space or other unforeseen conditions. Corrective work necessitated by conflicts after installation shall be at the responsible Contractor's expense.
- .11 Diagonal restraints shall be attached at the centerline of thrust.
- .12 Vertical piping loads, including water strainers, valves between pump base elbow supports, and the suction and discharge header piping shall be supported by the pump base spring isolators without stress or strain to the pump housing.

3.2 **EQUIPMENT ISOLATORS**

- .1 Mount vibration isolating devices and related inertia blocks on the concrete housekeeping pad.
- .2 Each fan and motor assembly shall be supported on a single structural steel frame. Provide all ductwork connected to vibration-isolated equipment at both inlet and outlet with flexible connectors having sufficient length and flexibility to eliminate vibration transmission and to not short circuit the effectiveness of the vibration isolation. Make flexible connections of glass fibreglass cloth sleeves, sealed to prevent air leakage. Install a minimum length of flexible connection on both sides equal to static pressure of the fan in inches but not less than 150mm.
- .3 The machine required to be isolated shall be supported by a structural steel frame or concrete inertia base.
- .4 Brackets shall be provided to accommodate the isolator. The vertical position and size of the bracket shall be specified by the isolation manufacturer.

- .5 The minimum operating clearance between the equipment frame or rigid steel base frame and the housekeeping pad or floor shall be 25mm. Minimum operating clearance between concrete inertia and base and housekeeping pad or floor shall be 50mm.
- .6 The equipment structural steel or concrete inertia base shall be placed in position and supported temporarily by blocks or shims, as appropriate, prior to the installation of the machine or isolators.
- .7 The isolators shall be installed without raising the machine and frame assembly.
- .8 After the entire installation is complete and under full operational load, the isolators shall be adjusted so that the load is transferred from the blocks to the isolators. When all isolators are properly adjusted, the blocks or shims shall be barely free and shall be removed.
- .9 Air handling equipment and centrifugal fans shall be protected using horizontal thrust restraints against excessive displacement weight which results from high air thrust when thrust forces exceed 10% of the equipment.
- .10 Rooftop equipment isolators must be bolted to the equipment and structure. Mountings must be designed to resist 160 km/h wind loads.
- .11 Isolation mounting deflection shall be the minimum as specified or scheduled on Drawings.
- .12 Verify that all installed isolator and mounting systems permit equipment motion in all directions. Adjust or provide additional resilient restraints to flexibly limit start-up equipment lateral motion to 6mm.
- .13 Prior to start-up, clean out all foreign matter between bases and equipment. Verify that there are no isolation short circuits in the base or isolators.

3.3 **PIPING ISOLATORS**

- .1 Where piping connects to mechanical equipment install expansion joints, or stainless hoses if expansion joints are not suitable for the service. All piping passing through the equipment walls, floors or ceilings shall be protected against sound leakage by means of an acoustical seal.
- .2 Isolate piping outside shafts as follows:
 - .1 All water piping in machine rooms, including strainers, filters, valves and associated equipment with water systems.
 - .2 Piping and associated equipment where exposed on roof.
 - .3 Water piping within 12.2m or 100 x pipe diameters, whichever is greater, from connected rotating equipment, using Type 3C hangers with the same static deflection as specified for the equipment. If piping is connected to equipment located beneath occupied spaces and hangs from ceilings under occupied spaces, the first four hangers shall have a minimum deflection of 20mm for pipe sizes up to and including 75mm, 40mm deflection for pipe sizes over 75mm and up to 150mm, and 65mm deflection for larger sizes.
- .3 The isolators shall be installed with the isolator hanger box attached to, or hung as close as possible to, the main structural elements of the building.
- .4 The isolators shall be suspended from substantial structural members, not from slab diaphragm unless specifically permitted.
- .5 Hanger rods shall be aligned to clear the hanger box.

- .6 Horizontal suspended pipe 50mm and smaller, and all steam piping shall be suspended using Type 2B isolator with a minimum 6mm deflection. Water pipe larger than 50mm shall be supported by Type 3C isolator with a minimum 32mm static deflection.
- .7 Horizontal pipe floor supported at slab shall be supported via Type 3A or 4, with a minimum static deflection of 25mm or same deflection as isolated equipment to which pipe connects whichever is the greater.
- .8 All vertical risers shall be supported by spring isolators designed to support the riser filled with water, if it is a water line. Assigned loads must be within the building design limits at the support points. The initial spring deflection shall be a minimum 20mm or four times the thermal movement at the isolator location, whichever is greater. Proper provision shall be made for seismic protection in seismic zones. Support spring mountings shall be Type 3A, anchors and telescoping guides as described under the Products section.
- .9 Pipe sway braces, where required, shall utilize two (2) neoprene elements (Type 2A to accommodate tension and compression forces).
- .10 Provide alignment connector at riser takeoffs, cooling and heating coils, and elsewhere as required to accommodate thermal expansion and misalignment.

3.4 **DUCT ISOLATORS**

- .1 All air ducts with a cross section of 0.19 m² or larger shall be isolated from the building structure by Type 3B hangers or Type 3A floor supports with a minimum deflection of 20mm. Isolators shall continue for minimum 15m from the equipment. If air velocity exceeds 5.3 m/s, hangers or supports shall continue for an additional 15m or as shown on the Drawings.

3.5 **ISOLATOR POSITION**

- .1 Install isolators close to building structure, and between building structure and supplementary steel if required.
- .2 Suspend isolators from rigid and massive support points.
- .3 Supplementary steel to be sized for a maximum deflection of 1.6mm at center span.
- .4 Support piping in shafts and floor supports entering shaft with Type 4 isolators or Type 3C hangers depending on piping loads and support point space conditions within shafts.
- .5 Guide piping in shafts as required with approved mounting designs incorporating all directional elastomeric mountings to building. Prevent direct contact of piping with building structure.

3.6 **MANUFACTURER'S REVIEW**

- .1 On completion of installation of all vibration isolation devices herein specified, the vibration isolation manufacturer shall inspect the completed system; check the vibration levels in the areas as requested by the Consultant, and report in writing any installation error, improperly selected isolation devices, or other faults in the system that could affect the performance of the system. A written report shall be submitted outlining corrective work necessary to comply with the above specifications. Corrective work shall be the responsibility of the respective installing Contractor performing the Work of Division 21, 22 or 23.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
 - .2 Provide seismic restraining to limit movement of piping, ducts, conduits, bus ducts, cable trays and equipment installed under the scope of Divisions 21, 22, and 23.
- .2 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.
- .3 The requirements of this Section are in addition to the requirements for equipment, piping and duct supports and vibration isolation specified under the Work of other Sections.
- .4 Where specifications of materials and methods of this Section differ from those under other Sections of Division 20, this Section shall govern, including but not limited to vibration isolation devices.
- .5 Seismically restrain the following equipment and systems:
 - .1 Piping:
 - .1 Medical gas, natural gas, vacuum, petroleum based liquids and compressed air: 25mm and over;
 - .2 Piping located inside of mechanical equipment and service rooms: 32mm and over;
 - .3 All other piping: 65mm and over.
 - .2 Fire protection piping – sprinkler systems:
 - .1 Design and install seismic restraint systems in accordance with the requirements of NFPA 13.
 - .3 Ductwork:
 - .1 Rectangular and oval ductwork with cross sectional area 0.55 m² and over;
 - .2 Round ducts with diameters 710 mm and over.
 - .4 Electrical systems:
 - .1 Conduit 65 mm and over;
 - .2 Cable trays supporting conduit which is 65 mm and over.
 - .5 Equipment:
 - .1 Vibration isolated equipment;
 - .2 Rigidly or gravity supported equipment.

- .6 The following services do not require seismic restraining:
 - .1 Piping suspended from hangers at a distance of 305 mm or less, measured from the top surface of the pipe, to the underside of the supporting structure above;
 - .2 Ductwork suspended by hangers at a distance of 305 mm or less, measured from the top surface of the duct to the underside of the supporting structure above;
 - .3 Electrical conduit or cable trays suspended by hangers at a distance of 305 mm or less, measured from the top surface of the conduit / tray to the underside of the supporting structure above.

1.2 **RELATED WORK**

- .1 The following Work is provided under other Sections or Divisions of the Work:
 - .1 Anchors, guides, building attachments: Section 20 05 29 - Bases, Hangers and Supports.
 - .2 Pipe movement control: Section 20 05 16 - Expansion Control.
 - .3 Vibration isolation: Section 20 05 48 – Vibration Control.

1.3 **DESIGN CRITERIA**

- .1 Design seismic and wind restraint systems to conform to the requirements of the provincial and federal codes applicable for the project location jurisdiction.

1.4 **SUBMITTALS**

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for seismic and wind restraining systems and products.
 - .3 Submit a test certificate for each restraint device, identifying maximum tested load capacities.
 - .4 Submit calculations for each piece of restrained equipment, piping, ductwork and conduit, including seismic and/or wind forces, restraint selection, and selection data.
 - .5 Provide a calculation analysis summary for each piece of equipment, including the following information:
 - .1 Equipment designation;
 - .2 Location;
 - .3 Horizontal seismic force factor;
 - .4 Equipment weight;
 - .5 Horizontal seismic force;
 - .6 Vertical uplift seismic force (where applicable);
 - .7 Equipment centre of gravity in three directions;
 - .8 Design condition (worst case) overturning moment;
 - .9 Number of restraint fastenings;
 - .10 Pull-out tension per fastener;

- .11 Horizontal shear per fastener;
- .12 Pull-out tension load rating per fastener;
- .13 Horizontal shear rating per fastener.
- .6 Include worst case combination of tension and shear loads at each snubber and restraint location.
- .7 Include anchor bolt diameters, embedment depth, full welding details including type and length for field welds, and required housekeeping base dimensions.
- .8 Calculations shall be sealed by a Professional Engineer licensed in the project location jurisdiction.

1.5 **REFERENCE STANDARDS**

- .1 SMACNA - Seismic Restraint Manual Guidelines for Mechanical Systems
- .2 ASHRAE - HVAC Applications Handbook, "Seismic and Wind Restraint Design" Chapter
- .3 MSS SP-127 - Bracing for Piping Systems Seismic - Wind - Dynamic Design, Selection, Application
- .4 ACI 355.2 - Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary

1.6 **QUALITY ASSURANCE**

- .1 Manufacturer's qualifications: company shall be a regular member of the Vibration Isolation and Seismic Control Manufacturers Association (VISCMA). The manufacturer must be regularly engaged in the manufacture of seismic and wind restraint products of type, size, and capacity required, whose products have been in satisfactory use in similar service for not less than 5 years with product data and installation instructions available online on the manufacturer's website along with a proof of VISCMA membership.
- .2 Provide the services of the restraining system manufacturer's technical representative to conduct site inspections of the Work in progress, and to conduct a final inspection of the Work. Provide a copy of the final inspection report to the Consultant and the Owner for review.
- .3 Request and arrange for a construction review by the Consultant of the completed seismic restraint installation before any ceilings are installed.

PART - 2 PRODUCTS

2.1 **GENERAL**

- .1 Standard of Acceptance
 - .1 Kinetics
 - .2 BVA / Vibro-Acoustics
 - .3 Mason Industries
 - .4 Tecoustics
 - .5 Hilti

2.2 CONCRETE ANCHORS

- .1 Post-installed anchors in concrete shall be qualified for seismic/wind restraint application.
- .2 Mechanical anchor bolts: Concrete screw type, drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications.
- .3 Adhesive anchor bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications.

2.3 SEISMIC SNUBBER

- .1 Structural steel angle with surfaces covered with ribbed neoprene pads to cushion contact with snubber. Customized snubber designs may use other structural shapes and configurations as required. Snubbers shall be designed to limit equipment motion to no more than 6 mm in any direction.

2.4 SEISMIC / WIND SPRING FLOOR MOUNTS

- .1 Laterally stable, restrained spring type with support for bolting to the equipment. Springs shall be supported either with a neoprene cup. Mount shall include an integral all-directional limit stop with an elastomeric grommet preventing metal-to-metal contact and with minimum 6mm clearance under normal operation.

2.5 SEISMIC / WIND RESTRAINED SPRING ISOLATOR

- .1 Laterally stable, restrained spring type with housings and heavy top plates for supporting the equipment and resisting wind loading. Housings shall be of welded high grade steel construction and include only (2) vertically restraining high strength limit stops. Maximum clearance around the restraining bolts shall be 6mm. Top plate and restraining bolts shall be out of contact with the housing during normal operation and all directional snubbers shall be incorporated to minimize short-circuiting of restraining bolts. Isolators shall have a static deflection of up to 100mm as needed. Provide factory installed oversized base plate where required for anchor distribution purposes.

2.6 SEISMIC CABLE RESTRAINTS

- .1 Preassembled adjustable seismic cable sway bracing restraints shall consist of 7x19 galvanized steel aircraft cable sized to resist seismic loads. Cable restraint system shall be completely preassembled to eliminate onsite assembly of restraint components and must allow quick and easy adjustment on the length of the cable after the installation to remove excessive sag on the cable. Cable end connections shall use steel heavy duty brackets, thimbles with cable installation mechanism. Wire rope restraints shall have wire rope clips.

2.7 RIGID RESTRAINTS

- .1 Seismic rigid sway bracing restraints shall include heavy duty brackets made of high-strength, low alloy steel designed to provide enough strength to withstand seismic load. To prevent any confusion, brackets shall be universal used for both structure and equipment attachments and shall accommodate post-installation of seismic restraints without the requirement of disassembling the hanger rod or any component of the equipment. No drilling shall be required to secure rigid restraint brackets to the rigid brace, and rigid restraint system shall include special grade hardware for attachments. Rigid restraint brackets shall be color-coded for capacity identification.

2.8 HANGER ROD STIFFENER

- .1 Consists of structural steel angle attached with a formed steel clamp to threaded rod support. Steel angle shall be provided by the Mechanical Contractor; steel clamp shall be provided by the seismic restraint manufacturer.

2.9 SEISMIC INLINE PUMP STANDS

- .1 Trapezoidal-shaped rigid support stands shall be made of high strength, low alloy steel designed to connect to pipe flanges which support vertical inline pumps. Stands shall include neoprene grommet washers for anchor bolts and shall be designed to provide adequate restraint for connected equipment to resist seismic loads. Provide vibration isolation pads under pump stands as shown on installation details.

2.10 SEISMIC PIPE STAND

- .1 Rigid support pipe stands shall be made of high-strength steel rigid restraints, low alloy designed to support the dead load, and provide enough strength to withstand at least 1 g of lateral seismic force. In addition to providing allowance for roof slopes, the adjustable height stands shall be used to accommodate changing pipe sizes.

2.11 SEISMIC RESTRAINT BRACKETS

- .1 Formed steel brackets for securing floor-mounted equipment complete with pre-drilled holes. Brackets shall be galvanized or powder coated enamel for corrosion protection.

2.12 SEISMIC V-CONNECTORS

- .1 V connectors shall allow standard 50mm, 75mm, 100mm or greater movements along the 6 directions of XY, YZ and XZ planes. V-connectors use two 45° elbows and one 90° elbow for a total of 180° in pipe change. Large connectors shall be supplied with shipping bars tack welded at factory to maintain designed length. For steam applications, a drain port and plug shall be specified and factory installed into the bottom of the 90° elbow to allow condensate to be drained. Flange, weld, threaded, groove or copper tube end fittings are provided to match connecting pipe.

2.13 RIGIDLY MOUNTED EQUIPMENT RESTRAINT

- .1 Undercut or heavy-duty sleeve type, for post concrete-cure installation:
 - .1 Carbon steel bolt, nut and sleeve;
 - .2 Selected for concurrent shear and tension loads with a safety factor not less than 2.0 times the estimated load.

PART - 3 EXECUTION

3.1 GENERAL

- .1 All equipment, piping and ductwork shall be restrained to resist seismic and/or wind forces per the requirements of the applicable provincial or federal building code as a minimum. Restraint attachments shall be made by bolts, welds or a positive fastening method. Friction shall not be considered. All attachments shall be proven capable of accepting the required wind load by calculations. Additional requirements specified herein are included specifically for this project.
- .2 Install seismic and wind restraint devices per the manufacturer's submittals. Any deviation from the manufacturer's instructions shall be reviewed and approved by the manufacturer.

- .3 Attachment to structure for suspended equipment, pipe and duct: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- .4 Wall penetrations through masonry and poured concrete walls may be used as bracing locations provided the wall can provide adequate resistance without significant damage, and sleeves and fire stopping materials are installed correctly.
- .5 Coordinate sizes and locations of cast-in-place inserts for post-tensioned slabs with seismic restraint manufacturer.
- .6 Provide hanger rod stiffeners where indicated or as required to prevent buckling of rods due to seismic forces.
- .7 Where rigid restraints are used on equipment, ductwork or piping, support rods for the equipment, ductwork or piping at restraint locations shall be supported by anchors rated for seismic use. Post-installed concrete anchors shall be installed in accordance with the requirements of ACI 355.2.
- .8 Ensure housekeeping pads have adequate space to mount equipment and seismic restraint devices, and are large enough to ensure adequate edge distance for restraint anchor bolts to avoid housekeeping pad breakout failure.
- .9 Install snubber devices only after equipment is installed and operating, to ensure no metal-to-metal contact.
- .10 Racked piping systems may have the rack braced (laterally, longitudinally, or combination thereof), provided each pipe supported by the rack is restrained to the rack.

3.2 **CONCRETE ANCHOR BOLTS**

- .1 Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural Consultant if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre- or post-tensioned tendons, electrical and telecommunications conduit, and all other embedded services.
- .2 Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
- .3 Mechanical anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
- .4 Adhesive anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
- .5 Set anchors to manufacturer's recommended torque, using a torque wrench.

3.3 **EQUIPMENT RESTRAINTS**

- .1 Seismically restrain equipment. Install fasteners, straps and brackets as required to secure the equipment.

- .2 Install seismic snubbers on mechanical equipment supported by floor-mounted, non-seismic vibration isolators. Locate snubbers as close as possible to vibration isolators and attach to equipment base and supporting structure as required.
- .3 Install neoprene grommet washers on equipment anchor bolts where clearance between anchor and equipment support hole exceeds 3.2 mm.
- .4 Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
 - .1 In block-wall:
 - .1 Up to three bolts, each bolt rated for 2.0 times estimated restraint load, or
 - .2 For four bolts or more, each bolt is rated for 1.0 times estimated concurrent load.
 - .2 In drywall:
 - .1 Minimum of four self-tapping screws drilled into the studs, with each screw rated for 1.0 times estimated restraint load.
- .5 Do not mix type of restraint on the same piece of equipment.
- .6 Do not include ductwork or piping restraints to restrain equipment.
- .7 For recessed wall-mount equipment, support the equipment the same way as surface mount equipment. In addition, fasten through top bottom and sides of panels to adjacent block wall or wall studs.

3.4 **DUCT SYSTEMS**

- .1 Seismically restrain all ductwork listed below, using seismic cable restraints:
 - .1 All ducts with cross-sectional area equal to or greater than 0.55 m².
 - .2 Any ductwork which, if it were to fail would result in damage to a piece of equipment or building function that has a component importance factor of 1.5.
 - .3 All ductwork weighing more than 25 kg/m.
- .2 "12-inch rule", where a duct can be exempted from seismic restraint requirements based on the length of the support rods, is accepted if one of the following conditions are met:
 - .1 The hangers shall be detailed to avoid significant bending of the hangers and their attachments. The maximum stress due to combined loading including bending in the hangers must be less than 21.6 ksi.
 - .2 Isolation hangers are added to the hanger rod to provide swivel joint and to prevent bending moment in hanger.
- .3 Space lateral supports at a maximum 9 m, and longitudinal supports a maximum of 18 m.
- .4 Duct risers shall be restrained at floor penetrations every 9 m maximum spacing.
- .5 Fire damper locations may be used as restraint locations for all directions except away from the damper.
- .6 Brace a change of direction longer than 3.7 m.

- .7 Install restraint cables so they do not bend across edges of adjacent equipment or building structure.

3.5 **PIPING SYSTEMS**

- .1 The component importance factor for piping systems shall be assigned as follows:
 - .1 Natural gas piping, medical gas piping, vacuum piping, petroleum based liquid piping, compressed air piping and any other piping carrying hazardous materials: $I_p=1.5$.
 - .2 All piping systems serving components required for the continued operation of an essential facility: $I_p=1.5$.
 - .3 Drain, waste, vent (DWV) piping in essential facilities: $I_p=1.0$.
 - .4 All piping associated with life safety systems, including fire protection sprinkler and standpipe systems: $I_p=1.5$.
 - .5 All other piping systems not identified above: $I_p=1.0$.
- .2 For projects with a Seismic Design Category (SDC) of C, provide seismic cable restraints on the following:
 - .1 All piping systems assigned a component importance factor, I_p of 1.5 with a nominal pipe diameter greater than 50 mm or trapeze-supported piping with combined operating weight over 15 kg/m .
- .3 For projects with an SDC of D, E or F, provide seismic cable restraints on the following:
 - .1 All piping greater than 75 mm nominal diameter.
 - .2 All piping systems assigned a component importance factor, I_p , of 1.5 with a nominal pipe diameter greater than 25 mm or trapeze-supported piping with combined operating weight over 15 kg/m .
- .4 “12-inch rule”, where a pipe can be exempted from seismic restraint based on the length of the support rods, is accepted if one of the following conditions are met:
 - .1 The hangers shall be detailed to avoid significant bending of the hangers and their attachments. The maximum stress due to combined loading including bending in the hangers must be less than 21.6 ksi.
 - .2 Isolation hangers are added to the hanger rod to provide swivel joint and to prevent bending moment in hanger.
- .5 Restraint spacing:
 - .1 For ductile piping, space lateral supports a maximum of 12 m, and longitudinal supports a maximum of 24 m.
 - .2 For non-ductile piping (e.g., cast iron, PVC) space lateral supports a maximum of 6m, and longitudinal supports a maximum of 12 m.
 - .3 For piping with hazardous material inside (e.g., natural gas, medical gas) space lateral supports a maximum of 6m, and longitudinal supports a maximum of 12 m.
 - .4 For pipe risers, restrain the piping at floor penetrations using the same spacing requirements as above.
- .6 Brace a change of direction longer than 3.7m.

- .7 Longitudinal restraints for single pipe supports shall be attached directly to the pipe, not to the pipe hanger.
- .8 For supports with multiple pipes (trapezes), secure pipes to trapeze member with clamps approved for application.
- .9 Piping on roller supports shall include a second roller support located on top of the pipe at each restraint location to provide vertical restraint.
- .10 Install restraint cables so they do not bend across edges of adjacent equipment or building structure.
- .11 Install flexible metal hose loops in piping which crosses building seismic joints, sized for the anticipated amount of movement.
- .12 Install flexible piping connectors where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment.
- .13 Coordinate seismic restraints with thermal expansion compensators, guides and anchor points. Thermal expansion anchor points shall be designed to accommodate seismic forces.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
 - .2 Provide permanent nameplates for mechanical equipment, valve tags, identification for piping and ductwork, all installed under the scope of Divisions 20, 21, 22, and 23.
- .2 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit schedule of Equipment Identification Nameplates, including proposed wording.
 - .3 Submit Valve Directory and Chart including quantity, size, location, purpose and normal operating position (opened or closed) for each valve.
 - .4 Provide a list of all systems to be labelled with hazardous warning symbols.
- .2 Samples
 - .1 Submit samples of equipment, piping, valve and ductwork identification markers.

1.3 REFERENCE STANDARDS

- .1 CAN/CGSB-24.3 - Identification of Piping Systems.
- .2 ANSI/ASME A13.1 - Scheme for the Identification of Piping Systems.
- .3 NFPA 13 - Installation of Sprinkler Systems
- .4 NFPA 25 - Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems

PART - 2 PRODUCTS

2.1 MATERIALS

- .1 General
 - .1 Manufactured identification systems:
 - .1 Laminated vinyl or polyester
 - .2 Resistant to chemicals and ultraviolet light

- .3 Minimum ambient temperature: -25°C
 - .4 Maximum ambient temperature: 121°C
- .2 Equipment Nameplates
 - .1 Laminated phenolic plastic, 75mm x 50mm, with minimum 10mm high letters:
 - .1 Black lettering on white background for equipment on 'Normal' power supply
 - .2 White lettering on red background for equipment on 'Emergency' power supply
 - .2 Three rows of text, based as shown in equipment Schedules.
 - .1 Line 1: Equipment ID (e.g. P-1)
 - .2 Line 2: Equipment Name (e.g. Northwest Zone Heating Pump)
 - .3 Line 3: Optional, up to 15 characters (e.g. Standby Pump)
 - .3 This identification is in addition to manufacturers' nameplate data.
- .3 Ductwork Identification
 - .1 Painted stencil lettering: 50 mm high.
 - .2 Paint colour:
 - .1 Black paint on insulated ductwork with canvas cover or other, light coloured jacketing.
 - .2 White paint on insulated ductwork with metal cover or other dark coloured jacketing.
 - .3 White paint on uninsulated ductwork
 - .3 Two levels of text in accordance with designations shown on Schedules:
 - .1 Level 1: Abbreviated name of air handling system for supply systems (e.g. AHU-1), or fan number for exhaust or ventilation only systems (e.g. F-1)
 - .2 Level 2: System name (e.g. General Supply)
 - .4 Direction arrows: 65 mm high
- .4 Pipe Identification – Adhesive Labels
 - .1 Pre-printed 6 mil thick vinyl cloth, plastic coated with pressure sensitive self-adhesive backing surface. On insulated pipe, use adhesive suitable for this application.
 - .2 Applicable WHIMS pictogram for identification of material hazard.
 - .1 Pipe diameter (including insulation) 75 mm or less: 29 mm width, 25 mm high lettering. Length of labels as dictated by legend.
 - .2 Pipe diameter (including insulation) greater than 75 mm: minimum width of 64 mm and with 50 mm high letters.
 - .3 Primary label colour: to CAN/CGSB-24.3 and ANSI/ASME A13.1.
 - .4 Pipe label to include service pressure for steam, compressed air, natural gas (if more than one gas service pressure inside of building), and vacuum.

- .5 Legend: black with the legend printed in full wherever feasible.
- .3 Direction arrow banding tape: colour coded vinyl tape with pressure sensitive adhesive backing, 50 mm wide, with directional arrows.
- .5 Pipe Identification – Coil Wrap Labels
 - .1 Reversible direction, semi-rigid plastic vinyl, with subsurface printing, and integral direction arrows.
 - .2 Applicable WHIMS pictogram for identification of material hazard.
 - .1 Up to 150mm diameter: coil wrap six rows of printing
 - .2 Over 150mm diameter: saddle type with two rows of printing, fastened with stainless steel springs
 - .3 Lettering Size:

Outside Dia.	Letter Height
Less than 19mm	6mm
19mm – 29mm	12mm
31mm – 35mm	19mm
63mm – 114mm	31mm
 - .4 Primary label colour: to CAN/CGSB-24.3 and ANSI/ASME A13.1.
 - .5 Pipe label to include service pressure for steam, compressed air, natural gas (if more than one gas service pressure inside of building), and vacuum.
 - .6 Legend: black with the legend printed in full wherever feasible.
- .6 Valve Identification
 - .1 Laminated phenolic plastic, 25mm dia., with minimum 10 mm high lettering, with brass keychain.
 - .2 Minimum two lines of text:
 - .1 Line 1: valve designation
 - .2 Line 2: valve position instruction
 - .3 For fire protection valves, use enamelled steel with fire department red enamel background, white letters, inscription in accordance with NFPA Standards.
 - .1 150 mm x 150 mm for automatic control valves and alarm valves.
 - .2 50 mm x 150 mm for other valves.
 - .3 Fitted on control valves, shut-off valves, drain valves and test valves.
 - .4 Co-ordinate valve numbers with the fire alarm annunciator panel numbering system provided under the scope of Division 26 - Electrical.
- .7 Sprinkler System
 - .1 Provide rigid sprinkler system signage in accordance with NFPA 13 and NFPA 25. Sprinkler system signage shall include, but not limited to, the following:

- .1 Identification Signs:
 - .1 Provide signage for each control valve, drain valve, sprinkler cabinet, and inspector's test.
 - .2 Provide valve tags for each operable valve. Coordinate nomenclature and identification of operable valves with the Owner.
- .2 Instruction/Information Signs:
 - .1 Provide signage for each control valve to indicate valve function and to indicate what system is being controlled.
 - .2 Provide signage indicating the number and location of low point drains.
- .3 Hydraulic Placards:
 - .1 Provide signage indicating the hydraulic design information. The placard shall include location of the design area, discharge densities, required flow and residual pressure at the base of riser, occupancy classification, hose stream allowance, flow test information, and installing contractor. Locate hydraulic placard information signs at each alarm check valve.
- .8 Standard of Acceptance:
 - .1 Brady
 - .2 Grainger
 - .3 S.M.S
 - .4 Seton
 - .5 Craftmark

PART - 3 EXECUTION

3.1 GENERAL

- .1 Pipe and valve identification classification colour coding and service identifiers to be in accordance with CAN/CGSB-24.3 and ANSI/ASME A13.1, and with CSA Z7396.1 for medical gas service.
- .2 Use existing coding system for building additions and alterations.

3.2 INSTALLATION

- .1 Equipment Nameplates
 - .1 Identify nameplates describing the function or use of the particular equipment involved.
 - .2 Do not commence fabrication of nameplates until after receipt of Consultant's review.
 - .3 Equipment includes but not limited to:
 - .1 Equipment as shown on schedules and specified
 - .2 Motor starters

- .3 Motor Control Centres
 - .4 Pushbutton stations
 - .5 Control panels
 - .6 Time switches
 - .7 Disconnect switches
 - .8 Contactors or relays in separate enclosures
- .4 Equipment nameplates for Building Automation System components are specified under Section 25 05 00.
- .5 Securely fasten nameplates to the equipment with round-head cadmium plated steel self-tapping screws where possible, or with double sided adhesive tape.
- .6 Locate nameplates to be easily read.
- .7 Do not paint over equipment manufacturers' or field installed nameplates.
- .8 Provide standoffs on insulated equipment.
- .2 Ductwork Identification
 - .1 Label ductwork to indicate the content and direction of flow.
 - .2 Locate labels as follows:
 - .1 Within 1.5m of air handling units and free standing fans.
 - .2 Within 3m of divisions in exposed ductwork.
 - .3 On each exposed duct passing through a wall, partition or floor (one on each side of such wall, partition or floor).
 - .4 At intervals not to exceed 15m along every exposed duct run exceeding 15m in length.
 - .5 On vertical exposed ducts at 1.8m above floor.
 - .6 On every concealed duct where it enters a floor area that it serves.
 - .3 Labels to be visible from 1.5m above the adjacent floor or platform.
 - .4 Clean surfaces with a trisodium phosphate solution before application of paint. Stencilling to be performed in a neat, quality manner. Upon completion of the project, hand over one complete set of stencils used to the Owner.
- .3 Piping Identification
 - .1 Label all piping installed as part of the Mechanical Work to indicate the content and direction of flow.
 - .2 For piping carrying steam, compressed air and vacuum, show on label the pressure or vacuum, and working units as applicable.
 - .3 Locate labels as follows:
 - .1 At every end of pipe run, adjacent to the valve or item of equipment serviced.
 - .2 At valves, tees and changes of direction.
 - .3 On each exposed pipe passing through a wall, partition or floor (one on each side of such wall, partition or floor).

- .4 At intervals not to exceed 15m along every exposed pipe run exceeding 15m in length.
- .5 On vertical exposed pipes at 1.8m above floor.
- .6 At every access point on concealed piping.
- .4 Labels to be visible from 1.5m above the adjacent floor or platform.
- .5 Adhesive Labels:
 - .1 Clean surfaces before application of labels.
 - .2 Secure label with direction arrow banding tape for full circumference of pipe, at each end of label.
- .6 (Natural gas piping: in addition to pipe labels specified above, paint all piping and tubing with one coat oil alkyd primer and one top coat of alkyd enamel, bright yellow.)
- .7 (Natural gas piping: as specified above except provide labels every 6m.)
- .4 Piping Identification - Medical Gas Systems
 - .1 Provided identification markings on medical gas systems:
 - .1 Maximum every 6m along the length of pipe
 - .2 Before and after barriers, floors and walls
 - .3 At each valve
 - .4 Behind access doors
 - .5 At each inlet and outlet point including vents
- .5 Piping Identification - Buried Piping
 - .1 Provide tracer tape along the entire length of pipe at a depth of:
 - .1 600mm below top of grade for water piping
 - .2 150mm above top of natural gas, propane, or fuel oil piping, and medical gas piping
 - .2 This tape is in addition to any required electrical tracing wire that may be required under other Sections of this Specification.
- .6 Valve Tags
 - .1 Provide valve tags on all valves, except as follows:
 - .1 At plumbing fixtures.
 - .2 On steam, condensate, chilled water and heating water isolation and balancing valves located immediately at the respective equipment being served.
 - .3 On isolation valves around control valves.
 - .2 All control, drain and test connection valves shall be provided with signs indicating their purpose.
 - .3 Provide a valve identification directory for each system.
 - .1 Quantity: two (2) copies of valve identification directories for each system

.2 Documented as follows (example given):

Valve No.	Service	Valve Location	Nearest Column
HV-1	Northwest Zone Heating	Penthouse, North Side	A-8

.7 Special Hazards and Warning Labels

.1 In addition to pipe and duct identification described above, for pipes and ducts containing hazardous materials provide universal warning labels next to the identification label and on associated fans, tanks and pumps, etc.

.1 Standard identification symbols in accordance with WHIMS labelling requirements.

.2 Minimum 100mm diameter with black symbol on yellow background.

.2 Provide labelling for systems as follows:

System	Biohazard	Corrosive	Flammable	Explosive	Radioactive
Isotope Drains and Exhaust					•
Laboratory Drain and Tank		•			
Fume Hood Exhaust		•	•	•	
Nuclear Medicine Hood Exhaust					•
Flammable Storage Exhaust			•	•	
Isolation Room Exhaust	•				
Decontamination Drain and Tank	•	•	•	•	

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section for the following:
 - .1 Performance testing of fire protection, plumbing and heating, ventilating, air conditioning systems;
 - .2 Survey of installed automatic controls and verification of functional performance;
 - .3 Performance testing of all vibration isolation equipment.
 - .2 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.

1.2 RELATED WORK

- .1 The following Work is provided under other Sections or Divisions of the Work:
 - .1 Factory testing and calibrating of equipment and control systems: reference each Specification Section for specific requirements.
 - .2 Testing and checking of equipment provided as part of the Work of other Divisions' Contractors, except where such equipment forms an integral part of the mechanical systems.
 - .3 Controls / Building Automation operation report: Section 25 05 00 - Common Work for Building Automation
- .2 The following Work is provided under other a separate Contract:
 - .1 Air and water balancing.

1.3 REFERENCE STANDARDS

- .1 CSA B64.10 / B64.10.1 - Selection and Installation of Backflow Preventers / Maintenance and Field Testing of Backflow Preventers
- .2 CSA B139 - Installation Code for Oil-Burning Equipment
- .3 CSA B149.1 - Natural Gas and Propane Installation Code
- .4 Federal Standard 209 - Cleanroom and Work Station Requirements, Controlled Environments

1.4 QUALITY ASSURANCE

- .1 Use factory trained representatives and submit manufacturer's check sheets for starting all systems and equipment.
- .2 Testing and certification of each backflow prevention device shall be by a "Certified Cross Connection Control Specialist". One copy of the certificate to be submitted to the municipal water department, and one copy is to be inserted into each O&M manual.

- .3 Prior to the starting, testing, balancing, adjusting, and cleaning processes, verify with the Consultant any tests required to be witnessed. Provide sufficient notice to the Consultant prior to the commencement of the procedures.
- .4 The Consultant shall be allowed to witness any testing, adjusting, starting, balancing, and cleaning procedure.
- .5 Assume all costs associated with the starting and testing, including the supply of testing or cleaning medium, and potable water and fuel consumed.
- .6 Prior to starting any equipment or systems, secure and review manufacturer's installation, operation, and starting instructions. Read in conjunction with the procedures defined in this Section.
- .7 Use the equipment manufacturer's personnel for start-up where required by the manufacturer to ensure the integrity of the manufacturer's warranty.
- .8 Compare final equipment installation to the published manufacturer's installation details and record discrepancies. Items potentially detrimental to equipment performance shall be corrected prior to starting of the equipment.
- .9 Some processes involved in the starting procedures defined in this Section may be a duplication of authorities' verification. To facilitate expedient completion of the Project, arrange for authorities to assist or witness these procedures.
- .10 All starting and testing procedures shall be performed in accordance with the applicable ASME, ASHRAE, CAABC, CSA, NFPA, SMACNA, ASTM, ASPE, NEEB, AWWA standards, and as required and outlined in these Specifications. In particular, note the testing requirements of NFPA-20 and of the authorities having jurisdiction for fire pumps.
- .11 Personnel involved in the starting, testing, balancing and adjusting procedures shall be experienced in the installation and operation of mechanical equipment and systems being checked, and shall be able to interpret results of readings and tests.
- .12 Assume all liabilities associated with the starting, testing and balancing procedures.

PART - 2 PRODUCTS

2.1 NOT APPLICABLE

PART - 3 EXECUTION

3.1 GENERAL

- .1 Conduct performance tests to demonstrate that equipment and systems meet the specified requirements after mechanical installations have been completed and pressure tested. Conduct tests as soon as conditions permit. Make changes, repairs, and adjustments required prior to operating tests.
- .2 Operate and test motors and speed switches for correct wiring and sequences and direction of rotation. Check and record overload heaters in motor starters.
- .3 Confirm voltages and operating amperages at full load.
- .4 Failure to follow instructions pertaining to correct starting procedures may result in re-evaluation of equipment by an independent testing agency selected by Owner at Contractor's expense. Should the results reveal that equipment has not been properly

started, equipment may be rejected, removed from site, and replaced at the Contractor's cost. Replacement equipment shall also be subject to full starting procedures, using the same procedures as specified for the originally installed equipment.

3.2 **EQUIPMENT START-UP REPORT**

- .1 Report format
 - .1 Prepare test forms in MS Excel or Word format.
 - .2 Include the following header information for each test report:
 - .1 Owner's name
 - .2 Project name
 - .3 Contractor's name
 - .4 Consultant's name
 - .5 Title of report
 - .6 The following statement: "The undersigned certifies that the test results recorded in this report are correct, and that results have been witnessed by the Contractor responsible for this test."
 - .7 Name and signature of the person submitting the report
- .2 Submit the above reports in a hardcopy form, separately bound from the Operations and Maintenance Manuals, and in Adobe Acrobat PDF format, in accordance with Section 01 33 00 - Submittal Procedures.
- .3 Provide a consolidated test report for all equipment, including the following start-up tests:
 - .1 Equipment / system summary tests;
 - .2 Equipment / system start-up tests;
 - .3 Manufacturer's start-up tests.
- .4 Equipment / system summary tests
 - .1 Provide a report with the following data for each piece of equipment which is powered or has automatic controls:
 - .1 Equipment designation and name
 - .2 Motor insulation Megger test - result and initialed by contractor
 - .3 Motor rotation (bump test) - result and initialed by contractor
 - .4 Equipment start-up report status - status and initialed by contractor
 - .5 Manufacturer start-up report status – status and initialed by contractor
 - .6 Test completion date
 - .2 Provide a report with the following data for pressure testing of piping systems:
 - .1 System name
 - .2 System limits (if system is not tested in its entirety)
 - .3 Type of test (pneumatic, hydrostatic)
 - .4 Pressure at start of the test
 - .5 Pressure at end of the test

- .6 Duration of the test
- .7 Test completion date
- .8 Contractor's testing staff's name and initials
- .3 Provide a report with the following data for equipment served by liquid, gas or vapor systems:
 - .1 Equipment designation and name
 - .2 Isolation valve position during test – status and initialed by contractor
 - .3 Steam traps operational - status and initialed by contractor
 - .4 Backflow preventers tested - status and initialed by contractor
 - .5 Pressure relief valves installed – record setpoint and initialed by contractor
- .5 Equipment / system start-up tests
 - .1 Provide a separate start-up report for each piece of the following equipment, and each system. The SMACNA "Systems Ready to Balance Check List", where applicable, may be used for this report. Provide the following tests in cooperation with the Contractor performing the Work of Section 20 05 93 - Testing, Adjusting and Balancing:
 - .1 HVAC units
 - .1 Check unit is level
 - .2 Mixing chamber - measure temperature profile for stratification
 - .3 Measure air flow and static pressure
 - .4 Entering dry bulb/wet bulb temp.
 - .5 Leaving dry bulb/wet bulb temp.
 - .6 Acoustic measurements
 - .2 Fans
 - .1 Check radiated and discharge sound power levels
 - .2 Determine rpm, air flow rates, static pressure and record on the fan curves
 - .3 Conduct fan performance test for total system volume on main air supply and exhaust units
 - .4 Conduct smoke control test to meet occupancy requirements
 - .3 Duct systems
 - .1 Motorized control/smoke/fire dampers
 - .1 Verify that damper strokes to fully open position
 - .2 Verify damper access
 - .3 Verify damper operation under fire alarm condition
 - .2 Air outlets
 - .1 Take sound readings at specified air flows at outlets

- .3 Fire dampers
 - .1 Test each damper to ensure proper blade movement and damper closure
 - .2 Verify damper accessibility for changing of the fusible links
- .4 Ductwork
 - .1 Low pressure supply, return and exhaust ductwork is to be tested by sound and feel for leakage
 - .2 Medium and high pressure supply, return and exhaust ductwork is to be pressure tested
- .4 Pumps
 - .1 Run for 12 hours.
 - .2 Ensure parallel pumps are equally balanced.
 - .3 Record motor power consumption
 - .4 Calculate pump efficiency
 - .5 Measure specific gravity of fluid
- .5 Boilers and boiler auxiliaries
 - .1 Start-up boilers as per manufacturers recommendations
 - .2 Set up and adjust burner operation through all firing rates, and record efficiencies
- .6 Refrigeration equipment
- .7 Sprinkler systems (to NFPA 13)
- .8 Standpipe systems (to NFPA 14)
- .9 Fire pumps
 - .1 Flow and inlet/discharge pressure for fire pump and jockey pump
 - .2 Conduct pre-test of pump prior to arranging approval test with local authorities
- .10 HVAC terminal units
 - .1 Inlet/outlet air flows and temp.
 - .2 Inlet/outlet water flows and temp.
 - .3 Air and water pressure drop across the unit
 - .4 Fan speed setting
 - .5 Check acoustic performance
- .11 Fume hood exhaust systems
 - .1 Independent testing agent hired by the Owner will conduct fume hood operation verification tests
 - .2 This Contractor shall be responsible for:
 - .1 Pressure test of welds
 - .2 Sound testing on the discharge side of the fans

- .12 Plumbing systems
 - .1 Perform tests as detailed in the respective Sections of the Division 22 – Plumbing Specifications
- .6 Manufacturer's start-up tests
 - .1 Provide a separate start-up report for each piece of the following equipment, utilizing the manufacturer's start-up check list. This report may be prepared by the manufacturer's service representative.
 - .1 Refrigeration equipment
 - .2 Packaged HVAC equipment
 - .3 Heating boilers
 - .4 Steam boilers
 - .5 Dearators
 - .6 Packaged steam humidity generators
 - .7 Domestic hot water heaters
 - .8 Air compressors
 - .9 Cooling towers
 - .10 Variable frequency drives
- 3.3 **AUTHORITIES' REVIEW**
 - .1 Submit copies of inspection and test reports prepared by the authorities having jurisdiction, including but not limited to:
 - .1 Plumbing and drainage municipal inspector reports
 - .2 HVAC municipal inspector reports
 - .3 TSSA pressure vessel and piping inspection reports
 - .4 TSSA fuel system inspection checklists
 - .5 Fuel distributor's inspection checklists
 - .6 ESA field certification reports
- 3.4 **DEFICIENCIES**
 - .1 Immediately report to Consultant any deficiency in the systems or equipment performance resulting in design requirements being unobtainable.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

.1 Section includes:

- .1 Labour, products, equipment and services necessary to complete the work of this Section for the following:
 - .1 Performance testing and balancing of air distribution, hydronic, plumbing and fire protection systems. Requirements include measurement and establishment of the fluid (hydronic and air) quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results.
 - .2 Measuring and reporting all specified space noise levels.
 - .3 Rechecking of testing and balancing during the alternate (heating/cooling) season.

.2 Related Requirements:

- .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
- .2 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.

1.2 WORK NOT INCLUDED

.1 The following systems do not require testing and balancing:

- .1 Domestic cold water supply distribution.
- .2 Domestic hot water supply distribution.
- .3 Steam and condensate systems distribution.
- .4 Natural gas supply distribution.
- .5 Medical gas systems.

.2 The following equipment does not require testing and balancing:

- .1 Electric convection heaters
- .2 Electric unit heaters

1.3 RELATED WORK

.1 The following work is provided under other Sections or Divisions of the Work:

- .1 Factory testing and calibrating of equipment and control systems: reference each Specification Section for specific requirements.
- .2 Testing and checking of equipment provided as part of the Work of other Divisions' Contractors, except where such equipment forms an integral part of the mechanical systems.
- .3 Measuring and reporting all specified vibration isolation levels: Section 20 05 86 - Rotating Equipment Vibration Testing.

1.4 **QUALITY ASSURANCE**

- .1 The testing and balancing of the water and air systems shall be performed by the same Testing, Adjusting and Balancing (TAB) Contractor.
- .2 The TAB Contractor must be an independent agency and member in good standing with the National Environmental Balancing Bureau (NEBB), the Canadian Associated Air Balance Council (CAABC) or the National Building Comfort Testing Association (NBCTA).
- .3 The TAB Contractor shall have a minimum three years of documented experience in the field of TAB work. The Contractor shall provide suitable evidence of past performance, including references, justifying the TAB Contractor's capabilities.
- .4 Pre-approved TAB Contractors, in alphabetical order:
 - .1 ACE Commercial Air Test & Balancing Ltd.
 - .2 AICL
 - .3 Clark Balancing Ltd.
 - .4 DASS Enterprises Inc.
 - .5 Designtest & Balance Co. Ltd.
 - .6 Dynamic Flow Balancing Ltd.
 - .7 Kanata Air Balancing & Engineering Services Ltd.
 - .8 Pro-Air Testing
 - .9 Vital-Canada Group Inc.
 - .10 VPG Associates Ltd.
 - .11 The Mechanical Contractor may, at their discretion, submit the name and qualifying documents of an alternative TAB Contractor for review by the Consultant. Acceptance of the alternative TAB Contractor is at the sole discretion of the Consultant. In case the alternative TAB Contractor is not approved, the Mechanical Contractor shall select the TAB Contractor from the pre-approved TAB Contractors' list.

1.5 **SUBMITTALS**

- .1 Submit all documentation in accordance with Section 01 33 00 – Submittal Procedures.
- .2 Submit proof of certification for the TAB Contractor's CAABC / NBCTA / NEBB membership within 14 days after the award of the TAB contract.
- .3 Submit a report prepared by the TAB Contractor within thirty (30) days after the award of the TAB contract, summarizing TAB Contractor's comments and recommendations regarding their review of the Contract Documents. The TAB Contractor shall meet with the Mechanical Contractor, the Owner and the Consultant as necessary to discuss.
- .4 Submit an outline of the proposed TAB procedures, or alternatively, provide a copy of the latest edition of the CAABC / NBCTA / NEBB procedural standards, within thirty (30) days after the award of the TAB contract.
- .5 During construction, when the pipe and/or duct installation is ongoing, submit written field review reports prepared regularly (once a month) by the TAB Contractor, including the date of visit, areas observed, and any anticipated problems that could adversely affect the TAB Work.

- .6 Submit layout drawings and report format a minimum 14 days prior to the commencement of the TAB Work.
 - .1 Layout drawings
 - .1 Identify specific location of all adjusting, balancing and permanent measuring devices, neatly marked on a set of plans. A set of reproducible drawings will be furnished by the Consultant for this purpose upon request.
 - .2 Propose additional devices deemed necessary for satisfactory operation and completion of the Mechanical Work.
 - .2 Report format
 - .1 Submit the proposed format of each report type.
 - .2 Include a complete list of instruments and tests for which they are to be used as they relate to this project, including proof of date for the last calibration.
- .7 Submit start-up reports, performance testing reports, and draft, interim and final TAB reports as detailed in this Section of the Specification.

1.6 **PERFORMANCE STANDARDS**

- .1 Perform TAB Work in accordance with the current issue of:
 - .1 CAABC / NBCTA / NEBB procedural standards
 - .2 SMACNA HVAC Systems Testing, Adjusting and Balancing guidelines.
 - .3 ASHRAE Guide - Testing, Adjusting and Balancing from the latest ASHRAE Application Handbook
 - .4 ANSI/ASHRAE Standard 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems
 - .5 ANSI/AHRI Standard 550/590 - Performance Rating of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapor Compression Cycle
 - .6 ASME Performance Test Code 4.1 - Energy Performance Assessment of Boilers
 - .7 Ontario Ministry of Environment Guideline A-9 - NOx Emissions from Boilers and Heaters

1.7 **DEFINITIONS**

- .1 For the purposes of this Section, the following definitions apply:
 - .1 "Balancing" - To proportion and regulate flows within the distribution system (subsystems, branches, mains, terminals) at appropriate pressures in accordance with the design intent. This includes setting discharge volume and patterns of terminal devices, and individual return and exhaust air volumes.
 - .2 "Testing" - To measure, interpret and report in writing, such parameters as may be required to verify design compliance and as specified herein.

1.8 **COORDINATION**

- .1 The TAB Contractor shall:
 - .1 Review with each Mechanical Subcontractor before fabrication, the location of balancing devices, test connections, access openings, and report conditions which could negatively affect optimum system performance.

- .2 By inspection, ensure that all testing, balancing and metering devices have been installed properly and in their pre-selected locations. The Mechanical Contractor shall obtain the approval of the TAB Contractor prior to adjusting the location of these devices due to field conditions.
- .3 Coordinate efforts so that items requiring replacement or have long delivery time (sheaves, motors) are tested as early as possible.
- .2 The Mechanical Contractor shall provide the following assistance and services to the TAB Contractor:
 - .1 Schedule sufficient time so that the initial testing and balancing can be completed before occupancy begins and coordinate with all Subcontractors involved.
 - .2 Keep the TAB Contractor informed of any major change made during construction. Furnish the TAB Contractor with a set of Record Drawings and with reviewed Shop Drawings.
 - .3 Furnish balancing devices, test connections access openings, balancing probe inlets and plugs.
 - .4 Ensure that all Mechanical systems are complete and ready for testing, adjusting and balancing by the TAB Contractor. Associated tasks shall include:
 - .1 Confirm the complete operational readiness of the building, including sealed walls, doors and ceilings to allow the balancing to be performed and required pressures to be set and maintained.
 - .2 Allow access to all components requiring testing, balancing, and servicing. This includes permanently installed ladders and catwalks.
 - .3 Verify that installation conforms with the design Drawings and Specifications.
 - .4 Promptly correct deficiencies of materials and Work that may delay the completion of the TAB Work.
 - .5 Provide Operation and Maintenance Manuals. Manuals must include the following:
 - .1 The manufacturers' method for adjusting and setting components for correct operation under actual load conditions.
 - .2 The manufacturers' recommended tolerance for maximum and minimum operating conditions.
 - .3 The recommended correction or A_k factors, to allow adjustment of flow, rpm, etc.
 - .4 A list of spare parts, identification numbers, and diagrams of their proper locations.
 - .5 Pressure drops for air and hydronic flows through the component or unit at design flow rate.
 - .6 Start up all mechanical systems, according to the following conditions:
 - .1 Proper lubrication of rotating or sliding parts has been verified.
 - .2 Motors, fans, and all equipment have the correct rotation.
 - .3 Installation of the correct drive (package) has been checked.
 - .4 Belt tension is appropriate for the type of drive.

- .5 Vibration isolators and bases are properly installed and are the correct type.
- .6 Smoke and fire damper operation (left in full open position) is correct.
- .7 Volume and control dampers (left in a neutral or wide-open position) function properly.
- .8 Verification that duct-leakage test has been performed and ducts are sealed to the minimum tolerance specified.
- .9 Verification that all registers, grilles, and diffusers are of the correct type, have been properly installed, and are in the open position.
- .10 Verification that all terminal units are the correct type and have been properly installed according to the manufacturer's recommendations.
- .11 Verification that motors, starters, and variable speed controllers with overload safety devices are the correct size and are operating properly.
- .12 Verification that automatic controls have been installed correctly and include all components specified, including interlocks, freeze stats, damper controllers, minimum positioning switches, control valves, actuators, and sensors.
- .13 Verification that pumps and related components have been properly installed and operate correctly.
- .14 Verification that strainers are clean and that the system has been vented and free of air.
- .15 Verification that expansion tanks have been properly installed and working.
- .16 Verification that coils and heat exchangers have been piped correctly and are clean.
- .17 The motor, amps, volts, and rpm, have been compared with nameplate data and have been adjusted within a motor-rated hp or amperes.
- .18 Verification that fan and pump power and speed are within design range.
- .19 Verification that the controls are complete and operational.
- .20 Verification of the correct type, quantity, and cleanliness of installed filters.
- .5 Provide a copy of all start-up reports for each piece of equipment, including initial tabulated data required for the start-up of the systems, to the TAB Contractor to be used as reference for the TAB Work.
- .6 Provide immediate labour from pertinent Mechanical Subcontractors, tools, equipment and materials to make equipment and system alterations and adjustments as required including control adjustments.
- .7 Technical representative of the Building Automation System (BAS) Contractor shall operate the BAS during air and water balancing testing.

- .8 Make available all equipment data (Shop Drawing performance data and operating instructions) to the TAB Contractor.
- .9 Service representative of the refrigeration machine manufacturer shall operate their equipment for performance testing of the refrigeration equipment. TAB Contractor shall witness and record all test results.
- .10 Service representative of the fuel fired heating equipment manufacturer, or other qualified service company technical representative shall operate their equipment for performance testing of the heating equipment. TAB Contractor shall witness and record all test results.
- .3 As part of the coordination effort, the Mechanical Contractor will be fully responsible for the Mechanical systems constructed, installed and adjusted to provide optimum performance as required by the design intent. Any re-adjusting required as the result of spot checks by the Consultant shall be done at no additional cost to the Owner. Provide all equipment, labour, instruments and incidentals and pay for all power and fuel to carry out the tests.

PART - 2 PRODUCTS

2.1 NOT APPLICABLE

PART - 3 EXECUTION

3.1 REQUIRED REPORTS

- .1 Provide the following reports:
 - .1 Air and water balancing report
 - .2 Acoustic survey report
 - .3 Alternate season test report
- .2 Report format
 - .1 Prepare test forms in MS Excel or Word format.
 - .2 Include the following header information for each test report:
 - .1 Owner's name
 - .2 Project name
 - .3 Contractor's name
 - .4 Consultant's name
 - .5 Title of report
- .3 Submit the above reports in a hardcopy form, separately bound from the Operations and Maintenance Manuals, and in Adobe Acrobat PDF format, in accordance with Section 01 33 00 - Submittal Procedures.

3.2 GENERAL REQUIREMENTS

- .1 Site visits
 - .1 The TAB Contractor shall visit the Site as required prior to the testing and balancing of systems, and advise the respective Subcontractors of their requirements for probe inlets. Submit a report to the Consultant after each site visit.

.2 Balancing tolerances

.1 Balance all systems to the performance parameters indicated on Drawings and in the Specifications.

.2 If interpretation, clarification or additions to performance parameters are required, request such information from the Consultant.

.3 Air flow rates

Under 70 L/S	±10% of flow
Over/at 70 L/S	±5% of flow

.4 Water flow rates

Hydronic Heating	±5% of flow
Chilled Water	±2% of flow
Condenser Water	±5% of flow
Process Chilled Water	±2% of flow
Process Cooling Water	±5% of flow
Domestic Cold and Hot Water	±5% of flow

.5 Heat flow rates

Air Coils	±5% of design capacity
Heat Exchangers	±5% of design capacity
Water Heaters	±5% of design capacity

.3 Drawing review

.1 Review all pertinent Drawings, Specifications, Shop Drawings and other documentation to become fully familiar with the systems and their specified and intended performance.

.4 Perform testing and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards.

.5 Cut insulation, ductwork, and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.

.6 Patch insulation, ductwork, and housings, using materials identical to those removed.

.7 Seal ducts and piping, and test for and repair leaks. Seal insulation to re-establish integrity of the vapour barrier.

.8 Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings. Mark with paint or other suitable, permanent identification materials.

.9 As part of the scope of this Section, the Contractor shall make any changes in the pulleys, belts, or sheaves, as required, for correct balance at no additional cost to the Owner.

3.3 MEASUREMENTS

- .1 Provide all required instrumentation to obtain proper measurements, calibrated to the tolerances specified. Instruments shall be properly maintained and protected against damage.
- .2 Use only those instruments that have the maximum field measuring accuracy and are best suited to the function being measured.
- .3 Apply instrument as recommended by the manufacturer.
- .4 Use instruments with minimum scale and maximum subdivisions and with scale ranges proper for the value being measured.
- .5 When averaging values, take a sufficient quantity of readings that will result in a repeatability error of less than 5%. When measuring a single point, repeat readings until two (2) consecutive identical values are obtained.
- .6 Continuous recording
 - .1 Set-up trend logs on the BAS to record temperature and humidity levels on a 24-hour basis, in areas as directed by the Consultant.

3.4 AIR BALANCING

- .1 General
 - .1 Test relative barometric pressures in various building areas, as deemed necessary by the Consultant and at least in all areas served by different systems.
 - .2 Operate, test and balance all air systems over their entire design range of operation including min. and max. fresh air, return air and supply air.
 - .3 Simulate full heating and cooling conditions. Record sufficient data to verify compliance with design requirements.
 - .4 Balance air systems within acceptable tolerances before water and hydronic systems are balanced.
- .2 Test procedures
 - .1 Air quantities in main ducts shall be measured using Pitot tube traverses of the entire cross section area of the duct. Openings in ducts for Pitot tube insertion shall be sealed with approved plugs. Outlet and inlet air quantities shall be determined in accordance with the CAABC / NBCTA / NEBB procedures.
 - .2 Total air quantities shall be obtained by adjustment of fan speeds. Branch duct air quantities shall be adjusted by volume dampers. Damper positions shall be permanently marked after TAB Work is complete.
 - .3 For systems handling outdoor air, the system shall be balanced at the normal minimum outdoor air condition. Where the system is designed to deliver 100% outdoor air or a variable amount of outdoor air, the total airflow tests shall be repeated for 100% maximum outdoor air and shall agree with conditions measured under minimum outdoor air operation before the system is considered to be in balance.
 - .4 Artificially load the air filters in air handling units to simulate the midpoint resistance. Balance the duct distribution system when in this mode.

- .5 Adjusting of individual outlets shall be performed as per CAABC / NBCTA / NEBB procedures or as otherwise approved by the Consultant. Outlets shall be set for the air pattern required and all main supply air dampers shall be adjusted and set for the design indicated. All required changes in air patterns or setting necessary to achieve correct air balance and to minimize drafts shall be performed by the TAB Contractor.
 - .6 Each variable air volume (VAV), fan powered VAV (both series and parallel type), and constant volume (CV) supply, return air and exhaust terminal unit shall be adjusted to deliver the maximum and minimum air quantities specified in all specified modes of operation. Use the prescribed procedures for each type terminal device. The individual supply outlets for each zone shall be adjusted after the respective control unit is set to the minimum and maximum design airflow settings. Factory calibration of all types of VAV and high velocity fan powered/reheat units shall be verified and reset as required by the TAB Contractor.
 - .7 Balance the low pressure side of the terminal units after ensuring that there is sufficient pressure at the unit inlet. Obtain from the Consultant the diversity assumed for the air handler. After all of the low pressure systems have been balanced, adjust the BAS to open the diversity amount of the VAV boxes to the maximum airflow. Ensure the variable frequency drive maintains the appropriate pressure levels to satisfy the design intent.
 - .8 Check that stratification has been eliminated before taking measurements. Make temperature traverse readings after each mixing compartment.
 - .9 Perform the tests and compile the data required. In addition to the tabulation forms, provide schematic diagrams showing all system components cross-referenced to form tabulations. The lists provided hereinafter shall be considered minimum requirements. All information required to prove system balance shall be provided.
- .3 Data Required
- .1 Submit the following data as a minimum. If contractor's standard forms provide for additional data, also submit such additional data. Indicate if tests were not specifically made. Do not repeat design data or other values not specifically tested.
 - .2 Fans:
 - .1 Identification
 - .2 Manufacturer
 - .3 Location
 - .4 System served
 - .5 Model or serial number
 - .6 Rated airflow L/S
 - .7 Rated speed RPM
 - .8 Rated pressures (suction and discharge, or differential)
 - .9 Measured airflow L/S
 - .10 Measured speed RPM
 - .11 Measured pressures (suction and discharge, or differential)
 - .12 Pulley size, type and manufacturer

- .13 Belt size and quantity
- .3 Motors:
 - .1 Manufacturer
 - .2 Model or serial number
 - .3 NEMA rating
 - .4 Rated amperage and voltage for each phase
 - .5 Rated horsepower
 - .6 Rated speed RPM
 - .7 Corrected full load amperage
 - .8 Measured amperage and voltage for each phase
 - .9 Calculated BHP kW
 - .10 Measured speed RPM
 - .11 Sheave size, type and manufacturer
- .4 Air handling units:
 - .1 Identification
 - .2 Manufacturer
 - .3 Model or serial number
 - .4 Location
 - .5 Area served
 - .6 Design and measured total airflow, outdoor air, return air, exhaust air, relief air (maximum and minimum)
 - .7 Design and measured pressure drops across filters, boxes, coils and air-to-air heat exchangers
 - .8 Design and measured temperature differences across coils and air-to-air heat exchangers
 - .9 Fan information for each fan as described above
 - .10 Motor information for each motor as described above
- .5 Air distribution systems (including inlets and outlets):
 - .1 Grille, register or diffuser reference number and manufacturer
 - .2 Grille, register or diffuser location
 - .3 Design velocity
 - .4 Design airflow L/S
 - .5 Effective (or free) area factor and size
 - .6 Measured velocity
 - .7 Measured airflow L/S
 - .8 Traverse locations and grid with actual velocities. Record duct static pressure at each traverse location. Provide traverses at all points necessary for balancing.

- .9 For VAV systems, pressure reading at the most distant point of the high pressure side of the system.

3.5 **FLUID BALANCING**

.1 General

- .1 Operate, test and balance all water and hydronic systems over their entire design range of operation.
- .2 Simulate full heating and cooling conditions. Record sufficient data to verify compliance with design requirements.

.2 Test procedures

- .1 Water flows shall be balanced by venturi and calibrated orifices with portable type flow meters, where provided by the respective installing Contractor, or calibrated meters provided by the TAB Contractor.
- .2 Pump flow capacities shall be determined by venturi, calibrated orifices, or multi-duty valves. All settings of balancing valves shall be permanently marked after balance is complete.
- .3 The cooling tower water distribution system shall be balanced to ensure an even water flow to each tower cell.
- .4 Systems installed with pressure independent control valves shall not require terminal level hydronic system balancing. Total system flow shall be verified to be within +/-10% of system design. 10% of the total installed product shall be randomly checked for individual conformance. Exact locations of tested product to be coordinated with the Consultant. Individual adjustments for the pressure independent valve assembly (valve and actuator combination) for field conditions shall be performed using the pressure independent control valve manufacturer's documented procedure following the guidelines of CAABC / NBCTA / NEBB.
- .5 Compare design documents with the shop drawings. If discrepancies are found, submit a request for information to resolve the discrepancies.

.3 Data Required

- .1 Submit the following data as a minimum. If the Contractor's standard forms provide for additional data, also submit such additional data. Indicate if tests were not specifically made. Do not repeat design data or other values not specifically tested.
- .2 Pumps:
 - .1 Identification
 - .2 Manufacturer
 - .3 Model or serial number
 - .4 Area or type of system served
 - .5 Rated flow rate L/S
 - .6 Rated head
 - .7 Rated pressures
 - .8 Measured discharge pressure (full flow and no flow)
 - .9 Measured suction pressure (full flow and no flow)

- .10 Measured flow rate L/S at operating conditions
- .11 Operating head
- .12 Operating RPM
- .3 Motors:
 - .1 Manufacturer
 - .2 Model or serial number
 - .3 NEMA rating
 - .4 Rated amperage and voltage for each phase
 - .5 Rated horsepower
 - .6 Rated speed RPM
 - .7 Corrected full load amperage
 - .8 Measured amperage and voltage for each phase
 - .9 Calculated BHP kW
 - .10 Measured speed RPM
- .4 Water chillers
 - .1 Identification
 - .2 Manufacturer and model
 - .3 Refrigerant type and weight
 - .4 Entering and leaving condenser water temp – design and measured
 - .5 Entering and leaving condenser water pressure – design and measured
 - .6 Entering and leaving chilled water temp – design and measured
 - .7 Entering and leaving chilled water pressure – design and measured
 - .8 Condenser and evaporator water flow rate – design and measured
 - .9 Peak kW power at peak tonnage load – design condenser water and evaporator water temperature conditions.
 - .10 NPLV kW power at 0, 25, 50, 75 and 100% load, at design condenser water and evaporator water temperature, as per ARI 550/590
 - .11 IPLV kW power at 0, 25, 50, 75 and 100% load, as per ARI 550/590
 - .12 Surge control setpoint at design condenser and evaporator water temperatures and flow.
 - .13 Condenser water pressure differential/flowrate fault setpoint
 - .14 Evaporator water pressure differential/flowrate fault setpoint
 - .15 Motor information as described above
- .5 Hydronic heating equipment (boilers, heaters)
 - .1 Identification
 - .2 Manufacturer and model
 - .3 System served

- .4 Gas and fuel oil input flow rating
- .5 Gas and fuel oil input pressure rating
- .6 Gas pressure regulator inlet and outlet pressure
- .7 Entering and leaving water temp – design and measured
- .8 Entering and leaving water pressure – design and measured
- .9 Water flow rate – design and measured
- .10 Steam flow rate and pressure – design and measured
- .11 Combustion efficiency test at maximum rated capacity; including flue gas analysis
- .12 Combustion efficiency test – as per the Ontario Ministry of Environment Guideline A-9, corrected to 3% O₂, for fuel input ratings exceeding 2932 kW
- .13 Thermal efficiency, based on ASME Performance Test Code 4.1, for fuel input ratings exceeding 2932 kW
- .14 Blower fan and motor information as described above
- .6 Water cooling towers:
 - .1 Identification
 - .2 Manufacturer and type
 - .3 Inlet and outlet air temperature, dry and wet bulb - design and measured
 - .4 Inlet and outlet water temperature - design and measured
 - .5 Motor, pump and fan information as described above
- .7 Heat transfer equipment:
 - .1 Identification
 - .2 Manufacturer and type
 - .3 Location
 - .4 System served
 - .5 Design inlet and outlet temperatures
 - .6 Design pressure drop
 - .7 Design flow rate
 - .8 Measured inlet and outlet temperatures
 - .9 Measured pressure drop
 - .10 Measured flow rate
 - .11 Connection size

3.6 **ALTERNATE SEASON TESTING**

- .1 Requirements
 - .1 Re-check testing and balancing of the HVAC systems and water flow conditions at flow meter locations at approximately six months after initial testing and balancing has been performed and accepted, as advised by the Consultant.

- .2 Include items which, because of their seasonal character could not be adequately completed during the initial balancing.
- .3 Include the reading and recording of temperatures and pressures at all gauges, as well as outdoor and indoor conditions.
- .4 Measure and record the motor amperages and drive RPM of all fans and pumps during re-checking.
- .2 Report
 - .1 Provide an addendum report to the original balancing report, in accordance with the reporting requirements described herein.

3.7 **ACOUSTIC SURVEY**

- .1 Test locations
 - .1 Provide acoustic noise measurements in locations agreed with the Consultant. As a minimum, the following areas are to be tested:
 - .1 Service Rooms – electrical and mechanical – one location per room
 - .2 Open office areas – minimum one test per 500 m²
 - .3 Enclosed office areas – minimum 20% of all offices
 - .4 Boardrooms and meeting rooms – one location per room
 - .5 Kitchens, cafeterias and seating areas - one location per space
 - .6 Open plant areas, minimum one test per 2,000 m²
- .2 Test methods
 - .1 Test noise levels on the dBA weighting scale over eight bandwidths.
 - .2 Report results in tabular and graphical plots, including NR curves for each space tested.
 - .3 Conduct two tests per test location:
 - .1 Background ambient: building ventilation and air conditioning systems turned OFF.
 - .2 Operating: building ventilation and air conditioning systems turned ON, but building otherwise not occupied, and process equipment turned off.
 - .4 Report any objectionable noise or vibration and be prepared to locate cause by instrumentation and analysis (including octave band analysis)

3.8 **DEFICIENCIES**

- .1 Immediately report to Consultant any deficiency in the systems or equipment performance resulting in design requirements being unobtainable.

3.9 **DRAFT REPORT**

- .1 Upon completion of the start-up, testing, adjusting and balancing of all systems, submit to the Consultant, two (2) typewritten copies of a full report on all testing, adjustments, and balancing performed, including the following:
 - .1 Summary of all systems
 - .2 Testing methods and instrumentation

- .3 Air systems testing and balancing data
 - .4 Fluid systems testing and balancing data
 - .5 Acoustic survey report
 - .6 Attachments including systems schematics with numbered terminals for referring to data above.
- .2 At the request of the Consultant, repeat the balancing procedure on 10% of any system or portion of a system (as selected by the Consultant). If the re-measured data is within the required tolerance of the reported data, the system shall be considered acceptable and the report accepted. If the data is not within the required tolerance of the reported data, the Consultant can request that the entire system or systems be rebalanced.
- 3.10 **INTERIM REPORT**
- .1 After completion of any retesting described above, submit three (3) typewritten copies of the interim report, in a 3-hole "D" style binder, and an electronic copy in Adobe Acrobat PDF format.
 - .2 This report is required to obtain Substantial Performance of the Contract.
- 3.11 **FINAL REPORT**
- .1 Submit the final report to the Consultant following the completion of the alternate season testing and balancing. Submit three (3) typewritten copies and an electronic copy in Adobe Acrobat PDF format as the draft report specified above.
- 3.12 **SPOT CHECKS**
- .1 Before acceptance of the air and water balancing report, the Consultant may request to witness spot-checks of the report results.
 - .2 If the spot check results indicate, in the opinion of the Consultant, unusual testing inaccuracy, omissions, or incomplete balancing/adjustment, re-balance the entire affected system(s) at no additional cost to the Owner.
- 3.13 **ACCEPTANCE**
- .1 The Substantial Performance of the Mechanical Work will be considered reached when the Interim TAB Report has been accepted by the Consultant and, in the opinion of the Consultant, all systems have been satisfactorily installed, operated, tested, balanced, and adjusted to meet the specified and design performance.
 - .2 The Substantial Performance will not depend upon alternate season testing, however, make such relevant repairs or modifications deemed necessary during this re-checking as part of the guarantee of the Work.
 - .3 The Total Performance of the Mechanical Contract will not be considered reached until the alternate season testing and balancing has been completed and the Final Report submitted and accepted by the Consultant.

3.14 **ADDITIONAL TESTING**

- .1 The Consultant may request such additional testing in connection with this project as deemed necessary.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
 - .2 Provide thermal insulation including piping insulation, equipment insulation, breeching insulation, engine exhaust insulation, duct insulation, adhesives, tie wires, tapes, sealer coatings, finishes, and mechanical protection, for services installed under the scope of Divisions 21, 22 and 23.
- .2 All insulation shall comply with the minimum R-value requirements listed in the (National Energy Code of Canada for Buildings).
- .3 Insulation material and installation shall meet the requirements of all applicable codes and standards, and be appropriately labelled.
- .4 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.

1.2 WORK NOT INCLUDED

- .1 The following items shall not be insulated, or are factory insulated.
 - .1 Ductwork:
 - .1 Variable air volume terminal units
 - .2 Supply air distribution ductwork downstream of terminal units, installed exposed in the occupied space, unless otherwise noted.
 - .2 Equipment:
 - .1 Packaged domestic hot water heaters
 - .2 Packaged boilers
 - .3 Ventilation equipment without a heating and cooling coil
 - .4 Heating system expansion tanks
 - .5 Air handling units with internal insulation
 - .3 Piping:
 - .1 Compressed air piping
 - .2 Natural gas piping
 - .3 Vertical sections of rainwater leaders (except where running exposed or concealed within high humidity areas including shower rooms, locker rooms, kitchens)
 - .4 Vertical sections of exposed sanitary drainage piping
 - .5 Condenser water supply and return piping inside the building, with operating temperature above 15.6°C

- .6 Terminal unit control valves in hot piping.

1.3 **RELATED WORK**

- .1 The following Work is provided under other Sections or Divisions of the Work:
- .1 Internal acoustic insulation of ductwork: Section 23 33 00 – Duct Accessories.
 - .2 Factory insulated ductwork: Section 23 33 00 – Duct Accessories.
 - .3 Insulation saddles and shields: Section 20 05 29 – Bases, Hangers and Supports

1.4 **SUBMITTALS**

- .1 Shop Drawings
- .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for insulation products, recovery jackets, adhesives and sealants.
 - .3 Submittal shall include product description, manufacturer's installation instructions, and appropriate specification compliance.
- .2 Samples
- .1 Before ordering insulation materials prepare sample board on which mount cross-section sample of types of insulation, including samples of vapour barrier installation with coatings (indoors), mastics (outdoors), reinforcing membranes, properly identified for various services and equipment on project, , including 'k' factors. State types of adhesives.
 - .2 Submit sample board to Consultant for review. After review and acceptance keep sample board in Consultant's site office for duration of project for reference. No deviation from accepted samples will be allowed.

1.5 **REFERENCE STANDARDS**

- .1 Thermal Insulation Association of Canada (TIAC) National Insulation Standard, excluding Section 12
- .2 Midwest Insulation Contractors Association (MICA) Standards Manual
- .3 NFPA 90-A - Standard for the Installation of Air-Conditioning and Ventilating Systems
- .4 NFPA 255 / UL 723 / ASTM E84 - Standard Method of Test of Surface Burning Characteristics of Building Materials
- .5 CAN/ULC-S102 - Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies
- .6 ASTM C165 - Standard Test Method for Measuring Compressive Properties of Thermal Insulations
- .7 ASTM C335/C335M - Standard Test Method for Steady-State Heat Transfer Properties of Pipe Insulation
- .8 ASTM C411 - Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation

- .9 ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
- .10 ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
- .11 ASTM C534 - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
- .12 ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation
- .13 ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
- .14 ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation
- .15 ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
- .16 ASTM C892 - Standard Specification for High-Temperature Fiber Blanket Thermal Insulation
- .17 ASTM C1136 - Standard Specification for Flexible, Low Permeance Vapour Retarders for Thermal Insulation
- .18 ASTM C1290 - Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts
- .19 ASTM C1393 - Standard Specification for Perpendicularly Oriented Mineral Fiber Roll and Sheet Thermal Insulation for Pipes and Tanks
- .20 ASTM C1617 - Standard Practice for Quantitative Accelerated Laboratory Evaluation of Extraction Solutions Containing Ions Leached from Thermal Insulation on Aqueous Corrosion of Metals
- .21 ASTM C1729 - Standard Specification for Aluminum Jacketing for Insulation
- .22 ASTM D624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
- .23 ASTM D1000 - Standard Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications
- .24 ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials
- .25 CGSB 51-GP-52MA - Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation
- .26 CAN/CGSB 51.11 - Mineral Fibre Blanket Thermal Insulation
- .27 CGSB 51.53 – Poly (Vinyl Chloride) Jacket Sheet, for Insulated Pipes Vessels and Round Ducts
- .28 National Energy Code of Canada for Buildings
- .29 ASHRAE 90.1 – Energy Standard for Buildings

1.6 **QUALITY ASSURANCE**

- .1 Qualified installers shall have successfully completed three or more similar type jobs within the last 5 years.
- .2 Insulation material shall be fire retardant with flame spread/smoke developed ratings not exceeding 25/50 when tested in accordance with CAN/ULC-S102, and complying with the requirements stated in the building code having jurisdiction. Insulation materials shall not flame, smolder, glow or smoke at their service temperatures.
- .3 Identify insulation, coverings and adhesives where required by Federal and/or Provincial health and safety WHMIS legislation.
- .4 All insulation materials, adhesive sealants and coatings, shall be ULC listed, non-hygroscopic, and mould-proof. Insulation products shall not contain asbestos, lead, mercury, mercury compounds, or formaldehyde.
- .5 Glass mineral wool insulation products shall have UL GREENGUARD Gold Certification and be formaldehyde free as certified by UL Environment; whenever possible.
- .6 Products shall contain no polybrominated diphenyl ethers (PBDE) such as Penta-BDE, Octa-BDE or Deca-BDE fire retardants.
- .7 Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795. Insulation materials applied to carbon steel shall be Mass Load Corrosion Rate (MLCR) tested per ASTM C 1617.
- .8 Contractor shall take precaution to protect insulation materials from moisture exposure or physical damage. Any glass mineral wool insulation that becomes wet or damaged shall be replaced at no additional cost.
- .9 HVAC ductwork insulation used in the air stream shall be discarded if exposed to liquid water.
- .10 Pipe insulation with factory applied all service jacket with self-sealing lap (ASJ+) facing having been installed per manufacturer's installation recommendation which may experience intermittent exposure to liquid water after installation, may be exempted from removal and replacement requirements.
- .11 Insulation shall not be applied until all surfaces are clean, dry, and free of dirt, dust, grease, frost, moisture, and other extraneous elements.
- .12 Work shall be performed at the temperatures recommended by the product manufacturer.
- .13 Standard of acceptance, unless otherwise noted for specific products, shall be:
 - .1 Fibreglass insulation and related products:
 - .1 Owens Corning
 - .2 Johns Manville
 - .3 Knauf Fibreglass
 - .4 Manson
 - .2 Elastomeric cellular foam insulation and related products:
 - .1 Armaflex
 - .2 Rubatex

- .3 Nomaco
- .4 K-Flex

1.7 DEFINITIONS

- .1 For the purposes of this Section, the following definitions apply:
 - .1 "Ambient" - as applied to temperatures means outdoor design temperature.
 - .2 "Coating" - light-consistency compound for indoor applications used in conjunction with reinforcing fabric, to provide either a breathable or vapour barrier finish to insulation.
 - .3 "Cold" – a system or equipment carrying medium at temperatures below 16°C.
 - .4 "Compression Fit Method" - to allow for expansion and contraction of sheet and roll insulation, leave a 12mm wide uncoated border at the butt-edge seams on the surface to be insulated and the insulation surface. Overlap the insulation 6mm at the butt-edge and compress the edges into place. Apply adhesive to the butt-edges of the insulation.
 - .5 "Conditioned supply duct" - ductwork conveying air which has either been heated or cooled.
 - .6 "Concealed" - mechanical services and equipment located in ceiling space above solid drywall and T-bar ceilings, in space beneath raised floor, in vertical service shafts, in trenches, and in non-accessible chases and furred spaces.
 - .7 "Ductwork" - includes ducts, fans, supply unit casings and plenums.
 - .8 "Exposed" - mechanical services and equipment in all other spaces not considered to be "concealed" as defined above. Services in tunnels are to be treated as "Exposed".
 - .9 "Exposed to weather or dampness" – mechanical services and equipment located in air intake, relief, and exhaust plenums directly connected to the outside of the building, in underground service trenches, buried below ground level, in areas subject to high humidity, and outside the building envelope in direct contact with the outdoor environment.
 - .10 "Finish Jacket" - final finish protective layer for insulation, including lagging fabric, PVC, metal, and adhesive films, that provides weather-protective finish depending on the application.
 - .11 "Hot" – a system or equipment carrying medium at temperatures above 20°C.
 - .12 "Mastic" - heavy-consistency waterproof compound for outdoor applications used in conjunction with reinforcing fabric that remains adhesive and generally pliable with age, to provide either a breathable or vapour barrier finish to insulation.
 - .13 "Service temperature" - for purpose of ductwork and piping temperature, is equal to the design operating temperature.
 - .14 "Unconditioned space" - rooms or spaces that are not supplied with conditioned air, including ceiling spaces which are not part of a ceiling return plenum system.

1.8 PRODUCT DELIVERY, STORAGE AND HANDLING

- .1 Retain insulation materials in original cartons or containers until immediately prior to application and store in dry location.

- .2 Keep adhesives in their original containers with manufacturer's name and catalogue number clearly stated. Protect contents against freezing.

PART - 2 PRODUCTS

2.1 FIELD APPLIED FINISHES

- .1 PVC (Polyvinyl Chloride) jacket – indoor/outdoor
 - .1 Minimum thickness: 20 mil
 - .2 Maximum permeability: 0.09 perms
 - .3 Flexible flat-sheets, pre-moulded one-piece fitting covers
 - .4 Tape: vinyl, pressure sensitive, colour matched
 - .5 For outdoor application UV resistant, with solvent weld closure
 - .6 Standard of Acceptance
 - .1 Johns Manville
 - .2 Sure Fit Systems
 - .3 Proto PVC – LoSmoke
- .2 Canvas jacket – indoor only
 - .1 ULC listed plain weave cotton fabricsealed using fire retardant lagging adhesive, weight: 220 gm/m²
 - .2 Or, re-wetable fibreglass lagging fabric with water activated self-adhesive
 - .3 Suitable for field painting
 - .4 Standard of Acceptance
 - .1 Fattal Canvas
 - .2 Alpha Assoc.
 - .3 Robson Thermal
 - .4 Clairmont Corp.
 - .5 Newtex
- .3 Metal jacket - indoor/outdoor
 - .1 Aluminum: alloy 3003 or 3105, minimum thickness per ASTM C1729 (indoor), 0.406mm thickness (outdoor), smooth, corrugated or stucco embossed, with factory-applied moisture barrier
 - .2 Stainless steel: T-304, minimum thickness per ASTM C1729, smooth, corrugated or embossed, with factory-applied moisture barrier
 - .3 Fittings: custom made, swaged ring or lobster back style on bends, die shaped over fittings, valves, strainers, flanges and grooved couplings
 - .4 Bands: 12 mm wide stainless steel with mechanical fasteners
 - .5 Sheets installed with 50mm overlap
 - .6 Standard of Acceptance
 - .1 Rio Tinto Alcan

- .2 ITW Insulation
 - .3 RPR
- .4 Laminated self-adhesive jacket (SAJ) - indoor/outdoor
 - .1 Permanent acrylic self-adhesive jacketing system
 - .2 UV resistant, water proof, zero permeability
 - .3 High puncture and tear resistance
 - .4 Standard of Acceptance
 - .1 Venture Tape
 - .2 PolyGuard
 - .3 K-Flex
- .5 Protective finish for elastomeric cellular foam insulation - indoor/outdoor
 - .1 Standard of Acceptance
 - .1 Armaflex
 - .2 Nomaco

2.2 **FACTORY APPLIED FINISHES**

- .1 All service jacket with advanced closure system self-sealing lap (ASJ+)
 - .1 Aluminum foil reinforced with glass scrim bonded to a Kraft paper interleaving with an outer film layer
 - .2 Conforming to ASTM C1136 Type I, II, III, IV, and VIII
 - .3 Vapour retarder with a self-sealing adhesive
- .2 All service jacket (ASJ)
 - .1 White Kraft paper bonded to aluminum foil and reinforced with glass fibres
 - .2 Conforming to ASTM C1136 Type I
 - .3 Vapour retarder
- .3 Foil scrim Kraft (FSK)
 - .1 Aluminum foil, fiberglass reinforced scrim with Kraft backing
 - .2 Conforming to ASTM C1136 Type II
 - .3 Vapour retarder.
- .4 Poly scrim Kraft (PSK)
 - .1 Metalized polypropylene, fiberglass reinforced scrim with Kraft backing
 - .2 Conforming to ASTM C1136 Type II
 - .3 Vapour retarder

2.3 **DUCTWORK INSULATION**

- .1 Type D1
 - .1 Fiberglass flexible blanket: to ASTM C1290

- .2 FSK or PSK finish
- .3 Service temperature: 4 to 121°C
- .4 Density: 12 kg/m³
- .5 Maximum allowable compression 25%
- .6 k-value: 0.042 W/m°C @ 24°C
- .2 Type D2
 - .1 Fiberglas semi-rigid board for flat surfaces, scored board for curved surfaces: to ASTM C612
 - .2 ASJ, FSK or PSK finish
 - .3 Service temperature: 4 to 121°C un-jacketed
 - .4 Density: 48 kg/m³
 - .5 k-value: 0.033 W/m°C @ 24°C
- .3 Type D3
 - .1 Inorganic mineral fibre flexible blanket or rigid board: to ASTM C518
 - .2 ULC approved ductwork fire rating: to 2 hours
 - .3 ASJ finish
 - .4 Maximum operating temperature: -173 to 1260°C
 - .5 Standard of Acceptance
 - .1 3M
 - .2 Thermal Ceramics
 - .3 CL4 Fire
 - .4 Unifrax
- .4 Type D4
 - .1 Phenolic board rigid board for flat surfaces: to ASTM C1126 Group 1
 - .2 Service temperature: -73 to 121°C un-jacketed
 - .3 Density: 37 kg/m³
 - .4 k-value: 0.022 W/m°C @ 10°C
 - .5 Standard of Acceptance
 - .1 Kingspan
- .5 Type D5
 - .1 Flexible elastomeric closed cell foam self-adhering sheet, roll type: to ASTM C534
 - .2 Manufacturer specific sealer and adhesive
 - .3 Service temperature: up to 82°C
 - .4 k-value: 0.04 W/m°C @ 24°C

2.4 EQUIPMENT INSULATION

.1 Type E1

- .1 Fiberglas flexible faced industrial blanket insulation, with end grains perpendicular to the jacket: to ASTM C1393 Types I, II, IIIA&B
- .2 ASJ finish
- .3 Service temperature: up to 454°C
- .4 Density: 40 kg/m³ minimum
- .5 k value: 0.035 W/m°C @ 24°C

.2 Type E2

- .1 Fiberglas rigid board for flat surfaces, or scored board for curved surfaces: to ASTM C612
- .2 ASJ finish
- .3 Service temperature: up to 232°C un-jacketed
- .4 Density: 48 kg/m³
- .5 k value: 0.033 W/m°C @ 24°C

.3 Type E3

- .1 Inorganic mineral fibre flexible blanket: to ASTM C553 Types I, II, III, IV, V, VI
- .2 Maximum operating temperature: 650°C
- .3 Density: 128 kg/m³
- .4 k value: 0.069 W/m°C @ 260°C
- .5 Tie wire: 0.045 mm stainless steel with twisted ends, on maximum 300 mm centres
- .6 Standard of Acceptance
 - .1 Roxul
 - .2 Johns Manville
 - .3 RockWool
 - .4 Knauf
 - .5 Thermafiber

.4 Type E4

- .1 Inorganic mineral fibre rigid board: to ASTM C612 Type 1A, 1B, II, III, IVA, and IVB
- .2 Maximum operating temperature: 650°C
- .3 Density: 128 kg/m³
- .4 k value: 0.071 W/m°C @ 260°C
- .5 Standard of Acceptance
 - .1 Roxul
 - .2 Johns Manville
 - .3 RockWool

- .4 Knauf
 - .5 Thermafiber
 - .5 Type E5
 - .1 Flexible elastomeric closed cell foam self-adhering sheet, roll type: to ASTM C534
 - .2 Manufacturer specific sealer and adhesive
 - .3 Service temperature: up to 82°C
 - .4 k-value: 0.04 W/m°C @ 24°C
 - .6 Type E6
 - .1 Removable / reusable high temperature insulation blankets
 - .2 Custom fabricated, removable insulation covers for hot surfaces
 - .3 Suitable for outdoor use
 - .4 Maximum touch-safe temperature protection: 95°C to UL2200
 - .5 Insulation: high density, fire resistant mineral or fibreglass insulation suitable for system operating temperature
 - .6 Cover: silicone impregnated fibreglass cover, for temperatures up to 260°C
 - .7 Internal liner: silicone impregnated fibreglass fabric, or stainless steel knitted wire mesh.
 - .8 Single piece construction
 - .9 Metal identification tag, referenced equipment served.
 - .10 Tie-straps with D-rings, or Velcro™ closures.
 - .11 Standard of Acceptance
 - .1 Firwin
 - .2 Unitherm
 - .3 Thermohelp Canada
- 2.5 **PIPE INSULATION**
 - .1 Type P1
 - .1 Fiberglas rigid, factory molded, split formed with pressure sensitive longitudinal adhesion strip: to ASTM C547 Type I
 - .2 ASJ finish
 - .3 Pipe size application: up to and including NPS 24
 - .4 Service temperature: -40 to 454°C
 - .5 k value: 0.04 W/m°C @ 93°C
 - .2 Type P2
 - .1 Inorganic mineral fibre rigid, split formed, moulded insulation: to ASTM C547
 - .2 ASJ+ or FSK finish
 - .3 Pipe size application: up to and including NPS 30

- .4 Maximum operating temperature: 650°C
- .5 k value: 0.064 W/m°C @ 204°C
- .6 Standard of Acceptance
 - .1 Roxul
 - .2 Johns Manville
 - .3 RockWool
 - .4 Knauf
 - .5 Thermafiber
- .3 Type P3
 - .1 Closed cell elastomeric preformed insulation, roll type sheet or tubular with self-closing adhesion strips: to ASTM C534
 - .2 k value: 0.039 W/m°C @ 24°C
 - .3 Service temperature: up to 82°C
- .4 Type P4
 - .1 Phenolic split formed or sidewall segmented (depending on size) rigid insulation: to ASTM C1126 Group 1; moulded pipe fitting and support insert for cold and dual temperature piping.
 - .2 ASJ finish
 - .3 Pipe size application: up to and including NPS 18
 - .4 Service temperature: -50°C to 110°C
 - .5 K value: 0.025 W/mK @ 70°C
 - .6 Standard of Acceptance
 - .1 Kingspan
- .5 Type P5
 - .1 Removable / reusable high temperature insulation blankets
 - .2 Custom fabricated, removable insulation covers for hot surfaces
 - .3 Suitable for outdoor use
 - .4 Maximum touch-safe temperature protection: 95°C to UL2200
 - .5 Insulation: high density, fire resistant mineral or fibreglass insulation suitable for system operating temperature
 - .6 Cover: silicone impregnated fibreglass cover, for temperatures up to 260°C
 - .7 Internal liner: silicone impregnated fibreglass fabric, or stainless steel knitted wire mesh.
 - .8 Single piece construction
 - .9 Metal identification tag, referenced equipment served.
 - .10 Tie-straps with D-rings, or Velcro™ closures.

- .11 Standard of Acceptance
 - .1 Firwin
 - .2 Unitherm
 - .3 Thermohelp Canada
- .6 Type P6
 - .1 Inorganic mineral fibre flexible blanket: to ASTM C518
 - .2 ULC approved metal pipe fire rating: to 2 hours per manufacturer's product listing
 - .3 ASJ finish
 - .4 Pipe size application: up to and including NPS 8
 - .5 Service temperature: -173 to 1260°C
 - .6 Standard of Acceptance
 - .1 CL4 Fire
 - .2 Unifrax
- .7 Type P7
 - .1 Refractory (ceramic) fibre blanket insulation, to ASTM C892
 - .2 Service temperature: up to 1260°C
 - .3 Density: 128 kg/m³
 - .4 k value: 0.20 W/m°C @ 800°C
 - .5 Standard of Acceptance
 - .1 Morgan Thermal Ceramics
 - .2 KT Refractories
 - .3 Thermaxx
- 2.6 **ADHESIVES**
 - .1 Contact bond cement
 - .1 Quick setting for metal surfaces
 - .2 Standard of Acceptance
 - .1 Henry
 - .2 Foster
 - .3 Johns Manville
 - .2 Lap seal adhesive
 - .1 For joints and lap sealing of vapour barriers
 - .2 Standard of Acceptance
 - .1 Henry
 - .2 Foster
 - .3 Johns Manville

- .3 Contact adhesive
 - .1 For fibrous insulation
 - .2 Standard of Acceptance
 - .1 Henry
 - .2 Foster
 - .3 Johns Manville
- .4 Lagging adhesive
 - .1 Water based
 - .2 Standard of Acceptance
 - .1 Henry
 - .2 Foster
 - .3 Design Polymerics
 - .4 Robson Thermal
- .5 Waterproof vapour retarder
 - .1 For flexible elastomeric closed cell foam

2.7 **MASTIC, COATING**

- .1 Interior, with vapour barrier:
 - .1 Fire resistant meeting 25/50
 - .2 Permeance rating 0.02 perms maximum
 - .3 White in colour
 - .4 Standard of Acceptance
 - .1 Henry
 - .2 Foster
 - .3 Johns Manville
 - .4 Robson
- .2 Exterior, with vapour barrier:
 - .1 Asphalt cutback
 - .2 Permeance rating 0.02 perms maximum
 - .3 Grey in colour
 - .4 Standard of Acceptance
 - .1 Henry
 - .2 Foster
 - .3 Johns Manville
 - .4 Robson

- .3 Interior, breather type:
 - .1 White in colour
 - .2 For insulation except elastomeric closed cell foam
 - .3 Standard of Acceptance
 - .1 Henry
 - .2 Foster
 - .3 Johns Manville
 - .4 Robson
- .4 Exterior, breather type:
 - .1 Abrasion resistive, flexible
 - .2 UV resistant
 - .3 Grey in colour
 - .4 Standard of Acceptance
 - .1 Henry
 - .2 Foster
 - .3 Johns Manville
 - .4 Robson

2.8 MISCELLANEOUS PRODUCTS

- .1 Reinforcing Membrane:
 - .1 Synthetic fibre:
 - .1 Leno weave
 - .2 Indoor and outdoor use
 - .3 Standard of Acceptance
 - .1 Henry
 - .2 Foster
 - .2 Glass-fibre fabric:
 - .1 Indoor use
 - .2 Standard of Acceptance
 - .1 Henry
 - .2 Foster
 - .3 Glass-fibre fabric for use with elastomeric closed cell foam:
 - .1 Indoor use.
 - .2 Standard of Acceptance
 - .1 Henry
 - .2 Foster

- .2 Vapour barrier tape
 - .1 Colour matched
 - .2 75 mm wide
 - .3 Vinyl backed or foil backed to suit insulation
 - .4 UL 181A listed
 - .5 Standard of Acceptance
 - .1 Johns Manville
 - .2 MacTac Canada Ltd
 - .3 Compac Corp
 - .4 Fattal Canvas
- .3 Bands
 - .1 Stainless steel or galvanized metal, 12 mm wide with mechanical cinch locks.
- .4 Weld pins, studs and clips
 - .1 Standard of Acceptance
 - .1 Midwest Fasteners Inc
 - .2 Continental Jordahl
 - .3 AGM Jordahl
- .5 Tie Wire
 - .1 1.6 mm stainless steel with twisted ends
- .6 Caulking
 - .1 Fast-drying colour matched flexible butyl elastomer based vapour barrier sealant.
 - .2 Standard of Acceptance
 - .1 Tremco
 - .2 Foster
 - .3 Henry
 - .4 Dow Corning
- .7 Staples
 - .1 Monel, flare type, minimum size 12 mm.

PART - 3 EXECUTION

3.1 GENERAL

- .1 Perform insulation work in accordance with the latest trade application methods published by TIAC and MICA, and to the Consultant's approval.
- .2 Remove grime, grease, oil, moisture or other matter to ensure that insulation is applied to clean and dry surfaces.

- .3 Apply insulation under ambient temperature conditions in accordance with insulation, mastic, coating or adhesive manufacturer's recommendations.
- .4 Apply insulation after the installation, pressure and leakage testing of piping, ductwork and equipment has been completed, heat tracing has been installed and tested, and the installation has been accepted by the Consultant.
- .5 Do not apply insulation on chrome plated surfaces of piping, valves, fittings, and equipment.
- .6 Cut and bevel insulation around nameplates and pressure vessel stamps.
- .7 Neatly finish insulation at supports, protrusions, sensors and interruptions.
- .8 Apply insulation neatly and tightly in unbroken lengths and with ends of sections firmly and squarely butted together. Lap canvas (or other specified wrapping) over joints and cement down with adhesive. Seal insulation exposed to weather or dampness with reinforced vapour barrier or breather coating/mastic.
- .9 On cold surfaces where a vapour seal must be maintained, insulation shall be applied with a continuous, unbroken moisture and vapour retarder.
- .10 Finish bare insulation with field installed jackets as specified in this Section. All aluminum, stainless steel and PVC recovery jackets shall be removable and reusable.
- .11 At walls, ceiling or floor openings, and sleeves extend insulation including coatings and finishes through to make insulation continuous, except where firestop material is required.
- .12 At fire separations, terminate insulation at the wall or floor, and pack the space between the sleeve and duct or pipe as specified in Section 20 00 19 – Basic Materials and Methods. Provide finishes in accordance with the fire stopping manufacturer's listing requirements.
- .13 Dampers, supports, anchors, etc. that are secured directly to cold surfaces shall be adequately insulated and vapour sealed to prevent condensation.
- .14 Outdoor ductwork and equipment shall be installed so as to shed water and not allow standing water. For outdoor piping passing through exterior walls or roof, terminate mastic lagging at the outside face of the sleeve and protect by storm flashing, caulked to lagging and to building structure.
- .15 Treatment of existing insulation
 - .1 Where new piping or ductwork connects to existing, and where the existing insulation is damaged through the installation of new work, remove damaged sections of insulation for a minimum of 1 m replace with new insulation and finish to match existing.

3.2 **DUCTWORK**

- .1 General
 - .1 Insulate ductwork in accordance with the requirements noted for duct insulation at the end of this Section.
 - .2 Insulate access doors or removable panels in ductwork as separate units to permit opening or removal without damage to adjoining insulation.
 - .3 Cover angles or standing seams on the outside of plenums, casings and ducts which extend beyond face of applied rigid insulation with the same material and thickness as adjacent ductwork.

- .1 Extend this insulation 75 mm on each side of the angle and place tight around the projecting leg of the angle.
 - .2 Apply rigid insulation overlapping the edge of the flexible insulation on angle so that the outstanding part of the insulated angle projects through the work.
 - .4 Cut and mitre rigid insulation at elbows and fittings. Attach to ductwork with 50% coverage of adhesive, and using mechanical fasteners with weld pins, speed clips and washers.
 - .5 When using pins to secure the insulation, cut off protruding ends of welded pins and cover speed washers with vapour barrier tape.
 - .6 At junctions between external insulation and acoustic insulation, overlap external insulation 300 mm over acoustic lining.
 - .7 Insulate all silencer casings where no internal media contacts the wall of the silencer.
 - .8 Outdoor rectangular and flat-oval ductwork:
 - .1 Build-up and slope insulation on top of ductwork to provide a 1:100 drainage slope.
 - .2 Where width of ductwork exceeds 600 mm, slope insulation in both directions.
- .2 Type D1
 - .1 Overlap insulation 50 mm on each lap joint; tightly butt end edges and joints. Seal with interior coating and scrim foil tape.
 - .2 On rectangular ducts 600 mm and wider, and on round ducts 450 mm and wider:
 - .1 Secure insulation to the underside of duct with weld pins, studs, and clips at 300 mm centres in both directions, with not less than 2 rows per side and bottom.
 - .2 Secure insulation laps with mechanical fasteners (staples).
 - .3 For round ductwork, the underside of duct is measured as being half the circumference of the duct.
 - .3 For other ductwork, fasten insulation with adhesive, applied in 150 mm wide strips at 300 mm centres.
 - .4 Tying cord may be used to temporarily hold insulation until adhesive has set.
- .3 Type D2
 - .1 Fans, ducts, and casing:
 - .1 Overlap horizontal boards over vertical boards; tightly butt all edges and joints and seal with interior coating and scrim foil tape.
 - .2 Secure insulation with welded pins and speed washer type fasteners at 300 mm centres. Provide a minimum of two rows of fasteners on each side of duct.
 - .2 Outside air duct and plenums:
 - .1 As above for fans, ducts, and casings, and;
 - .1 Apply first layer of insulation without integral vapour barrier,

- .2 Apply second layer of insulation with integral vapour barrier with staggered joints.
 - .3 Exhaust air plenums:
 - .1 As above for fans, ducts, and casings.
 - .4 Type D3
 - .1 Install fire rated insulation in strict accordance with manufacturer's recommendations and ULC listing requirements.
 - .2 Provide the services of the manufacturer's technical representative to inspect the installation prior inspection by the Consultant. Submit manufacturer's inspection certificate.
 - .5 Type D4
 - .1 Outside air duct and plenum - as above for fans, ducts, and casings, but with only one layer of insulation board.
 - .6 Type D5
 - .1 Wrap tightly onto ductwork and drain pans, and secure with 100% adhesive coverage.
 - .2 On round ducts, overlap insulation 50 mm on each lap joint and butt end edges tightly together.
- 3.3 **EQUIPMENT**
 - .1 General
 - .1 Insulate equipment in accordance with the requirements noted for equipment insulation at the end of this Section.
 - .2 Place insulation with joints staggered and tightly butted.
 - .3 Secure insulation with:
 - .1 Stainless steel bands 300 mm on centre, or
 - .2 Attach to equipment surfaces with adhesive, applied in strips 150 mm wide at 300 mm on centre.
 - .4 Do not use weld pins on plate and frame heat exchangers.
 - .5 Insulate curved surfaces with radius less than 250 mm using E1 Type insulation.
 - .6 Nozzles, removable heads, access panels and manholes
 - .1 Terminate insulation with straight cut with space of 25 mm at connection. Provide a separable section of insulation, complete with galvanized metal frame and cover, overlapping the adjacent insulation by 50 mm.
 - .2 Attach insulation section to equipment with clamps or bands.
 - .3 Arrange insulation section to permit removal of heads or manhole cover without damaging either the equipment insulation or the removable insulation section.
 - .4 Seal cut with insulation coating bevelled away from flanged or union connections.
 - .7 Instruments and instrument sensor risers

- .1 Tightly fit equipment insulation to instrument riser/piping.
- .2 In addition for cold and dual temperature equipment, insulate the instrument sensor riser for a length equal to four (4) times the diameter of the riser pipe.
- .8 Cold pumps, cold plate-and-frame heat exchangers
 - .1 Insulate with removable and replaceable boxes consisting of 1.6 mm aluminum or stainless steel sheeting, lined with insulation type as specified.
 - .2 Construct boxes so that packing gland is accessible for service from outside.
 - .3 Vapour seal box edges and joints, and between adjacent box sections after covers are in place.
 - .4 Attach boxes so that they may be removed without disturbing casing insulation.
 - .5 Adhere insulation directly to pump casing. Do not insulate the motor.
- .9 Centrifugal chiller (not factory insulated)
 - .1 Adhere insulation to clean, oil-free metal surfaces by compression fit method and with full coverage of adhesive.
 - .2 Seal butt joints, holes and corners with same adhesive.
 - .3 Insulate the following:
 - .1 Evaporator unit including nozzles and heads (2 staggered layers of 19 mm insulation.
 - .2 Intercooler including drop leg and heads.
 - .3 Suction connection between compressor and evaporator.
 - .4 Interstage gas connection.
 - .5 Liquid connection between intercooler drop leg and the evaporator unit.
 - .4 Insulate evaporator heads and float boxes with removable and replaceable boxes of 1.6 mm aluminum or stainless steel sheeting, lined with insulation type as specified. Attach boxes so that they can be removed without disturbing insulation.
- .10 Radiant panels
 - .1 Lay insulation on top of panels, with foil face facing down.
- .2 Type E1 and E3
 - .1 Apply insulation with manufacturer's recommended adhesive with 100% coverage.
 - .2 Build up voids with insulation to allow finishing layer to be installed in a single plane.
 - .3 Joints: file a longitudinal stapling flange and staple joints. Seal all joints with vapour barrier coating or tape.
 - .4 Insulate fittings, unions, flanges and valves with preformed block insulation or with segments cut from insulation of same type and thickness as pipe insulation.

- .5 Form insulation on fittings and valves without voids. Secure in place with galvanized metal bands.
- .3 Type E2 and E4
 - .1 Fasten insulation onto pins welded onto equipment. Weld pins on 400 mm centres. Do not use weld pins on plate and frame heat exchangers
 - .2 On curved surfaces, cut insulation into sections and secure with bands and wire mesh, or use scored board. Build up voids with insulation to allow finishing layer to be installed in a single plane. Provide metal corner beads to reinforce corners and edges.
- .4 Type E5
 - .1 Wrap tightly onto equipment and apply insulation with manufacturer's recommended adhesive with 100% coverage.
 - .2 Build up voids with insulation to allow finishing layer to be installed in a single plane. Use manufacturer's compression fit method of butt joining sheets.
- .5 Type E6
 - .1 Install blankets per manufacturer's instruction.
 - .2 Use lacing anchors, washers and 302/304 stainless steel safety lock wire supplied by blanket manufacturer.
- 3.4 **PIPING**
 - .1 General
 - .1 Insulate piping systems including pipe, valves, fittings, and pipeline accessories in accordance with the requirements noted for pipe insulation at the end of this Section.
 - .2 Insulate straight pipe sections by staggering adjacent longitudinal seams 1/4 turn at each butt joint. Locate longitudinal joints on top of the pipe for all piping installed indoors, and on the bottom of the pipe for all piping installed outdoors.
 - .3 Secure insulation at centre of each section, at each end, and at not more than 600 mm intervals with:
 - .1 Vapour barrier tape in addition to jackets with self-adhering lap joints for Type P1 insulation on Cold and Dual Temperature piping,
 - .2 Mechanical fastened (stapled) or jackets with self-adhering lap joints on Type P1 insulation on Hot piping,
 - .3 Bands or wire for Types P2, P4 and P7 insulation,
 - .4 Self-adhered or provide 100% coverage of contact adhesive for Type P3 insulation,
 - .4 Hot Piping Systems Insulation
 - .1 Insulate condensate piping to the same criteria as its associated steam system.
 - .2 Insulate safety relief valve piping located between floor or elevated work surface and up to 2400 mm above same, and piping passing within 1200 mm of a floor or elevated work surface.

- .5 Cold and Dual Temperature Piping Systems Insulation
 - .1 For drainage systems insulate:
 - .1 The body of each storm water roof drain;
 - .2 Horizontal storm water piping connected to roof drains, up to the nearest vertical change in direction or for 6m length, whichever is greater measured from the body of the roof drain;
 - .3 Mechanical room floor drains and any other drains including p-traps carrying cold condensate, associated drain piping up to the nearest vertical change in direction or for 6m length, whichever is greater measured from the drain;
 - .4 Sanitary drain lines serving urinals, up to the stack connection;
 - .5 Indirect and direct sanitary drains from drinking fountains;
 - .6 All drain lines passing through high humidity areas (such as pools, steam rooms);
 - .7 Sanitary drain piping from barrier-free lavatories and sinks, up to the wall penetration.
 - .2 For greater clarity, domestic hot water, domestic hot water recirculating, non-potable hot water, and non-potable hot water recirculating piping systems shall be treated as "Cold and Dual temperature" for the purpose of application of vapour barriers to both hot and cold domestic and non-potable water piping.
 - .3 Ground source heat pump system piping shall be treated as "Cold and Dual temperature" service.
 - .4 Insulate pure water piping systems where there is a possibility of condensation. Tempered water pure systems do not require insulation. Insulation is not required in the following locations:
 - .1 Piping supplied as part of a water treatment equipment package,
 - .2 Piping located inside dialysis service boxes, and
 - .3 Exposed pipe drops to a service connection within a room (but does not include a water treatment equipment room).
- .6 Boiler breeching, generator exhaust pipes and mufflers
 - .1 Stagger half sections and butt one-piece sections of the preformed insulation firmly together. Recover insulation with glass-fibre fabric, adhered with fire retardant and high temperature rated adhesive.
 - .2 Insulation shall be banded securely in place with 20mm x 0.5mm stainless steel bands on maximum 300mm centres and recovered with metal jacketing secured using additional banding or sheet metal screws. Position bands at butt joint overlaps and in between joints to secure jacket.
- .7 At each pipe expansion joint in insulated piping, install a metal sleeve with min. 1.6mm wall thickness, fabricated to fit around expansion joint without restricting the movement of joint. Sleeves shall be removable without damaging the adjoining insulation, to allow inspection and lubrication of the expansion joint. The sleeve shall be min. 75mm larger than the expansion joint, be fitted with insulation retaining flanges and with means to maintain position over the expansion joint. Apply the insulation over the sleeve.

- .8 At heat traced piping make allowance in sizing the inside diameter of the insulation for tracing cable.
- .2 Types P1 and P3
 - .1 Lap and seal all joints (longitudinal and transverse).
- .3 Type P2
 - .1 Seal all joints (longitudinal and transverse).
 - .2 Stop insulation on each side of unions and at connections to equipment.
- .4 Type P4
 - .1 Seal ends of insulation with mastic matching finish colour of insulation.
- .5 Type P5
 - .1 Install blankets per manufacturer's instruction.
 - .2 Use lacing anchors, washers and 302/304 stainless steel safety lock wire supplied by blanket manufacturer.
- .6 Type P6
 - .1 Install fire rated insulation in strict accordance with manufacturer's recommendations and ULC listing requirements.
 - .2 Provide the services of the manufacturer's technical representative to inspect the installation prior inspection by the Consultant. Submit manufacturer's inspection certificate.
- .7 Fittings, Flanges, Couplings, and Strainers
 - .1 Insulate fittings including elbows and tees:
 - .1 40mm and smaller:
 - .1 Mitre cut insulation to create tight fit.
 - .2 For PVC cover, trim backside of insulation on elbows to suit cover but do not reduce total thickness less than that of adjacent pipe insulation.
 - .2 50mm and larger:
 - .1 Use matching preformed insulation inserts, or fabricate mitred insulation segments made from same material as pipe insulation.
 - .2 Number of mitred segments to be sufficient to maintain thickness of insulation around throat of elbow.
 - .3 Secure inserts and fabricated segments with wire prior to application of coatings or finishes.
 - .2 Insulate flanges and grooved joint couplings:
 - .1 Insulate with preformed inserts or build-up insulation with same material as on adjacent pipe:
 - .1 Butt pipe insulation to each side of flange, coupling, valve, or strainer.
 - .2 Build up rigid insulation blocking on each side of fitting, coupling, valve or strainer, with a width dimension same as pipe insulation

- thickness.
- .3 Apply insulation layer over outside of flange, coupling, valve or strainer to a thickness equal to pipe insulation thickness.
- .4 Provide removable insulation section on strainer head.
- .2 Where phenolic insulation is used;
 - .1 Same as above except use factory made insulation inserts, or fabricate inserts to suit fixture.
- .3 Where elastomeric insulation is used;
 - .1 Same as above except adhere insulation to flange, coupling, or strainer with full coverage of adhesive.
 - .2 Do not adhere insulation across bolted connections. Insulate on each side of connection, add additional insulation layer across connection and fix it in place with bands.
- .8 Pipeline Accessories
 - .1 Insulate pipeline accessories:
 - .1 Valves
 - .2 Strainers
 - .3 Pressure reducing valves
 - .4 Safety valves
 - .5 Meters
 - .6 Steam separators
 - .2 Terminate insulation on pipe at 75 mm from line size accessories. Butt pipe insulation to each side of flange or joint of accessories. Bevel insulation at 45 degree angle away from accessories. Finish exposed face with appropriate mastic or coating.
 - .3 Insulate accessories for Hot Piping systems with design temperatures greater than 93°C:
 - .1 Where located within 2100 mm above a floor or work surface
 - .2 With Type P5 removable fitted insulation covers
 - .3 To allow free movement of valve actuator.
 - .4 No insulation is required on pipeline accessories for Hot Piping systems with design temperatures of 93°C or less.
 - .5 Insulate accessories for Cold and Dual Temperature Piping systems for chilled water and liquid refrigerant piping with:
 - .1 Detachable insulated box type with embossed aluminum or stainless steel jacket, with vapor barrier tape applied to seams when installed;
 - .2 Lined with two layers of 25 mm P3 elastomeric blanket or one layer of 25 mm thick P4 phenolic insulation, with no voids at corners or joints.
 - .3 At locations requiring access, extend insulation to create collar around bolted connection, and install a compression fit piece of insulation to cover equipment.

- .6 Insulate accessories for all other Cold and Dual Temperature Piping systems:
 - .1 Insulate with flexible blanket of same material and thickness of insulation applied on adjacent piping. Seal with reinforced vapour barrier sealer.
 - .2 At locations requiring access including valve handles, valve actuators, drain valves, cut back insulation and seal exposed edges.
- .9 Hangers and Supports
 - .1 Provide insulation protection in accordance with the requirements noted for hangers at the end of this Section, based on pipe size and service process temperature.
 - .2 For cold and dual temperature pipe systems, insulate the pipe anchor plates and frames with a flexible blanket of Type P3 insulation and seal with vapour barrier coating. Extend insulation along the anchor steel to a minimum distance of 150 mm outside the piping insulation thickness.
 - .3 Pipe saddle insulation protection
 - .1 Insulate the interior void spaces of pipe saddles, of same material as adjacent pipe insulation.
 - .2 Butt insulation up to sides and end of pipe saddle, and leave bottom surface of saddle exposed for direct contact with pipe support.
 - .4 Pipe shield insulation protection
 - .1 Install insulation shield between the outside of insulation and the pipe support. Pipe support shall be sized for the outside dimension of the insulation.
 - .2 Provide high density insulation insert of the same thickness as the adjacent pipeline insulation material, fabricated from Type P5 (phenolic) insulation:
 - .1 300 mm long for pipe sizes 75mm and smaller
 - .2 450 mm long for pipe sizes 100mm and larger
 - .3 Bond the insulation shield to the insulation insert with adhesive. Finish and seal complete assembly with breather or vapour barrier insulation coating, depending on application.
 - .1 Alternatively, finish insulation insert as part of the main pipe insulation. Provide two metal band clamps for each insulation shield and strap the shield to the finished pipe insulation.

3.5 **SEALING OF INSULATION**

- .1 Hot ducts, casings, and plenums - Indoors:
 - .1 Service temperature: 20°C to 65°C
 - .2 Apply vapour barrier tape to butt joints, overlapping by minimum 50 mm each side.
 - .3 Do not tape lap joints.
- .2 Hot ducts - Outdoors:
 - .1 Service temperature: 20°C to 65°C
 - .2 Apply reinforced breather mastic to all corners, lap edges and butt edges, overlapping joint by minimum 50 mm each side.

- .3 Cover mechanical fastener (staple) penetrations with reinforced breather mastic.
- .4 Insulate flanges and standing seams with overlapping strips of flexible insulation, and cover with reinforced breather mastic.
- .5 Do not use vapour barrier tape on outdoor applications.
- .3 Cold or dual temperature ducts, casings, and plenums - Indoors:
 - .1 Service temperature: ambient to 20°C
 - .2 Apply reinforced vapour barrier coating to all corners, lap edges and butt edges, overlapping joint by minimum 50 mm each side.
 - .3 Cover mechanical fastener (staple) penetrations with reinforced vapour barrier coating.
 - .4 Insulate flanges and standing seams with overlapping strips of flexible insulation, and cover with reinforced vapour barrier coating.
- .4 Cold or dual temperature ducts - Outdoors:
 - .1 Service temperature: ambient to 20°C
 - .2 Apply reinforced vapour barrier mastic to all corners, lap edges and butt edges, overlapping joint by minimum 50 mm each side.
 - .3 Cover mechanical fastener (staple) penetrations with reinforced vapour barrier mastic.
 - .4 Insulate flanges and standing seams with overlapping strips of flexible insulation, and cover with reinforced vapour barrier mastic.
 - .5 Do not use vapour barrier tape on outdoor applications.
- .5 Hot equipment – Indoors:
 - .1 No sealing of insulation is required prior to application of finish protection.
- .6 Hot equipment – Outdoors:
 - .1 Apply breather mastic with reinforcing membrane over equipment insulation, regardless of final finish application.
- .7 Cold and dual temperature equipment:
 - .1 Type E1, E2, E3 and E4 insulation - Indoors and Outdoors:
 - .1 Apply vapour barrier coating/mastic with reinforcing membrane over equipment insulation, regardless of final finish application.
 - .2 At pipe connections, cut-back insulation and seal with coating/mastic. Insulate pipe flanges in accordance with requirements for piping insulation.
 - .3 At instruments and instrumentation sensor riser, cut-back and seal insulation with coating/mastic at riser, and seal sensor riser insulation.
 - .2 Type E5 insulation - Indoors:
 - .1 Seal transverse and butt joints with sealer/adhesive.
- .8 Hot piping:
 - .1 Seal lap joints with self-adhesive lap joint, reinforced breather coat or vapour barrier tape, as applicable.

- .2 Seal butt joints with matching vapour barrier tape.
- .9 Cold and dual temperature piping:
 - .1 Tightly seal insulation with factory applied all-purpose jacket using self-adhering or field applied adhesive on longitudinal laps and butt joint.
 - .2 Where sealing strips are damaged, apply secondary layer of colour matched vapour barrier tape.
 - .3 Seal insulation without factory applied jackets with 100% coverage of vapour barrier coating/mastic as applicable, complete with reinforcing membrane.
 - .4 Seal insulation butt ends with vapour barrier coating every four (4) lengths of insulation but not to exceed 2400 mm of pipe length.
- .10 Elbows, tees, flanges, and fittings:
 - .1 Apply applicable breather or vapour barrier coating/mastic with reinforcing membrane over fitting insulation and overlap 50 mm onto adjacent pipe insulation.
 - .2 The use of vapour barrier tape to seal insulation is not permitted.
 - .3 Apply coating/mastic and reinforcing membrane regardless of final finish application.
- .11 Mastic application
 - .1 Do not allow mastic materials to come in contact with single ply membrane roofs.
 - .2 Clean up accidental spills immediately.
 - .3 Provide temporary drop sheets to protect the roof.

3.6 **INSULATION FINISH COVERINGS**

- .1 Install protective finish coverings on insulation in accordance with the requirements noted for finishes at the end of this Section, after breather and vapour barrier sealing is completed.
- .2 Cut finish jacket materials used for covering to allow 50 mm to 100 mm longitudinal overlap and similar circumferential overlap onto adjacent sheets.
- .3 On vertical tanks, vessels, and vertical pipes, arrange circumferential overlap on adjacent sheets outside of sheet below and under sheet above.
- .4 PVC jacket:
 - .1 Hot ducts, equipment and piping:
 - .1 Overlap longitudinal edges and adjacent sheets and staple fasten the sheets.
 - .2 Secure sheeting with colour matched tape around circumference, at least two places per section of sheet, and by stapling longitudinal and circumferential edges.
 - .3 Do not seal edges with vapour barrier tape.
 - .4 Seal PVC fitting covers at throat and heel seams by stapling and secure over insulation by banding or taping ends to adjacent pipe finish covering with colour matched tape.
 - .2 Cold and dual temperature ducts, equipment and piping:

- .1 Overlap longitudinal edges and adjacent sheets and seal longitudinal edges with vapour barrier coating adhesive for full depth and 100% coverage of overlap.
 - .2 Seal circumferential edges of PVC fitting covers with reinforced vapour barrier coating adhesive extending over adjacent pipe insulation section with an overlap of at least 50 mm.
 - .3 Seal PVC fitting covers at throat and heel seams by solvent bonding and secured over insulation with reinforced vapour barrier coating/mastic overlapping adjacent pipe insulation a minimum of 50 mm.
- .5 Metal jacket:
 - .1 Use lock-on systems or secure sheeting with bands 450 mm apart.
 - .2 Joint sealing:
 - .1 Hot ducts, plenums, equipment, pipes: do not seal joints.
 - .2 Cold and dual temperature ducts, plenums, equipment, pipes: seal joints with caulking.
 - .3 Curved surfaces: custom made swaged ring or lobster back covers.
 - .4 On outdoor hot and cold/dual temperature ducts and piping, caulk overlapping metal joints to permit expansion of metal jacket.
- .6 Laminated self-adhesive jacket:
 - .1 Apply in accordance with manufacturer's instructions.
- .7 Canvas jacket:
 - .1 Do not apply canvas to elastomeric closed cell foam insulation.
 - .2 Cotton lagging:
 - .1 Apply cotton lagging with minimum two coatings of breather or vapour barrier coating adhesive as applicable to the duct or piping system, and finish to provide a smooth surface, free of wrinkles and sags. Do not use metal bands.
 - .2 Where cotton lagging with appropriate coating is used, this satisfies the requirements of a sealer coating for hot or cold/dual temperature duct and piping systems.
 - .3 Fibreglass lagging:
 - .1 Apply re-wettable fibreglass lagging in accordance with manufacturer's instructions. Finish to provide a smooth surface, free of wrinkles and sags.
 - .2 Where re-wettable fiberglass lagging is used, this satisfies the requirements of a sealer coating for hot duct and piping systems.
 - .4 Seal canvas jacket with off-white coating to leave a smooth, non-porous surface ready to receive paint application.
- .8 Flexible elastomeric closed cell foam insulation:
 - .1 Apply thin coat of lagging adhesive and glass mesh.
 - .2 When dry, apply indoor or outdoor finish at 10 square meters per liter.
 - .3 Apply second coat of same material, at same rate of application, after four hours.

- .4 Finish with one coat of white acrylic latex as recommended by insulation manufacturer.
- .9 Finish all exposed insulation applied on piping beneath barrier free plumbing fixtures with a white, fitted antimicrobial pipe cover equivalent to Truebro manufactured by IPS.

3.7 MECHANICAL DAMAGE PROTECTION

- .1 Protect exposed insulated ductwork, piping and equipment located in high traffic areas, from floor level up to 1200 mm above floor with 1.2 mm stainless steel jacket, secured to floor slab.
- .2 Do not overlap fire damper slip joint with protective sheeting.

3.8 FIELD QUALITY CONTROL

- .1 The Consultant reserves the right to have protective finish coverings removed on up to 5% of all fittings, flanges, couplings, valves, and pipeline accessories to review the sealing of the insulation, at no change in cost.
- .2 If insulation sealing is found to be incorrect at any one location, remove the protective finish on all fittings, flanges, couplings, valves, and pipeline accessories for review.
- .3 Repair defective sealing and replace protective coverings at no change in cost.

3.9 INSULATION SELECTION

HVAC Duct Insulation			
System Description	Service Temp. °C	Insulation Type	Insulation Thickness mm
Rectangular conditioned supply ducts, concealed Rectangular return ducts, in unconditioned space Rectangular conditioned supply ducts, less than 36" wide, exposed Round and oval conditioned supply ducts, exposed Round and oval conditioned supply ducts, concealed Round and oval return ducts, in unconditioned space Tempered supply ducts, in unheated space	5 to 65	D1	38 Note 1
Air handling unit casing and plenums Free standing supply fans Rectangular conditioned supply ducts, greater than 36" wide, exposed Ducts and plenums housing heating and cooling coils	5 to 65	D2	25
Fresh air intake plenums, casings Fresh air supply ducts from outside air louvre or opening to mixing plenum of air handling unit, or to motorized damper in other systems	Ambient to 65	D2	Two layers each 50
		D4	75
Exhaust air plenums, casings	Ambient to	D2	50

HVAC Duct Insulation			
System Description	Service Temp. °C	Insulation Type	Insulation Thickness mm
Exhaust air ducts, from outside louvre or duct termination to 1.5m upstream of motorized or backdraft damper, or where there are no motorized or backdraft dampers, from louvre/duct termination to fan discharge	65		
		D4	38
Silencers	5 to 65	Concealed D1	38 Note 1
		Exposed D2	25
Exhaust ducts behind registers in high humidity areas, in minimum 3 m length	Ambient to 38	D1	38Note 1
Rectangular ducts conveying conditioned air, located outside the building envelope	5 to 65	D2	Two layers each 50
Round ducts conveying conditioned air, located outside the building envelope	5 to 65	D1	Two layers each 75 Note 1
Mixed air plenums, casings	5 to 65	D2	50
Fire rated ducts, 2 hrs.	N/A	D3	Note 2

Note 1: thickness is “out of box” before installation

Note 2: thickness and installation in strict accordance with ULC listing requirements.

HVAC Equipment Insulation			
Equipment Description	Max. Surface Temp. °C	Insulation Type	Insulation Thickness mm
Shell-and-tube heat exchangers, flash tanks, expansion tanks	150	E1, E3	50
Plate-and-frame heat exchangers	150	E2, E4	25
Radiant ceiling panels	150	E1	50
Boilers	150	E3, E4	50
Deaerators	150	E3	50
Condensate receivers	150	E3	50
Air separators	150	E3	25
Other equipment - hot	150	E1, E2, E3, E4	40

HVAC Equipment Insulation			
Equipment Description	Max. Surface Temp. °C	Insulation Type	Insulation Thickness mm
Flash tanks	Between 150 and 400	E3	38
Blowdown cooling tank	Between 150 and 400	E3	25
Boiler feed water heater tanks	Between 150 and 400	E3	50
Field assembled boilers	Between 150 and 400	E4	50
Boiler breeching/chimney connectors	Between 150 and 400	E3, E4	50
Boiler stacks and chimneys inside of building	Between 150 and 400	E3, E4	50
Boiler stacks and chimneys outside of building	Between 150 and 400	none	-
Other equipment - hot	Between 150 and 400	E3, E4	50
Diesel engine exhaust piping	Between 400 and 650	P2	Two layers each 50
Diesel engine exhaust silencer	Between 400 and 650	E3	Two layers each 50
Selective catalytic reduction (SCR) system	Between 400 and 650	E6	As required for safe touch
Engine exhaust gas heat exchanger	Between 400 and 650	E3, E4	Two layers each 50
Natural gas engine exhaust piping	Between 650 and 1093	P7 inside and P2 outside	25 50
Water softener tanks	38	E1, E5	25
Deionizer tanks	38	E1, E5	25
Heat exchangers, plate-and-frame	16	E2, E5	Two layers each 20
Water chiller components as specified	16	E5	Two layers each 20
Chilled water pumps	16	E5	20
Chilled water storage tanks	16	E5	Two layers each 50
Chilled water expansion tanks	16	E1, E5	25

HVAC Equipment Insulation			
Equipment Description	Max. Surface Temp. °C	Insulation Type	Insulation Thickness mm
Condenser water pumps used for free cooling	16	E5	Two layers each 20 removable box
Cooling tower sump - indoors	16	E5	25
Cooling tower sump – outdoors, traced	16	E2	50
Glycol pumps (below 11°C))	16	E5	20
Glycol expansion tank (below 11°C)	16	E1, E5	25
Condensation trays, drip pans	16	E5	25
Other equipment - cold	16	E1, E2, E5	25

Plumbing Equipment Insulation			
System Description	Max. Surface Temp. °C	Insulation Type	Insulation Thickness mm
Domestic hot water tanks and heaters	150	E1	75
Cold water booster pumps	16	E5	Two layers each 25 removable box
Water meters	16	E5	25

Process Equipment Insulation			
System Description	Max. Service Temp. °C	Insulation Type	Insulation Thickness mm
Process cooling water pumps	43	E5	20
Industrial water pumps, industrial water tank heater circulators, and industrial water feed pumps	43	E5	20
Weak acid cation tanks	43	E1	25
Decarbonator tanks	43	E1	25
Hydrogen cation tanks	43	E1	25
Weak base anion tanks	43	E1	25

Process Equipment Insulation			
System Description	Max. Service Temp. °C	Insulation Type	Insulation Thickness mm
Process water pumps, process water tank heater circulators, and process water feed pumps	43	E5	20

HVAC Piping Insulation				
System Description	Max. Serv. Temp. °C	Pipe Size NPS	Insulation Type	Insulation Thickness mm
Steam and condensate, 103 kPa to 860 kPa Boiler feed water including soft water tank heater piping, blow-off, blowdown Safety relief piping (up to 2.4m above floor)	122 to 176	Up to 1 1/4 to 2 1/2 and over	P1, P2 P1, P2 P1, P2 P1, P2	76 101 114
Steam and condensate, less than 103 kPa High temperature heating water Boiler make-up water piping including soft water tank heater piping	94 to 121	Up to 2 1/2 and over	P1, P2 P1, P2	63 76
		Up to 1 1/4 1/2 to 3 4 and over	P4 P4 P4	20 25 38
Valves, strainers, PRVs, relief valves, meters, steam separators	94 to 260	All sizes	P5	As required for safe touch
Equipment drain lines, safety valve vents, relief valve vents	110	All sizes	P1, P2	25
Hot water heating Glycol heating Pumped condensate	61 to 93	Up to 1 1/4 and over	P1, P2 P1, P2	38 50
		Up to 3/4 1 and over	P4 P4	20 25
Hot water heating runouts to terminal units (max. 3.7m length)	61 to 93	Up to 2	P1	25
		Up to 2	P4	20
Low temperature heating water Low temperature glycol heating	40 to 60	Up to 1 1/4 and over	P1, P2 P1, P2	25 38
		Up to 3 4 and over	P4 P4	20 25
Condenser water - outdoors	26 to 39	Up to 3 4 and over	P1, P2	25 38

HVAC Piping Insulation				
System Description	Max. Serv. Temp. °C	Pipe Size NPS	Insulation Type	Insulation Thickness mm
Electrically traced hot piping located outdoors	61 to 93	Up to 2 2½ to 4 6 and over	P1 P1 P1	63 75 90
Dual temperature cooling/heating	4.4 to 93	Up to 1 1¼ and over	P1 P1	38 50
		Up to 1 1¼ and over	P4 P4	25 38
Refrigerant	60	All sizes	P3, P4	20
Heavy fuel oil	50	All sizes	P1, P2	25
Chilled water	4.4 to 16	All sizes	P1	25
		All sizes	P4	25
Electrically traced cold piping located outdoors	4.4 to 16	Up to 2 2½ to 4 6 and over	P1 P1 P1	63 75 90
Refrigerant suction	Less than 4.4	Up to 3	P3	25
		All sizes	P4	25

Plumbing Piping Insulation				
System Description	Max. Serv. Temp. °C	Pipe Size NPS	Insulation Type	Insulation Thickness mm
Domestic hot and recirculating water	40.5 to 82	Up to 2	P1, P2	25
Non-potable hot water		2½ and over	P1, P2	38
Hot water and cold water supply to, sanitary drain from barrier free use lavatories and sinks	4.4 to 82	All sizes	P1	12
Domestic hot and recirculating water in unconditioned space or outdoors	40.5 to 82	Up to 2 2½ to 4 6 and over	P1 P1 P1	63 75 90
Storm and sanitary drainage Equipment condensate drains	38	All sizes	P1, P3	25
Pure water, RO water, de-ionized water	4.4 to 93	Up to 2 2½ and over	P1	25
			P1	38

Plumbing Piping Insulation				
System Description	Max. Serv. Temp. °C	Pipe Size NPS	Insulation Type	Insulation Thickness mm
Domestic cold water	4.4 to 16	All sizes	P1	25
Non-potable water		All sizes	P4	20
Domestic cold water or non-potable water, electrically traced	4.4 to 16	All sizes	P1	50

Fire Protection Piping Insulation				
System Description	Max. Serv. Temp. °C	Pipe Size NPS	Insulation Type	Insulation Thickness mm
Fire standpipe, wet sprinkler and drainage piping in unheated areas	38	All sizes	P1, P2	25
Drum drips of dry sprinkler system, electrically traced	38	All sizes	P1, P2	50
Fire rated pipes, 2 hrs, not enclosed by a rated enclosure	38	All sizes	P6	Note 1

Note 1: thickness and installation in strict accordance with ULC listing requirements.

Process Piping Insulation				
System Description	Max. Serv. Temp. °C	Pipe Size NPS	Insulation Type	Insulation Thickness mm
Process cooling water	43	All sizes	P1, P4	25
Industrial water including industrial water tank heater piping	93	All sizes	P1	25
Process water including process water tank heater piping	93	All sizes	P1	25
Process wastewater	93	All sizes	P1	25

3.10

HANGER PROTECTION

Hanger protection				
System Temperature °C	Pipe Size mmNPS	Pipe Saddle	Insulation Shield	High-Density Insert
>93	≥40	●	-	-
	≤32	-	●	-

Hanger protection				
System Temperature °C	Pipe Size mmNPS	Pipe Saddle	Insulation Shield	High-Density Insert
61 to 93	≥200	•	-	-
	≥40 and ≤150	-	•	•
	≤32	-	•	-
26 to 60	≥40	-	•	•
	≤32	-	•	-
Cold and Dual Temperature	≥40	-	•	•
	≤32	-	•	-

Duct Insulation Field Applied Finishes			
Arrangement	Environment	Location	Finish
Concealed	Indoors	Any	None
Exposed	Indoors	Service Rooms	Canvas, PVC, Metal or SAJ
	Indoors	Public Spaces	PVC, Metal or SAJ
	Outdoors	Any	Metal or SAJ

Equipment Insulation Field Applied Finishes			
Arrangement	Environment	System Type	Finish
Concealed	Indoors	Any	None
Exposed	Indoors	All except steam over 860 kPa	Metal or SAJ
	Indoors	Steam over 860 kPa	Canvas
	Outdoors	Any	Metal or SAJ

Piping Insulation Field Applied Finishes			
Arrangement	Environment	System Type	Finish
Concealed	Indoors	Any	None
Exposed	Indoors	All except steam over 860 kPa	PVC or SAJ
	Indoors	Steam over 860 kPa	Canvas
	Outdoors	Any	Metal or SAJ

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

.1 Section includes:

- .1 Labour, products, equipment and services necessary to complete the work of this Section.

.2 Scope of Work:

- .1 Provide commissioning for fire protection, plumbing, HVAC and building automation systems and equipment in accordance with the Contract Documents, the commissioning requirements included under Divisions 21, 22, and 23, and Section 01 81 20.
- .2 This Section shall be read in conjunction with all other Sections of the Division 21, 22, and 23 Specifications, which include details of specific tests / inspections to be performed on various equipment / systems in addition to those specified in this Section.
- .3 Commissioning Work of Divisions 21, 22, and 23 includes, but is not limited to:
 - .1 Testing and start-up of equipment.
 - .2 Testing, adjusting and balancing of fire protection, hydronic, plumbing and air systems.
 - .3 Cooperation with the Commissioning Authority in developing and implementation of the commissioning plan.
 - .4 Providing qualified personnel for participation in commissioning tests, including seasonal testing required after the initial testing.
 - .5 Providing equipment, materials, and labor as necessary to correct construction and/or equipment deficiencies found during the commissioning process.
 - .6 Providing operation and maintenance manuals and as-built drawings to the Commissioning Authority for verification.
 - .7 Providing training and demonstrations for the systems specified in this Division.
- .4 Conduct complete and thorough evaluation and documentation of the operation and performance of all components, systems, and sub-systems as defined under Section 21 08 00 – Commissioning of Fire Suppression, Section 22 08 00 - Commissioning of Plumbing, Section 23 08 00 - Commissioning of HVAC.
- .5 Attend all commissioning meetings organized by the Commissioning Authority. The meetings will be held (as a minimum) once a month during the first half of the construction period, and thereafter, the frequency will increase as deemed necessary by the Commissioning Authority to accomplish timely commissioning. Ensure and pay for the attendance at commissioning meetings of all sub-contractors (including but not limited to, the sheet metal, piping, sprinkler, water treatment, TAB) and major equipment suppliers as required by the Commissioning Authority.
- .6 Coordinate with and assist the Contractor performing the Work of Division 26 – Electrical for commissioning of the Division 26 – Electrical systems and equipment.

- .7 Prepare commissioning documentation including but not limited to:
 - .1 Progress and status reports, including deficiency lists
 - .2 Verification of Pre-start and Start-up procedures and results
 - .3 Performance testing procedures and results
 - .4 Training agenda and materials
 - .5 Records documents
 - .6 Final commissioning report
 - .7 Systems Operating Manual (SOM)
 - .8 Operation and maintenance manual
- .3 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.

1.2 **GENERAL**

- .1 Commissioning work shall be a team effort to ensure that all mechanical equipment and systems have been completely and properly installed, function correctly to meet the design intent, and to document system performance parameters for fine tuning of control sequences and operational procedures.
 - .1 Refer to Section 01 81 20 regarding Roles and Responsibilities of all parties involved in the commissioning process.
- .2 The Commissioning process develops, coordinates, and documents the following:
 - .1 Equipment start-up;
 - .2 Control system calibration;
 - .3 Testing and balancing;
 - .4 Verification and performance testing;
 - .5 Operation documentation;
 - .6 Operator training.
- .3 Mechanical system installation, start-up, testing, balancing, preparation of O&M manual and operator training are the responsibility of the Contractors performing the Work of Divisions 21, 22, and 23; coordination of the commissioning process is the responsibility of the Commissioning Authority in conjunction with the Construction Manager.
- .4 Designate a single person to act as commissioning manager for the Mechanical Divisions. The commissioning manager shall be responsible for progressing the activities of each Contractor performing work under the Mechanical Divisions, and shall report to the Commissioning Authority. Supply the name, qualifications, and experience of the proposed commissioning manager to the Commissioning Authority prior to the commencement of the commissioning Work. Selection shall be subject to the review and approval by the Commissioning Authority.

- .5 The Mechanical Contractor may elect to source the start-up and handover Work by a specialist commissioning company. Furnish to the Commissioning Authority the following details regarding the proposed firm:
 - .1 Principle representative and qualifications.
 - .2 Proposed personnel and relevant project experience.
 - .3 Previous similar assignments and references.
 - .4 Scope of work to be undertaken.
 - .5 Company resources and equipment.
 - .6 Use of a commissioning specialist shall not relieve the Mechanical Contractor and its sub-contractors and equipment suppliers of the obligation to name one of their own employees as the person responsible for progressing commissioning.

1.3 **RELATED WORK**

- .1 Section 20 05 83 - Start-Up and Performance Testing
- .2 Section 20 05 93 - Testing, Adjusting and Balancing
- .3 Section 21 08 00 - Commissioning of Fire Suppression
- .4 Section 22 08 00 - Commissioning of Plumbing
- .5 Section 23 08 00 - Commissioning of HVAC

1.4 **SUBMITTALS**

- .1 The commissioning process requires a review of selected submittals. The Commissioning Authority will provide a list of submittals that will be reviewed by the Commissioning Authority.
- .2 Submit the following documentation for approval by the Commissioning Authority:
 - .1 List of all measuring and recording instruments to be used during the commissioning process, along with calibration certificates, prior to commencing with any commissioning activity.
 - .2 Commissioning schedule, within 90 days of the award of the Contract.
 - .3 Copy of each type of equipment and system verification report, prior to commencing with verification tests. Include any specific testing requirements provided by the Owner and/or the Consultant in the test reports.
 - .4 Detailed functional performance test procedures and methodology. Include samples of data record sheets.
 - .5 Prior to preparation of the Systems Operating Manual, a table of contents listing all volume/chapter/system documents specific to this project. A template table of contents is not acceptable.

1.5 **DOCUMENTATION DELIVERABLES**

- .1 Identify documents including test documents and binder covers using equipment ID numbers provided on equipment schedules.
- .2 Scan original signed test reports, including verification and performance test reports, manufacturers service reports in *.pdf format. For original document chapters, provide chapter referencing within the pdf file.

- .3 Digital file naming convention:
 - .1 Store documents with filenames which include the equipment type, ID number, and type of document.
 - .2 Equipment type
 - .1 FP – Fire Protection
 - .2 PD – Plumbing and Drainage
 - .3 HG – Heating Generation
 - .4 CG - Cooling Generation
 - .5 HV – HVAC
 - .3 Equipment ID:
 - .1 As per equipment schedules / drawings, or as per Owner's standard.
 - .4 Document type:
 - .1 VT – Verification Test
 - .2 PT – Performance Test
 - .3 SOM – Systems Operating Manual
 - .4 TM – Training Manual/Material
 - .5 Example: A verification test report for the air conditioning unit tagged AC1
 - .1 HV-AC1-VT.*
- .4 Submit an electronic copy of each Verification and Functional Performance Test report, both preliminary and final issues.
 - .1 Collate final, accepted and signed test results in separate folders as follows:
 - .1 Fire Suppression
 - .2 Plumbing and Drainage
 - .3 HVAC
- .5 Submit one (1) draft copy of the SOM for review. All documents shall be stamped or watermarked as "DRAFT" and identified by issue date and revision letter.
- .6 Submit the final copy of the SOM in an 8½" x 11" D-ring binder, white, with insert sleeves on the cover and spine. Provide inserts for the front cover and spine in a form approved by the Commissioning Authority.
- .7 Provide an electronic copy of all commissioning documentation. File the documents in directories as follows:
 - .1 Primary directories: Verification / Performance / SOMS / Training
 - .2 Sub-directories: Fire Sup / Plumbing / HVAC / BAS

1.6 **REFERENCE STANDARDS**

- .1 ASHRAE Standard 202 - Commissioning Process for Buildings and Systems
- .2 ASHRAE Guideline 1.1 - HVAC&R Technical Requirements for the Commissioning Process

- .3 CSA B52 - Mechanical Refrigeration Code
- .4 CSA B139 - Installation Code for Oil Burning Equipment
- .5 CSA-B149.1 - Natural Gas and Propane Installation Code
- .6 ASME Power Test Code 4.1 - Boiler Efficiency Test
- .7 CSA Z320 - Building Commissioning Standard
- .8 CAN/ULC S1001 - Integrated Systems Testing of Fire Protection and Life Safety Systems and Fire Protection Commissioning
- .9 NFPA 13 - Standard for the Installation of Sprinkler Systems
- .10 NFPA 14 - Standard for the Installation of Standpipe and Hose Systems
- .11 NFPA 20 - Standard for the Installation of Stationary Pumps for Fire Protection
- .12 SMACNA HVAC Air Duct Leakage Test Manual

PART - 2 PRODUCTS

2.1 TEST EQUIPMENT - GENERAL

- .1 Furnish all special tools and equipment required during the commissioning process.
- .2 Submit a list of tools and equipment to be used during the commissioning process to the Commissioning Authority for approval.
- .3 Utilities (water, gas, fuel oil, electrical power) will be provided by the Owner.
- .4 Following equipment shall be provided as a minimum:
 - .1 Pressure measurements: manometers, pressure gauges, digital pressure readers, pressure trending devices;
 - .2 Temperature measurements: thermometers, digital thermometers, thermocouples, temperature trending devices;
 - .3 Velocity measurement: Pitot tube, propeller or revolving vane manometer, thermo anemometers, hot wire anemometers;
 - .4 Volume or mass flow measurement: venturi, nozzle and orifice flow meter, positive displacement meter;
 - .5 Rotative speed: tachometer;
 - .6 Sound measurement: electronic sound level meter for acoustic measurement with octave band analysis;
 - .7 Vibration measurement: accelerometer;
 - .8 Recording: chart recorder;
 - .9 Electrical measurements: voltmeter, ammeter and wattmeter;
 - .10 Any other equipment specified by the manufacturer to perform required testing and verification.

2.2 TEST EQUIPMENT – PROPRIETARY

- .1 Provide any proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not.
- .2 The manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed.
- .3 Proprietary test equipment and software shall become the property of the Owner upon completion of the commissioning process.

PART - 3 EXECUTION

3.1 GENERAL

- .1 Complete all phases of the Work so that the systems can be started, tested, balanced, and owner's acceptance procedures be undertaken.
- .2 Participate and assist in the development of the commissioning plan by the Commissioning Authority, by providing all necessary information pertaining to the equipment and installation. Provide commissioning schedule information to be incorporated into the overall commissioning schedule.
- .3 Acceptance procedures may begin prior to completion of a system and/or sub-system. Start of acceptance procedures before system completion does not relieve the Contractor from completing those systems in accordance with the commissioning and construction schedule.

3.2 COMMISSIONING SCHEDULE

- .1 Prepare a detailed and comprehensive installation completion / start-up / testing / commissioning schedule, identifying all trades and suppliers to be involved in coordination with the Construction Schedule. Update the schedule as appropriate through the construction period. This schedule shall include, but is not limited to the following items:
 - .1 Installation and testing of pipe systems.
 - .2 Installation, leak testing, and cleaning of duct systems.
 - .3 Chemical clean out and treatment of pipe systems, including disinfection of domestic water piping.
 - .4 Control system wiring.
 - .5 Electrical work performed under the Scope of Division 21, 22, and 23.
 - .6 Air and water balancing (by TAB Contractor).
 - .7 Electrical service connections (by Division 26).
 - .8 Equipment suppliers' prestart checkout and certification of the equipment installations, including controls.
 - .9 Start-up of various pieces of equipment and systems.
 - .10 Operational testing of system components.
 - .11 Performance testing of equipment and systems.
 - .12 Acceptance testing of equipment installations and system including fire and sprinkler systems, by authorities having jurisdiction and Owner's insurance company.

- .13 Troubleshooting.
- .14 Emergency system checkout.
- .15 Submittal of completed equipment and system check sheets.
- .16 Demonstration of systems and equipment.
- .17 Record Drawing preparation and submittal.
- .18 O&M manual preparation and submittal.
- .19 O&M personnel training program.
- .20 Verification and witnessing of commissioning tests and TAB by the Commissioning Authority and/or the Consultant.

3.3 **COMMISSIONING MEETINGS**

- .1 Participate in pre-commissioning and commissioning meetings as scheduled by the Commissioning Authority. The meetings will commence no later than two (2) months after the award of the Contract, will be held (as a minimum) once a month during the first half of the construction period, and thereafter, the frequency will increase as deemed necessary by the Commissioning Authority to accomplish timely commissioning.
- .2 Ensure and pay for attendance at all commissioning meetings by the Mechanical sub-contractors (including, but not limited to the sheet metal, piping, sprinkler, BAS, water treatment, TAB sub-contractors) and major equipment suppliers as required by the Commissioning Authority.

3.4 **PRE-FUNCTIONAL CHECKLISTS**

- .1 Complete all pre-functional checklists prepared by the Commissioning Authority to verify that system and equipment installation is complete and systems are ready for system functional performance testing. Submit completed checklists to the Consultant and the Commissioning Authority for review. The Commissioning Authority may spot check a sample of the completed checklists. If the Commissioning Authority determines that the information provided on the checklist is not accurate, the Commissioning Authority will return the marked-up checklist to the Contractor for correction and resubmission. If the Commissioning Authority determines that a significant number of a broader sample of checklists is inaccurate, all checklists will be returned to the Contractor for correction and resubmission.

3.5 **PARTICIPATION IN ACCEPTANCE PROCEDURES**

- .1 Provide skilled technicians to start-up and debug all systems provided within the Mechanical scope of Work. Include for labour, materials, and subsistence costs for these same technicians to assist the Commissioning Authority in completing the commissioning program.
- .2 Provide details regarding work schedules, time commitments, work sequence programming, to the Commissioning Authority, to permit the development and monitoring of a coordinated commissioning schedule.
- .3 Ensure that qualified technicians are available and present during commissioning testing to complete the tests, make adjustments and to assist in problem resolutions.
- .4 Should any equipment or system experience performance problems, or reconstruction or replacement of components is required, include for additional technician time for subsequent retesting of systems until the required system performance is achieved.

- .5 The Commissioning Authority reserves the right to approve the proposed technicians with regard to the technical skill level required for each type of equipment and/or system.

3.6 **PROBLEM RESOLUTION**

- .1 In the event that additional work is required to correct systems, misapplied equipment, and/or deficient performance under varying load conditions, this work will be carried out under the direction of the Owner. Assist the Owner and Commissioning Authority in developing an acceptable resolution to the problem, including the resources of equipment suppliers.
- .2 The Owner has final jurisdiction over any additional work required to achieve the required level of performance.
- .3 Complete corrective work in a timely fashion to permit completion of the commissioning process.

3.7 **ADDITIONAL COMMISSIONING**

- .1 Additional commissioning activities may be required after the completion of system performance testing. Allow for a reasonable reserve to complete this work, including assistance from manufacturers' service technicians.

3.8 **SEASONAL COMMISSIONING**

- .1 Commence initial performance testing commissioning at the completion of the installation Work and verification testing phase. Conduct performance testing, which is weather dependent, as applicable to current seasonal conditions. Complete performance testing on non-weather dependant systems in accordance with the agreed commissioning plan schedule.
- .2 For out-of-season system performance testing, conduct initial performance tests to demonstrate off-peak load performance. Schedule peak load performance testing over the succeeding nine (9) months to ensure all equipment is tested at peak load prior to the expiry of the construction contract warranty.
 - .1 Test heating equipment/systems during winter design extremes.
 - .2 Test cooling systems during summer design extremes with a fully occupied building.
 - .3 Alternatively, provide temporary equipment such as load banks to simulate full load conditions. Submit the proposed methodology for review by the Commissioning Authority and the Consultant.

3.9 **REPORT FORMAT**

- .1 Prepare reports in accordance with the requirements of Division 01.
- .2 Provide separate checklists for each piece of equipment and system tested, including interfaces, interlocks.
 - .1 For checklists generated in MS Excel format, provide a separate file for each piece of equipment. Do not store multiple pieces of equipment on separate worksheets in the same file.
- .3 Each item to be checked shall be recorded on a separate entry line , with the following information, reading from left to right across the entry:
 - .1 Checklist item No.

- .2 Test description
- .3 Test status – “Pass”, “Fail”, “Not Applicable”
- .4 Deficiency status – “Major”, “Minor”
- .5 Comments
- .4 Deficiency definitions:
 - .1 “Major” – an item which if not corrected renders the equipment or system unsuitable or un-safe for use by the Owner. Major deficiencies shall be corrected as a condition for achieving Substantial Completion.
 - .2 “Minor” – an item which does not impact on the operation of the equipment or system and will allow the Owner to use the system safely. Minor deficiencies may be corrected before or after Substantial Completion, but shall not prevent certification of Substantial Completion of the Work.

3.10 TESTS PROCEDURES

- .1 Perform tests in accordance with the requirements listed under the diverse Sections of the Division 21, 22, and 23 Specifications.

3.11 VERIFICATION TESTS

- .1 Scope of Work:
 - .1 Conduct operating tests to verify that all components, equipment, systems, and interfaces between systems operate in accordance with the requirements per the Contract Documents.
 - .2 Conduct tests to demonstrate and verify all operating modes, interlocks, specified control sequences, specific responses to abnormal or emergency conditions.
 - .3 Validate the results of the TAB report.
- .2 Roles and responsibilities:

Verification Testing	
Organized by:	Commissioning Authority
Test sheets provided by:	Mechanical Contractors
Testing conducted by:	Mechanical Contractors
Testing recorded by:	Mechanical Contractors
Tests witnessed by:	Commissioning Authority Consultant (optional) Owner (optional)
Reports reviewed by:	General Contractor Commissioning Authority Consultant
Reports accepted by:	Owner

- .3 Participants in the verification testing:
 - .1 Commissioning Authority: schedules all tests and assembles commissioning team members who are responsible for the implementation, witnessing and record keeping for the tests.
 - .2 Mechanical Contractor: provides the services of qualified technician(s) who are familiar with the construction and operation of the systems. Provides access to the mechanical Contract Documents, shop drawings, and equipment cut sheets of all installed equipment.
 - .3 Electrical Contractor: provides the services of a foreman electrician familiar with the electrical interlocks, interfaces with emergency power supply, and interfaces with the fire alarm and life-safety systems. Provides access to the Electrical Contract Documents, and all as-built schematics of sub-systems, interfaces and interlocks.
 - .4 Equipment suppliers: provide the services of manufacturers' service personnel to assist with the pre-start and initial start-up of equipment, as required.
- .4 Documentation and reporting requirements:
 - .1 Provide a separate test record for each piece of equipment and system.
 - .2 Records shall include information from the following sources:
 - .1 Manufacturers' installation requirements;
 - .2 Contractors' own checklists;
 - .3 Consultant's checklists;
 - .4 Owner's checklists.
 - .3 Test record shall include the following information as minimum:
 - .1 Front cover sheet – project name, Owner's name, equipment ID, name, test date(s), and space for sign-off signatures and dates as follows:
 - .1 Mechanical Contractor – "Submitted by"
 - .2 General Contractor – "Reviewed by"
 - .3 Consultant – "Reviewed by"
 - .4 Commissioning Authority – "Reviewed by"
 - .5 Owner – "Accepted by"
 - .2 Equipment checklists covering:
 - .1 Motor, power supply and drives;
 - .2 Equipment piping between equipment isolation valves;
 - .3 Installation pre-start tests specific to the class of equipment;
 - .4 Equipment cleaning records;
 - .5 Equipment start-up tests specific to the class of equipment;
 - .6 Electrical audit for CSA label or ESA field approval label;
 - .7 Gas and fuel fired equipment audit for CSA/CGA approvals or TSSA field approvals;
 - .8 Expansion tank installation and settings;
 - .9 Operator training, including attendee names and dates, and

- details of manufacturers' equipment demonstrations;
- .10 Status of as-built documentation, and Operating and Maintenance Manuals.
- .3 Piping system checklists covering:
 - .1 Hydrostatic and/or pneumatic pressure tests, including date of test, duration, initial and final pressures, and TSSA inspection reports where required;
 - .2 Municipal plumbing inspector reports attached;
 - .3 NFPA certificates attached for sprinkler and standpipe systems, sealed by a professional engineer licensed for the province where the Site is located;
 - .4 Flushing and cleaning records, including date of cleaning, chemical treatment contractors' test reports, volume of fluid in the system and amount of cleaner used;
 - .5 Chemical treatment showing type and quantity of chemicals added, chemical treatment contractors test reports included;
 - .6 Potable water systems disinfection reports confirming that the procedures were performed in accordance with all applicable codes;
 - .7 Piping installation including supports, insulation, vibration isolation, identification and tagging;
 - .8 TAB report, by system;
 - .9 Non-potable water systems cross-connection tests.
- .4 Ductwork system checklists covering:
 - .1 Duct cleaning records;
 - .2 Ductwork pressure test results;
 - .3 Inspection of fire damper linkages, by area/floor;
 - .4 TAB report, by system.
- .5 Specialty systems covering:
 - .1 Refrigeration systems compliance check to CSA B52;
 - .2 Fuel oil systems compliance check to CSA B139;
 - .3 Natural gas and propane systems compliance check to CSA B149.1;
- .5 Instrumentation:
 - .1 Provide all measurement instrumentation required to conduct the verification tests.
 - .2 Ensure that instruments have been calibrated within a six months period prior to the commencement of the tests.
- .6 Verification procedures:
 - .1 The Commissioning Authority will direct and witness the verification operating tests for all equipment and systems.

- .2 Set all system equipment into the operating mode to be tested, including but not limited to:
 - .1 Normal shut-down;
 - .2 Normal auto position;
 - .3 Normal manual position;
 - .4 Unoccupied cycle;
 - .5 Emergency power operation, including transition states;
 - .6 Alarm conditions;
 - .7 Special operating modes (e.g. purge mode).
- .3 Inspect and verify the position of each device and interlock identified on the checklists.
- .4 Repeat the above tests for each operating cycle that applies to the system being tested.
- .5 Check the operating condition of the following elements during all modes of system operation:
 - .1 Safety interlocks;
 - .2 Alarms;
 - .3 Smoke control and smoke venting interlocks;
 - .4 Life safety interlocks.
- .6 For failed test items, include appropriate comments on the checklist data sheet, and identify whether it is a "Major" or "Minor" deficiency.
 - .1 The Consultant retains the right to make the final decision regarding classifications of deficiencies.
- .7 Verify the operational control of the systems through the Building Automation System as follows:
 - .1 Airflow rates of terminal boxes in all modes of operation;
 - .2 Equipment operation in both heating and cooling modes;
 - .3 Minimum outdoor air intake positions, air-side economizer cycles, and multi-set outdoor air damper positions as required for each operating sequence and mode;
 - .4 Building pressurization and other specialty programs.
- .8 Verify the proper responses of instrumentation and control devices (actuators) as follows:
 - .1 For each controller or sensor, record the indicated monitoring and control system reading, and the test instrument reading.
 - .2 If the initial test indicates that the test reading is outside of the control range of the installed device, check the calibration of the installed device and adjust as required. Re-test the deficient device and record the results on the checklist data sheets.

- .9 The Commissioning Authority will direct and witness the field verification of the final TAB report as follows:
 - .1 10% of the report data for verification, selected at random.
 - .2 The TAB Contractor shall be provided with advance notice of the date of retesting, but not the equipment to be tested.
 - .3 The TAB Contractor shall make available and use the same equipment and instruments used to collect the original data.
 - .4 The test is considered failed if:
 - .1 For all readings other than sound, a deviation of more than 10 percent from the original TAB report results.
 - .2 For sound pressure readings, a deviation of 3 dB at any bandwidth, not including differences in background noise readings.
 - .5 A failure rate greater than 10% of the selected items (1% of all TAB test results) will result in rejection of the final TAB report.
- .7 Acceptance:
 - .1 The final reports will be reviewed by the Commissioning Authority and the Consultant, to determine if verification has been completed and the systems are functioning in accordance with the Contract Documents.
 - .2 The Commissioning Authority, in conjunction with the Consultant, will review and make final classification of all noted deficiencies. Deficiencies classified as "Major" shall be corrected before acceptance of the verification stage.

3.12 **FUNCTIONAL PERFORMANCE TESTING**

- .1 Scope of Work
 - .1 Conduct performance tests to verify that all equipment and system components are providing the required heating and cooling performance (capacity) in accordance with the Contract Documents, including but not limited to:
 - .1 Capability of the heat rejection water systems (condenser water) to deliver the required flow rates and water temperatures at design conditions.
 - .2 Capability of the hydronic and domestic water heating systems, chilled water systems, water-to-water and steam-to-water heat exchangers to deliver the required flow rates, and temperatures.
 - .3 Capacity of the electric heating systems at design temperatures.
 - .4 Confirm the ability of the HVAC systems to deliver the required cooling/heating services, at the design supply air temperatures, required static pressures, and correct outside air ventilation rates.
 - .2 Conduct performance testing for all other systems and equipment in accordance with Section 20 05 83 - Start-Up and Performance Testing.
- .2 Roles and responsibilities:

Functional Performance Testing	
Organized by:	Commissioning Authority
Test sheets provided by:	Mechanical Contractors

Functional Performance Testing	
Testing conducted by:	Mechanical Contractors
Testing recorded by:	Mechanical Contractors
Tests witnessed by:	Commissioning Authority Consultant (optional) Owner (optional)
Reports reviewed by:	General Contractor Commissioning Authority Consultant
Reports accepted by:	Owner

- .3 Participants:
 - .1 Participants are the same as described under the verification testing stage.
- .4 Documentation and reporting requirements:
 - .1 Provide a separate test record for each piece of equipment and system.
 - .2 Record shall include the following information as minimum:
 - .1 Front cover sheet – project name, Owner’s name, equipment ID, name, test date(s), and space for sign-off signatures and dates as follows:
 - .1 Mechanical Contractor – “Submitted by”
 - .2 General Contractor – “Reviewed by”
 - .3 Consultant – “Reviewed by”
 - .4 Commissioning Authority – “Reviewed by”
 - .5 Owner – “Accepted by”
 - .2 Second and subsequent pages shall include the test records as follows:
 - .1 Description of test methodology, including reference standards (e.g. SMACNA, ARI, ASME);
 - .2 Permanent and temporary resource requirements to implement the test (e.g. power, temporary drains, water supply, fuel supply);
 - .3 Summary of results;
 - .4 Test data sheets and measured data;
 - .5 Ambient conditions at time of the test;
 - .6 Load simulation method used, if applicable.
- .5 Instrumentation:
 - .1 Refer to the instrumentation requirements for the verification stage.
- .6 Functional performance test procedures:
 - .1 The Commissioning Authority will direct and witness as required the performance tests for selected or all equipment and systems.

- .2 For each test, provide instrumentation required to calculate the total capacity of the system for each mode of operation under test.
- .3 Special testing requirements:
 - .1 Test heating boiler and steam boiler performance in accordance with ASME Power Test Code 4.1, for thermal and combustion efficiency.
- .4 Simulate internal loads if necessary and/or defer the tests to the appropriate season. All tests must be completed with results approved by the Commissioning Authority within twelve (12) months after the date of Substantial Completion.
- .7 Acceptance
 - .1 Any deficiency identified will be reviewed by the Consultant in cooperation with the General Contractor to determine if correction of the deficiency is part of the Mechanical Contractor's contractual obligations.
 - .2 If it is determined that the correction of the performance deficiency falls under the scope of the Mechanical Contract, the Mechanical Contractor shall rectify the deficiency and repeat the performance test until the required performance levels are achieved.
 - .3 If it is determined that the Mechanical system was constructed in accordance with the Contract Documents, and the correction of the performance deficiency does not fall under the scope of the Mechanical Contract, the Owner will decide whether to accept the performance as is, or direct the Mechanical Contractor to make corrections to the Mechanical Work as required to achieve a performance level which meets the design intent. In this case, after completion of the remedial work conduct a repeated performance testing and submit a revised report.

3.13 **SYSTEMS OPERATING MANUAL**

- .1 Scope of Work:
 - .1 The Systems Operating Manual (SOM) is in addition to the Operating and Maintenance Manual (O&M Manual) required under Section 20 00 13.
 - .2 The SOM provides operational information related to the system, while the O&M Manuals provides information related to the equipment in the system.
 - .3 Obtain information from the Consultant with respect to the design criteria and operational requirements of the system, for incorporation into the SOM.
- .2 Roles and responsibilities:

Systems Operating Manuals	
Organized by:	Mechanical Contractor
O&M Manual provided by:	Mechanical Contractor
SOM provided by:	Mechanical Contractor
Manuals reviewed by:	Commissioning Authority Consultant
Manuals accepted by:	Owner

- .3 Structure of the SOM:
 - .1 The SOM structure shall follow the structure of the Mechanical Specifications. Set up separate volumes for each Division; set up separate chapters for each major system within each Division.
 - .2 Each chapter topic shall be divided into individual system documents as required for multiple system types, and break down a major system into a series of sub-systems.
 - .3 Each system document shall include the following information, as minimum:
 - .1 General description of each system including:
 - .1 Major equipment components;
 - .2 Interconnections;
 - .3 Basic operating principle (supplied by the Consultant);
 - .4 Design criteria (supplied by the Consultant);
 - .5 Redundancy level/equipment;
 - .6 Cross-reference to system schematic as-built drawings.
 - .2 System operating instructions including:
 - .1 Starting up the system, automatic and manual;
 - .2 Shutting down the system, automatic and manual;
 - .3 Emergency or unusual conditions;
 - .4 Safety precautions;
 - .5 Troubleshooting suggestions;
 - .6 Automatic control sequences;
 - .3 Cross-reference to the preventative maintenance instructions for each piece of equipment of the system in the O&M Manual.
 - .4 Operators' notes section at the end of each SOM to allow the operations staff to update the SOM with operating tips, warnings.

3.14 OPERATION AND MAINTENANCE TRAINING

- .1 Scope of Work
 - .1 Conduct operator training with assistance from manufacturers' service technicians in addition to the requirements of Section 20 00 13.
- .2 Roles and responsibilities:

Systems Operating Manual	
Organized by:	Mechanical Contractor
Lecture material provided by:	Mechanical Contractor
Systems training provided by:	Mechanical Contractor
Resource material by:	Sub-Contractors Equipment Manufacturers Consultant

Manuals reviewed by:	Commissioning Authority Consultant
Manuals accepted by:	Owner

.3 Equipment training:

- .1 Provide equipment training in accordance with Section 20 00 13. The manufacturer's representative training will emphasize operating instructions and preventative maintenance.

.4 Systems training:

- .1 In addition to the equipment training described above, provide additional training to describe the operational requirements and design intent for each system.
- .2 Include classroom instruction, delivered by competent instructors, based on the contents of the SOM. Place emphasis on overall systems diagrams and descriptions, design criteria and conditions.
- .3 If required, obtain and pay for the services of the Consultant to provide the instructor services and to provide lecture material for inclusion in the SOM.
- .4 Training topics shall include:
 - .1 Types of installed systems;
 - .2 Design intent and design criteria;
 - .3 Design constraints;
 - .4 Different operating modes such as occupied, unoccupied, emergency conditions;
 - .5 Seasonal operating modes;
 - .6 Scheduling of space occupancies;
 - .7 IAQ control;
 - .8 Energy efficiency;
 - .9 System operating sequences;
 - .10 Automatic controls;
 - .11 Service, maintenance, diagnostics and repairs;
 - .12 Use of reports and logs;
 - .13 Troubleshooting.
- .5 Structure each session to start with the classroom instruction for the overall system, followed by hands-on instruction for each equipment, with the participation of the manufacturers' representatives as required. Demonstrate the start-up and shut-down of each system.
- .6 Organize and schedule each training session to deliver the required instruction in an efficient and effective manner on a schedule agreed upon with the Owner. Allow for three (3) training sessions for each topic, separated by approximately one week each, to allow for shift coverage.
- .7 Structure each training session based on type of maintenance personnel attending the training session, such as plumbers, fitters, general maintenance, controls

- technicians. Develop the proposed training plan and obtain approval from the Owner before commencing the training.
- .8 Complete the training as close to the date of the Substantial Completion as possible, so that the Owner's operations staff is prepared to operate the system after Substantial Completion is certified.
- .5 Training manuals
- .1 Provide training material hand-outs for each session. This information shall be abstracted from the SOM and shall be presented in abbreviated form (i.e. bullet points).
- .2 Collect training material and bind into separate binders in accordance with the requirements for the SOM.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
 - .2 Provide variable frequency drives and harmonics filters for equipment supplied under the scope of Divisions 21, 22 and 23.
- .2 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for variable frequency drives including, but not limited to:
 - .1 Outline dimensions, conduit entry locations and weight;
 - .2 Control and power wiring diagrams;
 - .3 Complete technical product description including a list of options provided;
 - .4 Detailed statement of non-compliance issues to this Specification, absent which the manufacturer and/or the Contractor shall be liable to provide all additional components required to meet this Specification;
 - .5 Termination diagrams for electrical contacts, relays, thermostats, timers and components in control circuits shown.
 - .3 Submit a computerized harmonics analysis of the building's power distribution system based on the most recent single line diagram. Analysis shall illustrate the effect of VFDs on the system harmonics.

1.3 REFERENCE STANDARDS

- .1 IEEE 519 - IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems
- .2 UL 508C - Power Conversion Equipment
- .3 NEMA ICS 7.0 - Adjustable Speed Drives
- .4 ICC-ES AC-156 - Acceptance Criteria For Seismic Certification by Shake-Table Testing of Non-Structural Components

1.4 QUALITY ASSURANCE

- .1 Read together with the Division 26 – Electrical Specification and adhere to its requirements. Supply and install all electrical apparatus that is required for a complete installation of the

Mechanical Work and is not covered under the Work of the Division 26 – Electrical Contractor.

- .2 Product:
 - .1 VFD and options shall be UL listed and CSA certified as a complete assembly;
 - .2 VFDs that require the Owner to supply external fuses are not acceptable;
 - .3 VFD and options tested to ANSI/UL 508C and listed by an internationally recognized testing agency such as UL or ETL, subject to the drives are suitable for the use on nominal voltages up to 600 V AC with a nominal supply range of $\pm 5\%$.
- .3 Standard of Acceptance
 - .1 ABB
 - .2 Danfoss
 - .3 Siemens
 - .4 Toshiba
 - .5 Cutler Hammer
 - .6 Allen Bradley
 - .7 Baldor
 - .8 Graham (Danfoss)
 - .9 Schneider Electric
 - .10 Emerson
 - .11 Hitachi
 - .12 Johnson Controls

PART - 2 PRODUCTS

2.1 DESIGN

- .1 The VFD shall convert incoming fixed frequency three-phase AC power into an adjustable frequency and voltage for controlling the speed of three-phase AC induction motors. The motor current shall closely approximate a sine wave.
- .2 The VFD shall be UL listed for a short circuit current rating (SCCR) of 100 kA and labelled with this rating.
- .3 The VFD shall have a dual 5% impedance DC link reactor on the positive and negative rails of the DC bus to minimize power line harmonics and protect the VFD from power line transients. The chokes shall be non-saturating. Swinging chokes that do not provide full harmonic filtering throughout the entire load range are not acceptable. VFDs that do not include 5% DC link impedance shall include 5% AC line reactors in the options enclosure.
- .4 The VFD must be able to produce full torque at low speed to operate direct drive fans.
- .5 The VFD must be capable of connection and disconnection to motor while the VFD is under load. This switching shall be accomplished without interlocks or damage to the VFD.
- .6 All VFDs shall contain integral EMI filters to attenuate radio frequency interference conducted to the AC power line.

- .7 Provide sine wave output filters on all 460 Volt and 575 Volt VFDs to limit the dV/dt to 1,000 Volts/0.5 micro seconds at the motor terminals where the developed wiring length between the VFD and the motor exceeds 30m.
- .8 Provide incoming, motor power rated disconnect switch with an operating mechanism, door interlocked and padlockable in the open position.
- .9 AC line voltage variation, -10 to +10% of nominal with full output.
- .10 All VFDs shall be plenum rated.
- .11 Seismic rating:
 - .1 Drive and bypass package shall be seismic certified;
 - .2 Seismic importance factor of 1.5 rating is required;
 - .3 Rating certification shall be based upon actual shake table test data as defined by ICC-ES AC- 156.

2.2 **PROTECTION**

- .1 Provide the following VFD protection features as a minimum:
 - .1 Line over and under voltage protection.
 - .2 Phase loss and unbalance protection.
 - .3 Short circuit protection for line to line and line to ground faults.
 - .4 Electronic instantaneous overcurrent protection.
 - .5 Current sensors on all three output phases to accurately measure motor current, protect the VFD from output short circuits, output ground faults, and act as a motor overload.
 - .6 Motor preheat feature to keep the motor warm and prevent condensation build up in the motor when it is stopped in a damp environment by providing the motor stator with a controlled level of current.
 - .7 Internal over-temperature protection.
 - .8 Electronic motor stall protection to trip the VFD off should a motor overload or stall occur.
 - .9 VFD shall catch a rotating motor operating forward or reverse up to full speed without VFD fault or component damage.
 - .10 The VFD shall store in memory the last 10 alarms. A description of the alarm, and the date and time of the alarm shall be recorded. The VFD shall include graphing capability for the last 2 alarms to provide additional diagnostic analysis.
 - .11 When used with a pumping system, the VFD shall be able to detect no-flow situations, dry pump conditions, and operation off the end of the pump curve. It shall be programmable to take appropriate protective action when one of the above situations is detected.
 - .12 The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 135% of rated torque for up to 0.5 second while starting.

2.3 ENVIRONMENT

- .1 The VFD shall have the following minimum environmental tolerances:
 - .1 Ambient temperature range of 0°C to 45°C. Units located in non-heated areas shall be provided with thermostatically controlled heater weather enclosure.
 - .2 Maximum humidity of 95% non-condensing.
 - .3 Maximum altitude of 1,000m for rated output.

2.4 PERFORMANCE

- .1 The VFD shall have the following performance features as a minimum:
 - .1 Minimum line side displacement power factor of 0.96 at all speeds and loads.
 - .2 Adjustable minimum and maximum motor frequency of 0 to 120 Hz.
 - .3 Separately adjustable acceleration and deceleration ramps from 0.1 to 3,600 seconds with damping and smoothing parameters for (0% to 100% speed).
 - .4 DC injection braking.
 - .5 Automatic restart after an inverter fault trip. The VFD shall attempt to restart automatically 5 times with lock-out after the fifth attempt if a restart has not occurred.
 - .6 The VFD shall restart the motor at the speed at which it is rotating and then re-accelerate to the speed called for by the speed reference signal.
 - .7 Capable of running without a motor connected for setup and testing.
 - .8 Capable of accepting the opening of a remote motor disconnect while running without causing damage to the VFD.
 - .9 Auto restart after power outage.
 - .10 Skip frequency reject point to prevent the fan/pump from operating at a resonant speed. Adjustable centre frequency with a band width of 0 - 10 Hz.
 - .11 Automatic/manual signal follower for 4-20 mA, 0-20mA, 0-10 VDC or 2-10 VDC reference.

2.5 OPERATOR INTERFACE

- .1 Provide a door mounted keypad with an Alpha-numeric high resolution display to allow the operations personnel to set up and monitor the VFD parameters, observe output speed, load or other programmable values and monitor status and fault information, complete with tactile keys and backlit display.
- .2 The VFD shall be programmable to provide a digital output signal to indicate whether the VFD is in Hand or Auto mode. This is to alert the Building Automation System whether the VFD is being controlled locally or by the Building Automation System.
- .3 Provide maintenance monitoring to display the time since starting, total elapsed run time and total kWh. Also provide maintenance target alarm to alert the operator with a displayed message.
- .4 Provide the following control functions on the door mounted keypad:
 - .1 Run (Hand and Auto Mode)
 - .2 Stop (Hand and Auto Mode)

- .3 Parameterization button (to toggle between parameters)
- .5 Provide a selectable display to observe the following parameters:
 - .1 Frequency
 - .2 Motor Current
 - .3 Motor Voltage
 - .4 VFD Output Power
 - .5 VFD Output Energy
 - .6 VFD Temperature
- .6 Controller shall accept up to three feedback signals. It shall be programmable to compare the feedback signals to a common setpoint or to individual setpoints, and to automatically select either the maximum or the feedback signal as the controlling signal. It shall also be possible to calculate the controlling feedback signal as the average of all feedback signals or the difference between a pair of feedback signals.
- .7 The VFD shall have three additional PID controllers which can be used to control damper and valve positioners in the system and to provide setpoint reset. Floating point control interface shall be provided to increase/decrease speed in response to contact closures.
- .8 A run permissive circuit shall be provided to accept a "system ready" signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of initiating an output "run request" signal to indicate to the external equipment that the VFD has received a request to run.
- .9 VFD shall be programmable to display feedback signals in appropriate units, such as, Pascals (Pa), inches of water column (in-wg), pressure per square inch (psi) or temperature (°C/°F).
- .10 VFD shall be programmable to sense the loss of load and to signal this condition via a keypad warning, relay output and/or over the serial communications bus. To ensure against nuisance indications, this feature must be based on motor torque, not current, and must include a proof timer to keep brief periods of no load from falsely triggering this indication.

2.6 **COMMUNICATION AND CONTROL**

- .1 Four dedicated, programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.
- .2 Two terminals shall be programmable to act as either as digital outputs or additional digital inputs.
- .3 Two programmable relay outputs, Form C 240 VAC, 2A, shall be provided for remote indication of VFD status.
- .4 Two programmable analog inputs shall be provided that can be either direct-or-reverse acting.
 - .1 Each shall be independently selectable to be used with either an analog voltage or current signal.
 - .2 The maximum and minimum range of each shall be able to be independently scalable from 0 to 10 VDC and 0 to 20 mA.

- .3 A programmable low-pass filter for either or both of the analog inputs must be included to compensate for noise.
- .4 The VFD shall provide front panel meter displays programmable to show the value of each analog input signal for system set-up and troubleshooting.
- .5 One programmable analog current output (0 to 20 mA) shall be provided for indication of VFD status. This output shall be programmable to show the reference or feedback signal supplied to the VFD and for VFD output frequency, current and power. It shall be possible to scale the minimum and maximum values of this output.
- .6 It shall be possible through serial bus communications to read the status of all analog and digital inputs of the VFD.
- .7 Standard programmable firefighter's override mode shall allow a digital input to control the VFD and override all other local or remote commands. It shall be possible to program the VFD so that it will ignore most normal VFD safety circuits including motor overload. The VFD shall display FIRE MODE whenever in firefighter's override mode. Fire mode shall allow selection of forward or reverse operation and the selection of a speed source or preset speed, as required to accommodate local fire codes, standards and conditions.
- .8 The VFD shall include a standard EIA-485 communications port and capabilities to be connected to the following serial communication protocols at no additional cost and without a need to install any additional hardware or software in the VFD:
 - .1 Johnson Controls Metasys N2
 - .2 Modbus RTU
 - .3 Siemens Apogee FLN
 - .4 BACnet (BTL)
- .9 Option boards for the following protocols shall be available:
 - .1 BACnet IP to MS/TP
 - .2 Ethernet
 - .3 DeviceNet
 - .4 Profibus DP V1
 - .5 Modbus TCP
 - .6 LonWorks
- .10 VFD shall have standard USB port for direct connection of a Personal Computer (PC) to the VFD. The manufacturer shall provide a no-charge PC software to allow complete setup and access of the VFD and logs of VFD operation through the USB port. It shall be possible to communicate to the VFD through this USB port without interrupting VFD communications to the building automation system.
- .11 The VFD shall have provisions for an optional 24 VDC back-up power interface to power the VFD's control card. This is to allow the VFD to continue to communicate to the building automation system even if power to the VFD is lost.

2.7 **SYSTEM OPERATION**

- .1 If "Manual" mode is selected the VFD/motor shall start when the run key is depressed. The speed shall be controlled by depressing the Accelerate or Decelerate keys on the keypad or by the direct speed set mode.

- .2 If "Auto" mode is selected the VFD/motor shall start when a contact closure run command is received from the BAS. The speed shall be controlled by a speed reference signal from the BAS.
- .3 In the event of a power outage the VFD shall automatically restart when the power returns provided the run command is maintained.
- .4 In the event of an inverter fault trip, the VFD shall attempt to restart automatically up to maximum of five attempts. If, after five attempts, restart does not occur, the VFD shall lock out.

PART - 3 EXECUTION

3.1 INSTALLATION

- .1 Install each VFD in accordance with manufacturer's recommendations and municipal, provincial and national safety codes.
- .2 Use motors with a minimum of class F insulation. Motor shall meet the requirements of NEMA MG-1 Part 31. Motor shall be rated for inverter duty.
- .3 Provide on-site start-up of the VFDs by a factory-authorized technician. Allow for a minimum of ½ day per system. Also, include an allowance for a second visit to site of one-day duration to train operating personnel in the operation and maintenance of the VFDs.
- .4 Upon completion of the installation, the supplier of VFDs shall supply service and maintenance manuals including wiring and connection diagrams.
- .5 Upon completion of the start-up, the supplier of VFDs shall supply a typed report and one USB drive with parameters ready for uploading for future use.

3.2 HARMONIC FILTERS

- .1 Install harmonic filters in accordance with manufacturer's requirements.
- .2 Commission filters onsite. Provide test records of site condition performance at 0%, 50% and 100% motor load including measurements of voltage and current harmonic distortion at input terminals of filter.
- .3 Obtain measurements with a recording type Fluke 41 or equivalent harmonics analyzer for individual and total harmonic currents and voltages.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 This Section supplements all Sections of Division 21 – Fire Suppression.
 - .2 The intent of the Division 21 – Fire Suppression Specifications and the accompanying Drawings is to provide complete and workable fire suppression systems as shown, specified and required by applicable codes. Include all work specified under Division 21 – Fire Suppression and shown on the accompanying Drawings.
 - .3 The Drawings that accompany the Division 21 – Fire Suppression Specifications are diagrammatic. It is the responsibility of this Contractor to ensure that adequate and appropriate hose coverage, extinguisher coverage, sprinkler head coverage, pipe sizing, zoning and valving for the fire suppression systems as per NFPA 13 and 14 hazard classifications, Owner's insurer' standards, provincial and federal codes, and requirements of authorities having jurisdiction are provided. Provide additional valves and resize piping as required. The Contract Drawings do not show each offset, bend, tee, or elbow which may be required to install the Fire Suppression Work in the space provided and to avoid conflicts. Follow the Drawings as closely as is practical to do so and install additional bends, offsets and elbows where required by local conditions from measurements taken at the Site, subject to approval, and without additional cost to the Owner.
 - .4 Major aspects of the Fire Suppression Work shall include but not necessarily be limited to, the following items:
 - .1 Wet sprinkler system throughout the Q/A Labs;
 - .2 Refer to the following Sections of the Division 21 – Fire Suppression Specification for further details:
 - .1 Valves for Fire Suppression – Section 21 05 23
 - .2 Schedules for Fire Suppression – Section 21 06 00
 - .3 Commissioning of Fire Suppression – Section 21 08 00
 - .4 Fire Suppression Piping – Section 21 11 00
 - .5 Fire Suppression Sprinkler Systems – Section 21 13 00
 - .6 Portable Fire Extinguishers – Section 21 25 00

1.2 QUALITY ASSURANCE

- .1 Manufacturer Qualifications:
 - .1 Companies specialized in manufacturing Fire Suppression products specified under the Sections of Division 21 – Fire Suppression with minimum three years of documented experience.

- .2 Installer Qualifications:
 - .1 Companies specialized in performing work of the type specified under the Sections of Division 21 – Fire Suppression:
 - .1 Minimum three years of experience, or
 - .2 Approved by product manufacturers.
- .3 Conform to ULC, FM, IAO and Owner's Underwriter's requirements as applicable for this project.
- .4 Layout drawings:
 - .1 Fire suppression 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 21 – Fire Suppression 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.
 - .2 Prepare complete fire suppression systems layout drawings, arranging piping runs and sprinkler heads in proper relation to other equipment such as light fixtures and ducts to ensure clear ceiling heights indicated on the Drawings. Coordinate location of sprinkler heads in suspended ceilings with the location of lighting, grilles, diffusers and similar items. Maintain maximum headroom in areas with no ceilings. Refer to additional design requirements contained in other sections of the Division 21 Specification.
 - .3 Obtain approval of the fire suppression systems layout drawings by Owner's insurer or Factory Mutual as applicable, and the Consultant before any work is started.
 - .4 Fire suppression 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 Layout drawings are to be sealed by a registered Professional Engineer, licenced in the province where the Site is located.

1.3 **DESIGN CRITERIA**

- .1 Sprinkler system
 - .1 Operating pressures:
 - .1 Maximum system pressure: 951 kPa measured at east fire pump outlet.
 - .2 Minimum pressure at sprinkler heads: 172 kPa
 - .3 Component pressure rating: 1207 kPa

1.4 **SUBMITTALS**

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for backflow preventers.

- .3 Submit sealed fire suppression systems layout drawings and associated hydraulic calculations. Drawings to include support details and weights of the pipe systems.
- .4 Identify all changes to the fire alarm system resulting from shop drawings. All cost related to changes initiated by this Contractor shall be the responsibility of Division 21 – Fire Suppression Contractor.

1.5 **PERMITS AND INSPECTIONS**

- .1 Submit layout drawings to the municipal Building and/or Fire Department; apply for and obtain permits required for the Fire Suppression Work and pay all costs levied for permits and inspections.

1.6 **REFERENCE STANDARDS**

- .1 NFPA 14 - Standard for the Installation of Standpipe and Hose Systems
- .2 NFPA 24 - Standard for the Installation of Private Fire Service Mains and Their Appurtenances
- .3 NFPA 291 - Recommended Practice for Fire Flow Testing and Marking of Hydrants
- .4 CSA B64.5.1 - Double check valve backflow preventers for fire protection systems (DCVAF)
- .5 CSA B64.4.1 - Reduced pressure principle backflow preventers for fire protection systems (RPF)
- .6 ASSE 1013 - Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Principle Fire Protection Backflow Preventers
- .7 ASSE 1015 - Performance Requirements for Double Check Backflow Prevention Assemblies and Double Check Fire Protection Backflow Prevention Assemblies
- .8 ASSE 1047 - Performance Requirements for Reduced Pressure Detector Fire Protection Backflow Prevention Assemblies
- .9 ASSE 1048 - Performance Requirements for Double Check Detector Fire Protection Backflow Prevention Assemblies

PART - 2 PRODUCTS

2.1 **HANGERS AND SUPPORTS**

- .1 In accordance with Section 20 05 29 - Bases, Hangers and Supports.

2.2 **THERMAL INSULATION**

- .1 In accordance with Section 20 07 00 - Mechanical Insulation.

2.3 **VIBRATION ISOLATION**

- .1 In accordance with Section 20 05 48 – Vibration Control

2.4 **IDENTIFICATION FOR EQUIPMENT, VALVES AND PIPING**

- .1 In accordance with Section 20 05 53 - Mechanical Identification

2.5 **GAUGES**

- .1 In accordance with Section 20 05 19 - Meters and Gauges

2.6 **ELECTRIC WIRING**

- .1 In accordance with Section 20 05 13 - Common Wiring Requirements

2.7 **SEISMIC RESTRAINING**

- .1 In accordance with Section 20 05 49 - Seismic Control

2.8 **ESCUTCHEONS**

- .1 Escutcheons shall be satin-finish, corrosion-resisting steel, polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Obtain Interior Designer's approval for the required finish. Escutcheons shall be either one-piece or split-pattern, held in place by internal spring tension or setscrew.

PART - 3 EXECUTION

3.1 **GENERAL**

- .1 Execute the Fire Suppression Work in accordance with requirements specified in the various Sections of Division 21 – Fire Suppression.

3.2 **FIRE-SUPPRESSION DEMOLITION**

- .1 Refer to Division 01 – General Requirements, Division 02 – Existing Conditions and Section 20 00 23 – Work in Existing Buildings for general demolition requirements and procedures.
- .2 Disconnect, demolish, and remove fire-suppression systems, equipment, and components indicated to be removed.
 - .1 Piping to be removed: remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - .2 Piping to be abandoned in place: drain piping and cap or plug piping with same or compatible piping material.
 - .3 Equipment to be removed: disconnect and cap services and remove equipment.
 - .4 Equipment to be removed and reinstalled: disconnect and cap services; remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 - .5 Equipment to be removed and salvaged: disconnect and cap services; remove equipment and deliver to the Owner.
- .3 If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.3 **WATER SUPPLY TEST**

- .1 Perform a water flow test on the municipal water service in proximity to the building connection, in accordance with NFPA 14 and NFPA 291. Flow test must be conducted within one (1) year prior to the completion of the final design for the Fire Suppression systems. Submit a record of the test.

.2 Obtain municipal approval and pay for all fees associated with the testing.

.3 Water supply flow test data shall include:

- .1 Static pressure
- .2 Residual pressure
- .3 Water flow
- .4 Testing Contractor's name
- .5 Date of test
- .6 Size of street main, NPS
- .7 Location of hydrant where the test was performed

3.4 **ESCUTCHEONS**

.1 Install escutcheons at finished surfaces where bare or insulated exposed piping passes through floors, walls, or ceilings in finished areas. Escutcheons shall be fastened securely to pipe or pipe covering.

3.5 **PAINTING**

.1 Coordinate the finish paint of fire suppression piping with the Contractor performing the Work of Section 09 91 00 – Painting as follows:

- .1 Concealed from view: not painted.
- .2 Exposed to view: pipe and hangers exposed to view in finished areas shall be painted with one coat approved rust inhibiting primer.
- .3 Alarm gong: shall be factory painted with two coats of red enamel.

3.6 **FLUSHING AND CLEANING**

- .1 Inspect the systems, and remove any heavy debris and excessive oil and dirt.
- .2 Flush all completed systems with clear water at the highest obtainable pressure and velocity, in accordance with NFPA requirements.
- .3 During flushing and cleaning, maintain all isolating and control valves in the open position.
- .4 Flush underground piping and lead-in connections before connection is made to system risers.
- .5 Provide adequate personnel to monitor the flushing operation and to ensure that drain lines are unobstructed in order to prevent flooding of the building. The Division 21 – Fire Suppression Contractor shall be responsible for any flood damage resulting from flushing of the system.

3.7 **TESTING**

- .1 Execute fire suppression systems and equipment tests in accordance with NFPA requirements, and as described under Section 21 08 00 - Commissioning of Fire Suppression. Co-ordinate tests with the performance verification of the fire alarm system. Test water mains and water service lines providing fire service, or water and fire service in accordance with NFPA 24. The additional water added to the system must not exceed the limits given in NFPA 24.
- .2 Furnish pumps, gauges and other equipment required to complete test.

- .3 Charge system with water only when there is no possibility of freeze-up.
- .4 Perform tests after fire pumps have been tested.
- .5 Prior to testing, ensure that valves, flow switches, pressure switches, supervisory switches and other devices are functioning.
- .6 Adjust setting of pressure reducing stations to the required setpoints.
- .7 Notify Consultant at least 48 hours before commencing with test, and give Consultant a written certificate confirming these tests.
- .8 Execute tests in presence of Consultant and Owner's authorized representative.
- .9 Test all fire suppression lines hydrostatically at not less than 1380 kPa pressure, or at 345 kPa above the maximum static pressure developed in the system if the maximum static pressure is in excess of 1034 kPa, or as required by authorities having jurisdiction, for a period of not less than four (4) hours without any drop in pressure. Do testing before piping is buried or furred in and before pressure sensitive devices are installed in the pipework.
- .10 If any leaks are discovered by the above tests, remove and replace the faulty portions of the systems and repeat the test. Repeat this procedure until the system is accepted by the Consultant's representative on the site. Do not caulk threaded joints.
- .11 Perform all tests before piping is furred in, and prior to installation of heat tracing cables.
- .12 Connect fire hoses only when flushing out and pressure tests have been completed.
- .13 In existing buildings, for new additions to an existing sprinkler or standpipe system, in addition to the NFPA requirements for pressure testing, conduct an initial pressure test as follows:
 - .1 Isolate the new piping from the existing system;
 - .2 Pressure test the new piping at 350 kPa using oil-free compressed air or nitrogen;
 - .3 Maintain pressure test for one hour without loss of pressure;
 - .4 If any leaks are discovered, repair leaks and retest.
- .14 In existing buildings, conduct the final pressure test in accordance with NFPA requirements, and isolate service valves on other floors during testing.

3.8 **COMPLETION**

- .1 Provide a written, sealed certification to the Owner that the fire suppression systems were installed, flushed and tested in accordance with appropriate codes, approved plans and calculations. Provide a copy of the sealed declaration to the Consultant.
- .2 Submit a certificate covering materials and tests to Underwriter's Inspection Authority, together with a request for inspection and approval of the complete fire suppression system. On receipt of approval, forward the certificate to the Owner.

3.9 **DEMONSTRATION**

- .1 Prior to final acceptance of the Fire Suppression systems, provide operational training in all aspects of these systems to the Owner's key personnel. Training shall include emergency procedures, safety requirements, and demonstration of the systems, including all interfaces with the Fire Alarm and Building Automation Systems.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
 - .2 Furnish and install general duty valves for fire suppression systems, and supervisory switches on riser valves and other isolating valves.
- .2 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Sections 20 00 13 – Mechanical General Provisions and 21 05 00 - Common Works for Fire Suppression shall apply to and govern this Section.

1.2 RELATED WORK

- .1 The following work is provided under other Sections or Divisions of the Work:
 - .1 Wiring of valve supervisory switches to fire alarm system: Division 26 – Electrical.

1.3 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for fire suppression valves.

1.4 REFERENCE STANDARDS

- .1 NFPA 14 - Standard for the Installation of Standpipe and Hose Systems
- .2 NFPA 26 - Supervision of Valves Controlling Water Supplies
- .3 Manufacturers' Standardization Society of Valve and Fittings Industry (MSS) SP-70, 71, 80, 85, 110.
- .4 ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
- .5 ASTM A216 - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service.
- .6 ASTM B124 - Standard Specification for Copper and Copper Alloy Forging Rod, Bar, and Shapes.
- .7 ASTM A536 - Standard Specification for Ductile Iron Castings
- .8 ANSI/ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250
- .9 ANSI/ASME B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings, Classes 150 and 300

1.5 QUALITY ASSURANCE

- .1 Valves shall be rated for the maximum system working pressure to which they are exposed but shall not be rated at less than 1034 kPa.
- .2 Standard of Acceptance
 - .1 Jenkins (not for ball valves)
 - .2 Mueller
 - .3 Crane (not for ball valves)
 - .4 Tyco
 - .5 National Fire Equipment
 - .6 Viking
 - .7 Cla-Val
 - .8 Nibco
 - .9 Victaulic
 - .10 MAS

PART - 2 PRODUCTS

2.1 SPRINKLER AND STANDPIPE VALVES

- .1 Approvals
 - .1 Valves shall be ULC and FM listed for fire protection.
- .2 Gate valves up to 50mm, threaded
 - .1 Class 150 or Class 300, bronze body, solid wedge bronze disc, rising stem, OS & Y, screw in yoke bonnet.
- .3 Gate valves 65mm and over, flanged
 - .1 Class 125 or Class 250, to ASTM A126 class B, cast iron body with flat face flanges, bronze or bronze faced solid wedge disc, bronze seat rings, rising stem, OS & Y, bolted bonnet.
- .4 Gate valves 65mm and over, grooved end
 - .1 Class 125 or Class 250, to ASTM A536 Grade 65-45-12, ductile iron body with grooved end, EPDM coated cast iron solid wedge disc, bronze seat rings, rising stem, OS & Y, bolted bonnet.
- .5 Ball Valves up to 50mm, grooved or threaded
 - .1 Rated for 2400 kPa, to ASTM B124, brass or bronze body, full port, solid chrome-plated brass ball, stainless steel stem, TFE seats, with brass or weatherproof ductile iron gear box.
- .6 Butterfly valves up to 65mm, threaded
 - .1 Rated for 1200 kPa, bronze body, stainless steel disc, with lever handle

- .7 Butterfly valves 65mm and over, lug style
 - .1 Class 125/150 or Class 250, cast iron body, ductile iron disc nickel plated, EPDM seat, "OPEN/SHUT" indicator
- .8 Butterfly valves 65mm and over, grooved joint style
 - .1 Rated for 2068 kPa, ductile iron body, electroless-nickel coated ductile iron disc, EPDM pressure-responsive seat, stainless steel stem (offset from the disc centerline to provide complete 360-degree circumferential seating), "OPEN/SHUT" indicator, with weatherproof actuator housing, hand wheel, and supervisory switches.
- .9 Swing check valves 65mm and over, flanged
 - .1 Class 125 or Class 250, to ASTM A216 class B, cast iron body with flat faced flanges, regrind, renew bronze disc and seat ring, bolted cover. Check valves on Siamese connection to have rubber faced disc.
- .10 Swing check valves 65mm and over, grooved joint style
 - .1 Rated up to 2517 kPa for sizes through 200mm and to 1725 kPa for 250mm and larger, to ASTM A-536, Grade 65-45-12, ductile iron body, non-slam aluminum bronze or elastomer coated ductile iron disc, stainless steel spring and shaft, PPS coated or welded-in nickel seat, suitable for vertical or horizontal installation.
- .11 Post indicator valves:
 - .1 Gate valves with non-rising stem and hub ends to suit the pipe. Valve shall open when turned in the direction to suit the Local Fire Department.
 - .2 Indicator posts shall be target type, with telescope barrel and locking handle
- .12 Drain valves:
 - .1 Brass ball valve with cap and chain, 20mm hose thread.

2.2 ELECTRICAL SUPERVISION

- .1 For OS & Y valves, switches shall be ULC, FM equivalent to System Sensor or Potter OSYSU-A1 or OSYSI-A2. All butterfly valves shall be factory assembled with ULC listed and FM approved internal monitor switches, one single-pole double-throw or two single-pole double-throw switches as required. Switches shall be installed inside the gearbox and preset at the factory. Switches shall activate alarm when valve is not fully open. Switch shall be complete with contacts for alarm and supervision. Plug-in type switches are not acceptable.
- .2 Where it is impractical to use one of the switches described above (i.e., for drain valves), use magnetic plug type supervisory switch equivalent to Potter PMS type.

2.3 VALVE IDENTIFICATION

- .1 In accordance with Section 20 05 53 - Mechanical Identification.

PART - 3 EXECUTION

3.1 GENERAL

- .1 Valves shall be the same size as the pipe in which installed.

- .2 Valves shall be located in such a manner that the top works, operators, and bonnets may be easily removed.
- .3 Install valves in upright position with stem above horizontal or as per manufacturer's instructions.
- .4 Arrange valve hand wheels and operating levers to be accessible.
- .5 Shut-off valves upstream of fire pumps shall be supervised O.S.&Y. gate valves.
- .6 Install supervised-open shutoff valves to control all sources of water supply except fire department connections. Where there is more than one shutoff valve, provide permanently marked identification signs indicating the portion of the system controlled by each valve.
- .7 Provide shut-off valves on all mains and sub-mains, and on each riser to allow for complete control, shut off and drainage the system.
- .8 Install supervisory switches on all system shutoff valves, suitable for operation with building fire alarm system.
- .9 Electrical connections of the supervisory switches to the fire alarm system will be provided under the scope of the Division 26 – Electrical Contractor.
- .10 Provide all necessary drips and drains to completely empty the system.
- .11 Install chain operators and chains on valves 1.8m or higher above floor. Keep chains out of working areas or ceilings.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 21 05 00 - Common Works for Fire Suppression shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 This Section includes requirements for commissioning the fire suppression systems, subsystems and equipment. This Section supplements the general requirements specified under Section 20 08 00 - Commissioning Requirements.

1.2 COMMISSIONED SYSTEMS

- .1 Automatic control related to fire suppression systems, not covered under the Work of Division 25 – Building Automation;
- .2 Wet and dry fire sprinkler systems;

PART - 2 PRODUCTS

2.1 NOT APPLICABLE.

PART - 3 EXECUTION

3.1 TESTING OF FIRE SUPPRESSION SYSTEMS

- .1 Fire suppression systems:
 - .1 The fire suppression systems include sprinkler systems, flow switches, supervised valves. All equipment shall be started up as per the manufacturers' recommendations, and be tested per the requirements of NFPA 13, 14 and 20.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 21 05 00 - Common Works for Fire Suppression shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 Furnish and install pipe and fitting for fire suppression systems, including but not limited to:
 - .1 Sprinkler systems;

1.2 RELATED WORK

- .1 The following work is provided under other Sections or Divisions of the Work:
 - .1 Fire rated assembly around fire suppression piping: Section 09 21 16 - Gypsum Board Assemblies.

1.3 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for fire suppression piping, fittings joints and hangers.

1.4 REFERENCE STANDARDS

- .1 NFPA 13 - Standard for the Installation of Sprinkler Systems
- .2 NFPA 14 - Standard for the Installation of Standpipe and Hose Systems
- .3 NFPA 24 - Standard for the Installation of Private Fire Service Mains and Their Appurtenances
- .4 ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
- .5 ASTM A536 - Standard Specification for Ductile Iron Castings
- .6 ASTM D1784 - Standard Specification for Rigid Polyvinyl Chloride (PVC) Compounds and Chlorinated Polyvinyl Chloride (CPVC) Compounds
- .7 ASTM D2467 - Standard Specification for Polyvinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 80
- .8 ASTM D3139 - Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
- .9 ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

- .10 ASTM F442 - Standard Specification for Chlorinated Polyvinyl Chloride (CPVC) Plastic Pipe
- .11 ANSI/ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250
- .12 ANSI/ASME B31.1 – Power Piping
- .13 CSA B51 - Boiler, Pressure Vessel, and Pressure Piping Code
- .14 AWWA C151 - Ductile Iron Pipe, Centrifugally Cast for Water
- .15 AWWA C900 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 12 In. (100 mm Through 300 mm), for Water Transmission and Distribution

1.5 **QUALITY ASSURANCE**

- .1 All fittings shall be registered by the manufacturer, and shall be identified by the appropriate Canadian registration number (CRN).
- .2 All grooved products including couplings, fittings and valves shall be supplied by the same manufacturer.
- .3 All fittings, coupling and valves shall be ULC listed and FM approved.
- .4 Piping, fittings, and other system components shall be rated for the maximum system working pressure to which they are exposed but shall not be rated at less than 1034 kPa.
- .5 Standard of Acceptance
 - .1 Grooved joint system
 - .1 Victaulic
 - .2 Shurjoint
 - .3 Gruvlok

PART - 2 PRODUCTS

2.1 **PIPE, HANGERS AND GASKETS**

- .1 Pipe – above grade:
 - .1 Schedule 40 continuous weld steel to ASTM A53 Grade B, up to 50mm, grooved or screwed.
 - .1 Piping to be galvanized for dry and pre-action systems.
 - .2 Schedule 40 electric resistance weld steel to ASTM A53-63R Grade B, for 65mm to 250mm, welded.
 - .3 Schedule 10 thin wall, rolled grooved only to ASTM A53-72A, for 40mm and over. Thin wall piping shall only be used where approved by the authorities having jurisdiction.
 - .4 CPVC extruded pipe to ASTM D1784 / ASTM F442, ULC listed for use in wet automatic fire sprinkler systems.
- .2 Pipe hangers:
 - .1 As specified under Section 20 05 29 - Bases, Hangers and Supports

- .3 Gaskets for flanged joints:
 - .1 Red rubber sheet 1.6 mm thick.

2.2 **FITTINGS FOR ABOVE GRADE PIPE**

- .1 Fittings:
 - .1 Black cast iron screwed up to 50mm.
 - .2 Forged steel, butt welding Schedule 40 for 65mm and over.
- .2 Unions:
 - .1 Black malleable ground joint union, bronze to iron seat up to 50mm.
- .3 Joints:
 - .1 Flanged, forged steel, slip-on or weld neck, raised face style.
- .4 Valves:
 - .1 As specified under Section 21 05 23 - Valves for Fire Suppression.

2.3 **FITTINGS FOR GROOVED PIPE**

- .1 Couplings:
 - .1 Malleable or ductile iron 40mm and over, rigid 'installation ready' type to NPS 4, standard rigid type 150mm and over. Use flexible type coupling in seismic areas per NFPA 13.
- .2 Fittings:
 - .1 Malleable iron or ductile iron to 40mm to 300mm.
 - .2 Fabricated steel 350mm and over.
- .3 Joints:
 - .1 Flanged, cast iron, raised face flange with coupling groove 65mm and over.
- .4 Gaskets for grooved couplings:
 - .1 EPDM Grade "E", dry lubricated

2.4 **FITTINGS FOR CPVC PIPE**

- .1 Fittings:
 - .1 ASTM F437 (schedule 80 threaded), ASTM F438 (schedule 40 socket) and ASTM F439 (schedule 80 socket).
- .2 Joints:
 - .1 Cemented employing solvent cements to ASTM F493. Solvent cement shall be listed by NSF International for use with potable water, and approved by the manufacturers. The solvent cements shall be compatible with their CPVC pipe and fittings.

PART - 3 EXECUTION

3.1 PIPING INSTALLATION

- .1 Consider the piping layout shown on the Drawings as diagrammatic, indicating the general runs and connections, and that the piping may, or may not, in all parts be shown in true position.
- .2 All welding and fabrication shall be to the requirements of NFPA 13 and 14, ANSI/ASME B31.1 and CSA B51.
- .3 Ream all piping and keep plugged to prevent entry of dirt.
- .4 Accurately cut pipe to the established measurements and work into place without springing or forcing. In any situation where bending of the pipe is required, use a standard pipe-bending template. Pipe hangers, supports, restraint of system piping and seismic bracing shall be installed accordance with NFPA 13.
- .5 Anchor, guide and laterally support vertical and horizontal piping to support filled weight and absorb thrust under operating conditions.
- .6 Erect piping so that gravity forces and thrust from changes in direction do not stress connections to apparatus.
- .7 Grooved joint piping systems shall be installed in accordance with the manufacturer's guidelines and recommendations. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Grooved end shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove. Use a torque wrench for installation if required for the joint type. Required torque shall be in accordance with the manufacturer's recommendations. A factory trained field representative shall provide on-site training to contractor's field personnel in the installation of grooved piping products. Factory trained representative shall periodically review the product installation. Remove and replace any improperly installed joints.
- .8 CPVC pipe system shall be installed in accordance with manufacturer's instructions for set and cure times for solvent cement joints. Avoid significant stresses during set and cure times. Do not apply any stress that will disturb an un-dried joint. Sprinkler fittings shall be allowed to cure in accordance with the manufacturer's guidelines. Ensure that the outlets are clear of any excess cement prior to installing sprinkler heads.
- .9 Install drain valves at low points in water piping systems and in valved run-outs from risers so that system or isolated parts of system can be drained.
- .10 Provide fire rated pipe insulation on piping as required by design, where the pipes are not enclosed by a fire rated assembly.
- .11 CPVC – above grade
 - .1 Install in accordance with the manufacturer's recommendations.
 - .2 Provide fire stop seals on all fire separation penetrations. Fire stopping used for plenum rated piping shall be a listed system as supplied by the pipe manufacturer.
 - .3 Do not use combustible piping in return air ceiling plenums or in vertical riser shafts.

3.2 JOINTS, UNIONS, FLANGES AND COUPLINGS

- .1 Pipe joints
 - .1 Preparation
 - .1 Ream pipe ends and thoroughly clean all dirt, cuttings and foreign matter from pipe after cutting and threading.
 - .2 Thoroughly clean all fittings, valves and equipment before connections are made.
 - .2 Mechanical joints:
 - .1 Assemble mechanical joint on ductile iron pressure pipe with cast iron gland, rubber sealing gasket and high strength malleable iron bolts in accordance with the manufacturer's recommendations.
 - .3 Threaded joints:
 - .1 Use Teflon tape or Masters metallic compound with the compound applied to the male threads only and particular care taken to prevent the compound from reaching the interior of the pipe or fittings.
 - .4 Carbon steel welded joints:
 - .1 To ANSI B31.1 Section IX for welding.
 - .2 Fusion welded joints made by electric arc welding, gas metal arc welding, or oxy-acetylene gas welding.
 - .3 Unless more stringent methods of inspections are specified, the Consultant will visually inspect welded joints for fusion of metal, icicles, alignment. Remove any defects and remake defective joints to the Consultant's satisfaction.
 - .5 Grooved end piping systems:
 - .1 Install couplings and fittings in accordance with manufacturer's instructions.
- .2 Unions and flanges
 - .1 Provide unions or flanges in the following locations:
 - .1 For by-passes around equipment or control devices in piping systems.
 - .2 At connections to equipment.
 - .2 If unions are concealed in walls, partitions or ceilings, build access thereto.
 - .3 Flange joints
 - .1 Assemble joints with appropriate flanges, gaskets and bolting.
 - .2 Allow clearance between flange faces such that the connections can be gasketed and bolted tight without undue strain on the piping system, with flange faces parallel and bores concentric.
 - .3 Centre gaskets on the flange faces so as not to project into the bore.
 - .4 Lubricate bolts before assembly and provide 2 hardened steel washers under the head of each unit to assure uniform bolt stressing.
 - .5 Machine off raised face flanges when joining to a flat companion flange and use a full face gasket.

- .6 Follow gasket manufacturer's instructions for correct bolting procedure.
- .7 Use calibrated torque wrench and tighten bolts in recommended sequence in four equal steps to required final torque value.
- .3 Couplings
 - .1 Minimize couplings on runs of pipes.
 - .2 Do not use running couplings in any pipeline.
- .4 Tee connections in welded piping
 - .1 Factory fabricated standard butt-weld fittings.
 - .2 Mitering, notching or direct welding of branches to mains is not permitted.
- .5 Change of direction
 - .1 Use standard pipe fittings.
 - .2 Use long radius welded steel elbows unless short radius elbows are specifically authorized by the Consultant.
 - .3 Mitered joints or field fabricated pipe bends are not permitted.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
 - .2 Wet pipe sprinkler systems;
 - .3 Water flow switches and pressure switches on alarm valves and risers.
- .2 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Sections 20 00 13 – Mechanical General Provisions and 21 05 00 - Common Works for Fire Suppression shall apply to and govern this Section.

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for sprinkler system equipment.
 - .3 Submit layout drawings as described under Section 21 05 00 - Common Works for Fire Suppression.
 - .4 Submit load calculations for sizing of sway bracing for systems that are required to be protected against damage from earthquakes.
 - .5 For listed window sprinklers include the respective Building Materials Evaluation Commission (BMEC) authorization report and any other approvals from authorities having jurisdiction.
- .2 Samples
 - .1 Submit samples for the following
 - .1 Each type of sprinkler.
 - .2 Signs.
- .3 Maintenance Materials
 - .1 Provide the following materials at project handover:
 - .1 Storage cabinet
 - .2 Sprinkler wrench
 - .3 Spare stock of sprinklers. Include at least one head for each type and each temperature rating installed in the system, and to NFPA 13 requirements.

1.3 REFERENCE STANDARDS

- .1 NFPA 13 - Installation of Sprinkler Systems
- .2 NFPA 15 - Water Spray Fixed Systems

- .3 NFPA 24 - Standard for the Installation of Private Fire Service Mains and Their Appurtenances
- .4 NFPA 26 - Supervision of Valves Controlling Water Supplies
- .5 NFPA 72 - Installation, Maintenance and Use of Protective Signalling Systems
- .6 NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

1.4 DESIGN CRITERIA

- .1 System shall be designed to NFPA requirements using hydraulic method for hazard classification shown with design densities and design areas for each zone as detailed in the below table:

Sprinkler System Design Criteria				
Occupancy Type	Hazard Classification	Water Flow Density		Comment
		Flow Rate (L/s/sqm)	Area (sqm)	
Office, patient care and treatment areas	Light	0.068	139	Wet - Pipe sizes shall be based on 16.3 m ² per head
Residential / hospitality: suites, corridors, amenity areas; restaurant seating areas	Light	0.068	139	Wet
			83.6	Wet - Quick response heads in ceilings at less than 3.0m above finished floor
Service spaces (mechanical, electrical, telecom rooms), penthouse mech. room, laboratories, repair shops, restaurant service areas, laundry.	Ordinary Group 1	0.102	139	Wet
Server rooms	Ordinary Group 1	0.102	139	Pre-action
Loading dock	Ordinary Group 2	0.102	372	Dry
Parking garage	Ordinary Group 1	0.102	181.2	Dry
Retail stores, storage rooms, garbage rooms, clean and soiled linen rooms, pharmacy, boiler plants, energy centers, warehouse spaces, workshops	Ordinary Group 2	0.136	139	Wet
Library stacks, high	Ordinary	0.116	279	Wet

Sprinkler System Design Criteria				
Occupancy Type	Hazard Classification	Water Flow Density		Comment
		Flow Rate (L/s/sqm)	Area (sqm)	
density, file storage	Group 2			
Flammable storage, diesel tank room, generator room	Extra Group 2	0.272	232	Wet

- .2 Hydraulic calculations shall be based on flow test data to the requirements of NFPA 13, and applicable provincial and federal building codes, down-rated in accordance with requirements of authorities having jurisdiction.
- .3 The reflected ceiling plan as prepared by the Consultant shall not be altered or revised; the number and location of heads shown shall remain as shown as a minimum.
- .4 Base hydraulic calculations for the window sprinkler system on all sprinkler heads on the hydraulically most remote side of the floor-to-floor fire separation operating simultaneously.
- .5 Add the hydraulic water demand for the window sprinkler system to the hydraulic water demand for any sprinkler and standpipe system serving the floor area on the hydraulically most remote side of the sprinklered window assembly.

1.5 **QUALITY ASSURANCE**

- .1 Unless otherwise noted, equipment and apparatus shall be ULC listed and FM approved for fire service.
- .2 The system installation shall be carried out by a sprinkler contracting company that is a member in good standing of the Canadian Automatic Sprinkler Association.

PART - 2 PRODUCTS

2.1 **GENERAL**

- .1 Restricted Materials
 - .1 Do not use any materials which incorporates or uses silicone based products either as part of its construction, maintenance materials or as packaging material.

2.2 **SPRINKLER HEADS**

- .1 Ratings
 - .1 Temperature rating and orifice size in accordance with the requirements of Owner's Underwriter for conditions involved, and/or as shown on the Drawings.
 - .2 Standard orifice size: 12mm diameter orifice or 20 mm diameter orifice.
 - .3 Standard temperature rating: 57°C to 74°C .
 - .4 Use intermediate or high temperature rated heads to suit local conditions, e.g. near unit heaters, heating equipment (boilers), other heat-generating equipment such as kitchen cooking line.

- .2 Type
 - .1 Automatic spray type.
 - .2 Quick response type for Light and Ordinary hazard applications; standard response type for Extra hazard applications.
 - .3 Indicated by application in accordance with the following:
 - .1 No ceilings
 - .1 Upright, bronze body, glass bulb type
 - .2 Suspended or drop ceilings – T-bar, gypsum board
 - .1 Pendent, chrome plated body and escutcheon plate, link and lever type.
 - .2 Pendent, chrome plated body and escutcheon plate, glass bulb type.
 - .3 Recessed or semi-recessed, chrome plated body ring and cup, glass bulb type.
 - .4 Flush concealed with adjustable, diffusible (chrome plated) (white) (factory painted, colour to be selected) cover plate.
 - .3 Side wall
 - .1 Side wall, bronze body and chrome escutcheon plate, fusible solder type
 - .2 Side wall, chrome plated body and escutcheon plate, fusible solder type
 - .4 Window
 - .1 Horizontal or vertical pendent arrangement, polyester coated, (chrome plated) (white colour)
 - .5 Residential suites, corridors
 - .1 Side wall extended coverage, concealed, complete with white painted domed cover plate
 - .6 Secured or institutional finished areas
 - .1 Standard coverage, tamper resistant chrome plated heads, pendent or horizontal sidewall as applicable, with chrome plated escutcheon and retaining flange
 - .7 Freezers, walk-in coolers.
 - .1 Dry pendant quick response type.
 - .8 Deluge systems
 - .1 Open type heads, of style to suit location.
 - .9 Sprinkler heads located in pool deck and change rooms areas, pool chemical storage areas, and pool mechanical room areas shall be complete with the manufacturer's applied, approved waxed coating.
 - .10 Sprinkler heads exposed to potential physical damage such as located in storage areas, mechanical rooms, receiving areas, IT and communication closets, computer rooms shall be provided with sprinkler guards. Sprinklers guards shall be listed, supplied, and approved for use with the

sprinkler head by the sprinkler manufacturer.

- .3 Spare heads and cabinet
 - .1 For each sprinkler system: ULC approved metal cabinet containing the required number of spare sprinkler heads of each type and temperature rating.
 - .2 Wrench for removal and replacement of sprinkler heads.
- .4 Standard of Acceptance
 - .1 Viking Group
 - .2 Reliable Automatic Sprinkler
 - .3 Tyco Fire
 - .4 Victaulic

2.3 **FLEXIBLE SPRINKLER HOSE FITTINGS**

- .1 Flexible sprinkler hose fittings for use in suspended lay-in and gypsum board ceilings designed as intermediate or heavy duty systems per ASTM C635 and C636.
- .2 Technical data:
 - .1 Hose tube diameter: 25mm or 28 mm outside diameter
 - .2 Lengths available: 700mm, 1000 mm, 1200 mm, 1500 mm and 1800mm
 - .3 Inlet: 25mm or 32mm NPT, male pipe threads
 - .4 Outlet reducer: straight with 12mm or 20mm NPT, or 90° angle with 12mm or 20mm NPT, both styles female thread
 - .5 Corrugated tube is polished, boron treated and annealed after forming to insure relief of all material stresses and removal of all scale.
 - .6 Maximum Working Pressure: 1379 kPa
 - .7 Test Pressure: 2792 kPa
 - .8 Approved for wet and dry systems as noted in NFPA 13
 - .9 Maximum ambient temperature: 225°F with EPDM seal;
 - .10 Minimum bend radius: 75 mm 300mm for projects requiring FM approval
- .3 Materials:
 - .1 Flexible tube: 304 stainless steel
 - .2 Outlet reducer (straight or angled) and inlet nipple: carbon steel with yellow zinc plating
 - .3 Seal: EPDM
 - .4 Slip nut: brass
 - .5 Support brackets and support bar: galvanised steel

2.4 **ALARM CHECK VALVES**

- .1 Wet Sprinkler Systems
 - .1 Alarm check valve shall be specifically listed for use in wet pipe systems, rated for (2,068 kPa). Valve shall be of a ductile iron construction intended for use in either

the vertical or horizontal position. When variable water supply pressures exist, the alarm check valve shall be installed with a retard chamber. Valve shall be connected to a pressure switch equivalent to Potter PS10A, to initiate electrical alarms. Valve shall be complete with external bypass, test bypass, pressure gauges, and drain connections.

.2 Standard of Acceptance

- .1 Viking Group
- .2 Reliable Automatic Sprinkler
- .3 Tyco Fire
- .4 Victaulic

2.5 **PRESSURE REDUCING STATIONS**

- .1 Provide ULC listed and FM approved pressure reducing stations where shown on the Drawings. Stations shall be complete with isolating valves, strainer, pressure gauges, cast iron body and bronze trim.
- .2 Select valves for inlet and outlet pressures as shown on the Drawings.

2.6 **ANCILLARY EQUIPMENT**

- .1 Water gong
 - .1 Water operated outside alarm bell, weather protected.
- .2 Flow switch riser manifold
 - .1 Factory assembled unit consisting of flow switch, pressure gauge, sight glass on test and drain connection, and relief valve where required for grid systems. Assembly shall be painted red with white identification markings indicating flow direction and tapping uses.
- .3 Test and drain fitting
 - .1 For each system, provide a sectional test and drain equivalent to Tyco Model F350 or a combined test and drain fitting with orifice sized according to the installed sprinkler heads equivalent to Victaulic Style 720 TestMaster II.
- .4 Low pressure alarm sensor
 - .1 115 Volt or 24 Volt (to suit fire alarm system) adjustable piping mounted pressure sensor with contacts arranged to actuate a fire alarm system trouble signal if piping pressure drops to a pressure below the switch setting.
- .5 Water flow alarm switch
 - .1 Pipe mounted water flow alarm switch equivalent to Potter Model VSR-F complete with:
 - Vane type sensor operating two single-pole, double-throw, snap action switches when sustained water flow exceeds 0.63 L/s .
 - .1 Integral, field adjustable retard device with automatic reset to delay switch operation to reduce the possibility of false alarms caused by a single or series of transient water flow surges.
 - .2 Tamper-proof cover.

- .3 U-bolt and piping saddle.
 - .6 Excess pressure pump
 - .1 Construction
 - .1 Close coupled bronze gear pump with stainless steel shaft;
 - .2 Motor size, pump size, and head capacity as shown;
 - .3 Pressure switch with pressure differential of 100 kPa to operate excess pressure pump;
 - .4 Shut-off valve and strainer on pump inlet;
 - .5 Relief valve, check valve and shut-off valve on pump discharge connection.
 - .2 Standard of Acceptance - inlet pressure less than 550 kPa
 - .1 Albany
 - .2 Venus
 - .3 Standard of Acceptance - inlet pressure greater than 550 kPa
 - .1 Price Pump Company
 - .7 Sprinkler control cabinet
 - .1 Construction
 - .1 765 mm high x 765 mm wide x 305 mm deep
 - .2 Flush type with 1.6mm steel tub, 2.5 mm metal door, and 2.5 mm flush adjustable plaster trim with full rebate for door.
 - .3 Fully concealed, 180° opening door hinges and Corbin latch with lock of flush cast construction.
 - .4 Without bolts and/or screws on the face of the cabinet.
 - .5 Interior surfaces of cabinet prime painted.
 - .6 Flanged OS & Y gate valve, drain and test equipment as shown.
 - .7 Identified by red lettered sign.
 - .8 Fitted with alarm test module.
 - .2 Standard of Acceptance
 - .1 National Fire Equipment
 - .2 Croker
 - .3 Potter Roemer
 - .4 Wilson & Cousins
 - .8 Flow indicator
 - .1 For mounting in zone piping.
 - .2 Fitted with:
 - .1 Sealed retard,
 - .2 Visual indication of switch activation,

- .3 Mechanical delay adjustment.
- .3 Standard of Acceptance
 - .1 Tyco Fire
 - .2 Potter Electric
 - .3 System Sensor

PART - 3 EXECUTION

3.1 GENERAL

- .1 Install and test sprinkler systems in accordance with NFPA 13 and 20.
- .2 Install piping using Schedule 40 threaded or welded, Schedule 10 grooved, or combination thereof as allowed under NFPA 13 and by the Owner, in accordance with Section 21 11 00 – Fire Suppression Piping.
- .3 Install drain pipes and valves to drain parts of systems and so arranged that any one sprinkler zone can be drained without shutting down any other parts of the system.
- .4 For each sprinkler zone provide a control valve, flow switch, and a test and drain assembly with pressure gauge.
- .5 Field power wiring will be provided under the scope of the Division 26 – Electrical Contractor. Provide certified wiring schematics to the Division 26 - Electrical Contractor for all equipment requiring power supply.
- .6 Electrical connections of pressure and flow switches, and of control panels requiring monitoring, to the fire alarm system will be provided under the scope of the Division 26 – Electrical Contractor.

3.2 INSTALLATION

- .1 Sprinkler heads are to be installed symmetrically in ceiling tiles.
- .2 Runouts to all sprinkler heads shall be off the top or side of the main. Heads may not be located off the bottom of the main.
- .3 Provide drain valves at trapped low points in the piping system. Pipe drains to discharge at safe points outside of the building terminating with standard hose nipple 150mm above grade or to funnels attached to drains of adequate size to readily carry the full flow from each drain under maximum pressure. Install drips and drains where necessary and required by NFPA 13. The drain piping shall not be restricted or reduced and shall be of the same diameter as the drain collector.
- .4 Provide additional sprinkler heads with associated piping for sprinkler protection under ducts, under obstructions, and in blind spaces. Identify additional sprinkler heads on shop drawings and resubmit drawings to permit inclusion of these sprinkler heads in hydraulic calculations.
- .5 Provide seismic protection in accordance with NFPA 13.
- .6 The sprinkler bulb protector must remain in place until the sprinkler is completely installed and before the system is placed in service. Remove bulb protectors carefully by hand after installation. Do not use any tools to remove bulb protectors.

3.3 **WET PIPE SYSTEMS**

- .1 Provide excess pressure pumps to maintain excess pressure on downstream side of alarm check valves. Provide piping connections to each riser, and controls for automatic operation of pumps.
- .2 Mount a water motor gong on the exterior surface of the building where noted, complete with water piping connections to alarm check valves. Provide drain piping to a point 150mm above grade.
- .3 Equip each riser with pressure and flow switches with the following functions:
 - .1 To start and stop excess pressure pumps
 - .2 Security Agency alarm
 - .3 Supervisory system central station alarm
 - .4 Interior alarm bell

3.4 **FLEXIBLE SPRINKLER HOSE FITTINGS**

- .1 Install the flexible sprinkler head drops per manufacturer's installation instruction.
- .2 The sprinkler head shall be located near the center of the ceiling tile and between the main support rails of the suspended ceiling support system.
- .3 Select the required length for the flexible hose based on actual field conditions, with consideration to obstructions.
- .4 To minimize friction loss, a large bend radius shall be used; however, this must be a smooth, constant radius. The radius of the flex hose must not fall in the non-corrugated ends. Avoid long lengths of hose for the distance, as this would require more bends to install, possibly including low spots or kinks.
- .5 Install the sprinkler head on the hose using non-hardening thread sealant or Teflon tape on the male threads of the sprinkler head. Hand tighten the sprinkler head, then tighten 1/4 turn to approximately 8.5 Nm (75 lbf in) of torque using torque limiting wrench. Use the same technique when connecting the hose to the pipe outlet connection, however do not apply sealant compound on the pipe outlet threads.
- .6 Properly form the required bend radii using a bend tool, or cylindrical formed object or pipe, to provide constant and smooth radius.

3.5 **PRESSURE GAUGES**

- .1 Install pressure gauges at:
 - .1 Water supply connections.
 - .2 Before and after pumps.
 - .3 At the highest point of each sprinkler riser.
 - .4 Where shown on the Drawings.

3.6 **TEST CONNECTIONS AND DRAINS**

- .1 Locate inspector's test connections, complete with valve, sight glass, and drain piping either at the high points of the sprinkler system or at the end of the longest run of the sprinkler piping in accordance with NFPA 13.

3.7 **EXCESS PRESSURE PUMPS**

- .1 Install an excess pressure pump across each alarm valve. Support pumps rigidly by steel mounting plate attached to the flange above the alarm valve.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 21 05 00 - Common Works for Fire Suppression shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 Furnish and install portable fire extinguishers, associated cabinets and support hardware.

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for fire extinguishers and extinguisher cabinets.

1.3 REFERENCE STANDARDS

- .1 CAN/ULC-S503 – Carbon-Dioxide Fire Extinguishers
- .2 CAN/ULC-S508 – Standard for the Rating and Fire Testing of Fire Extinguishers
- .3 NFPA 10 - Standard for Portable Fire Extinguishers

1.4 QUALITY ASSURANCE

- .1 All fire extinguishers shall be ULC listed.
- .2 Standard of Acceptance
 - .1 Guardian Fire Equipment
 - .2 Badger
 - .3 Strike First
 - .4 Potter Roemer
 - .5 American Fire Hose
 - .6 Tyco Fire

PART - 2 PRODUCTS

2.1 PRESSURIZED WATER EXTINGUISHERS

- .1 Stored pressure type, squeeze-grip operated of stainless steel construction, 9.4 L size, 2-A rating.

2.2 **MULTIPURPOSE DRY CHEMICAL EXTINGUISHERS**

- .1 Stored pressure rechargeable type with hose and shut-off nozzle, for A, B and C class protection, red enamel finish. Sizes 1.13 kg, 2.3 kg, 4.5 kg, 9 kg as required.

2.3 **ORDINARY DRY CHEMICAL EXTINGUISHERS**

- .1 Stored pressure type with hose and shut-off nozzle, for B and C class protection, glossy enamel finish. Sizes 2.5 kg, 4.5 kg, 9 kg as required.

2.4 **CARBON DIOXIDE EXTINGUISHERS**

- .1 Insulated handle, hose and horn discharge assembly, self-closing lever or squeeze-grip operation, for B and C class protection, glossy baked enamel finish. Sizes 2.3 kg, 4.5 kg, 6.8 kg, 9 kg as required.

2.5 **CLEAN AGENT EXTINGUISHERS**

- .1 Low toxicity, zero ozone depletion agent, stored pressure rechargeable type with hose and shut-off nozzle, for A, B and C class protection, polyester-urethane finish. Sizes 1.1 kg, 2.2 kg, 4.3 kg, 6.0 kg as required.

2.6 **WET CHEMICAL EXTINGUISHERS**

- .1 Soft discharge rechargeable type with hose, valve, and stainless steel, self-closing lever handle operation, for A and K class protection, polished stainless steel finish. Size 6L.

2.7 **DRY POWDER EXTINGUISHERS**

- .1 Extended soft flow applicator wand, brass valve, stainless steel, self-closing lever handle operation, for D class protection, size 13.6kg.

2.8 **EXTINGUISHER BRACKETS**

- .1 Supplied by extinguisher manufacturer.

2.9 **EXTINGUISHER CABINETS**

- .1 Recessed surface mounted, semi-recessed or fully recessed type as shown on the Drawings.
- .2 Constructed of 1.9 mm steel; of 0.75mm 316 stainless steel in pool areas and other areas indoor environment promoting corrosion.
- .3 180° opening door of 2.0 mm steel with latching devices, 5 mm glass panel and baked enamel primed door finish. Cabinets used in parking area and other unfinished areas accessible to the public shall be with plexi-glass panel.

2.10 **IDENTIFICATION OF EXTINGUISHERS**

- .1 Include bilingual tag or label attached to extinguishers, in accordance with the requirements of NFPA 10, and provincial or municipal fire codes, indicating month and year of installation, with additional space for service dates.

PART - 3 EXECUTION

3.1 INSTALLATION

- .1 Extinguishers in all service spaces such as mechanical and electrical rooms, and in garage areas shall be 6A80BC rating multi-purpose dry chemical powder type.
- .2 Extinguishers in Q/A Labs shall be minimum 2A:10B:C dry chemical fire extinguisher.
- .3 Extinguishers in general areas shall be minimum 3A40BC rating multi-purpose dry chemical powder type. In light hazard office areas, pressurized water extinguishers with 2A rating may also be used.
- .4 Mount extinguishers in cabinets in all areas accessible by public, and on brackets in all other areas.
- .5 Spacing of extinguishers shall conform to the requirements of the authority having jurisdiction. Maximum spacing for ordinary hazard shall be 9 m for 10 BC extinguisher and 15 m for 20 BC extinguishers, but in no case shall there be less than one extinguisher in each electrical room, kitchen or mechanical room. Maximum spacing for Type A extinguishers in general offices shall be 25 m. Review locations with the authority having jurisdiction prior to installation.
- .6 Install extinguishers at project completion which are fully charged and ready for operation upon installation. Provide extinguishers complete with manufacturer's warranty with inspection tag attached.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 This Section supplements all Sections of Division 22 – Plumbing.
 - .2 The intent of the Division 22 – Plumbing Specifications and the accompanying Drawings is to provide complete and workable plumbing systems as shown, specified and required by applicable codes. Include all work specified under Division 22 - Plumbing and shown on the accompanying Drawings.
 - .3 The Drawings that accompany the Division 22 – Plumbing Specifications are diagrammatic. It is the responsibility of this Contractor to ensure that adequate and appropriately sized plumbing vent system and valving for the plumbing systems as per provincial and federal codes, and requirements of authorities having jurisdiction are provided. Provide additional valves and resize all plumbing piping as required. The Contract Drawings do not show each offset, bend, tee, or elbow which may be required to install the Plumbing Work in the space provided and to avoid conflicts. Follow the Drawings as closely as is practical to do so and install additional bends, offsets and elbows where required by local conditions from measurements taken at the Site, subject to approval, and without additional cost to the Owner.
 - .4 Major aspects of the Plumbing Work shall include but not necessarily be limited to, the following items:
 - .1 Sanitary drainage and venting system within the building including connection to buried sanitary sewer 1.5m outside the building wall, sewage pumps and associated drainage specialties;
 - .2 Laboratory drainage system including collection and neutralization equipment;
 - .3 Domestic cold, hot and recirculating water supply and distribution systems and equipment within the building, including municipal and revenue water meters, hot water heaters, pumping equipment;
 - .4 Plumbing fixtures, faucets, trim and other accessories;
 - .5 Excavation, bedding, and backfilling of pipe trenches for buried piping inside the building and to 1.5m outside.
 - .6 Refer to the following Sections of the Division 22 – Plumbing Specification for further details:
 - .1 Valves for Plumbing – Section 22 05 23
 - .2 Commissioning of Plumbing – Section 22 08 00
 - .3 Instrumentation and Control for Plumbing – Section 22 09 00
 - .4 Domestic Water Piping – Section 22 11 16
 - .5 Domestic Water Piping Specialties – Section 22 11 19

- .6 Sanitary Waste and Vent Piping – Section 22 13 16
- .7 Sanitary Waste Piping Specialties – Section 22 13 19
- .8 Electric Domestic Water Heaters – Section 22 33 00
- .9 Emergency Plumbing Fixtures – Section 22 45 00

1.2 RELATED WORK

- .1 The following Work is provided under other Sections or Divisions of the Work:
 - .1 Finish painting: Section 09 91 00 – Painting.
 - .2 Electrical power wiring: Division 26 - Electrical.

1.3 QUALITY ASSURANCE

- .1 Manufacturer Qualifications:
 - .1 Companies specialized in manufacturing plumbing and drainage, compressed air, vacuum, medical and laboratory gas products specified under the Sections of Division 22 – Plumbing with minimum three years of documented experience.
- .2 Installer Qualifications:
 - .1 Companies specialized in performing work of the type specified under the Sections of Division 22 – Plumbing:
 - .1 Minimum three years of experience, or
 - .2 Approved by product manufacturers.
- .3 Conform to CSA, municipal, provincial and federal plumbing codes', Owner's Plumbing Standard requirements as applicable for this project.
- .4 Layout drawings:
 - .1 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.
 - .2 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.
 - .3 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.

1.4 DESIGN CRITERIA

- .1 Domestic cold water system
 - .1 Operating pressures:
 - .1 Maximum system pressure: 63 psig measured at the water hydrant east of building.

- .2 Minimum pressure at fixtures: 172 kPa
 - .3 Maximum pressure at fixtures: 538 kPa
 - .4 Municipal water supply: 276 kPa
 - .5 Component pressure rating: 860 kPa
 - .2 Domestic hot water system
 - .1 Operating temperatures:
 - .1 Supply at plant: 60°C
 - .2 Supply at fixtures: 49°C
 - .2 Operating pressures:
 - .1 Minimum pressure at fixtures: 172 kPa
 - .2 Maximum pressure at fixtures: 538 kPa
 - .3 Component pressure rating: 860 kPa
- 1.5 **SUBMITTALS**
 - .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for water meters, flashing system and backflow preventers.
- 1.6 **PERMITS AND INSPECTIONS**
 - .1 Submit layout drawings to the municipal Building Department; apply for and obtain permits required for Plumbing Work and pay all costs levied for permits and inspections.
- 1.7 **REFERENCE STANDARDS**
 - .1 AWWA C510 - Double Check Valve Backflow Prevention Assembly Standard
 - .2 AWWA C511 - Reduced-Pressure Principle Backflow-Prevention Assembly Standard
 - .3 AWWA C651 - Disinfecting Water Mains
 - .4 CSA B64.5 - Double check valve (DCVA) backflow preventers
 - .5 CSA B64.4 - Reduced pressure principle (RP) backflow preventers
 - .6 CSA B272 - Pre-Fabricated Self Sealing Roof Vent Flashings
 - .7 O.Reg. 215 - Fuel Industry Certificates
 - .8 ASSE 1013 - Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Principle Fire Protection Backflow Preventers
 - .9 ASSE 1015 - Performance Requirements for Double Check Backflow Prevention Assemblies and Double Check Fire Protection Backflow Prevention Assemblies
 - .10 NSF/ANSI 61 - Drinking Water System Components

1.8 **QUALITY ASSURANCE**

- .1 Material or equipment containing a weighted average of greater than 0.25 percent lead are prohibited in any potable water system intended for human consumption, and shall be certified in accordance with NSF 61 or NSF 372. Endpoint devices used to dispense water for drinking shall meet the requirements of NSF 61, Section 9.

PART - 2 PRODUCTS

2.1 **MUNICIPAL WATER SERVICE METER**

- .1 Compound or positive displacement type, to the approval of the authorities.
- .2 Meter shall be suitable for future installation of remote reader.
- .3 Water meter to read in cubic meters (m3) and U.S. gallons per minute (USGPM).

2.2 **BACKFLOW PREVENTERS**

- .1 Double check valve assembly (DCVA)
 - .1 Two positive-seating check modules with captured springs and rubber seat discs, replaceable check module seats and seat discs, lead-free cast copper silicon alloy body, two resilient seated isolation valves and four top mounted, resilient seated test cocks. Service of all internal components through a single access cover secured with stainless steel bolts. The assembly shall meet the requirements of CSA B64.5, ASSE Std. 1015 and AWWA C510.
 - .2 Maximum working pressure: 1206 kPa
- .2 Reduced pressure (RP) backflow preventer assembly
 - .1 Internal pressure differential relief valve located in a zone between two positive seating check modules with captured springs and silicone seat discs, replaceable seats and seat discs in both check modules and the relief valve, lead-free cast copper silicon alloy body and shutoffs, two resilient seated isolation valves, four resilient seated test cocks and air gap drain fitting. There shall be no threads or screws in the waterway exposed to line fluids. Service of all internal components shall be through a single access cover secured with stainless steel bolts. The assembly shall meet the requirements of CSA B64.4, ASSE Std. 1013 and AWWA C511.
 - .2 Maximum working pressure: 1206 kPa
- .3 Standard of Acceptance
 - .1 Beeco
 - .2 Watts
 - .3 Febco
 - .4 Ames
 - .5 Wilkins

2.3 **HANGERS AND SUPPORTS**

- .1 In accordance with Section 20 05 29 - Bases, Hangers and Supports.

2.4 **THERMAL INSULATION**

- .1 In accordance with Section 20 07 00 - Mechanical Insulation.

2.5 **IDENTIFICATION FOR EQUIPMENT, VALVES AND PIPING**

- .1 In accordance with Section 20 05 53 - Mechanical Identification

2.6 **GAUGES**

- .1 In accordance with Section 20 05 19 - Meters and Gauges

2.7 **ELECTRIC MOTORS**

- .1 In accordance with Section 20 05 12 - Common Motor Requirements

2.8 **ELECTRIC WIRING**

- .1 In accordance with Section 20 05 13 - Common Wiring Requirements

2.9 **EXPANSION COMPENSATION**

- .1 In accordance with Section 20 05 16 - Expansion Control

2.10 **VIBRATION ISOLATION**

- .1 In accordance with Section 20 05 48 - Vibration Control

2.11 **SEISMIC RESTRAINING**

- .1 In accordance with Section 20 05 49 - Seismic Control

2.12 **ESCUTCHEONS**

- .1 Escutcheons shall be satin-finish, corrosion-resisting steel, polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Obtain Interior Designer's approval for the required finish. Escutcheons shall be either one-piece or split-pattern, held in place by internal spring tension or setscrew.

2.13 **FLASHING**

- .1 Flashing for through-roof penetration and other waterproofed areas:
 - .1 Manufactured from composite material;
 - .2 Minimum dimensions of 500 mm x 500 mm;
 - .3 With sleeve extending at least 150 mm above roof.

PART - 3 EXECUTION

3.1 **GENERAL**

- .1 Execute the Plumbing Work in accordance with requirements specified in the various Sections of Division 22 – Plumbing.
- .2 Install complete plumbing, drainage and vent piping in accordance with the municipal, provincial and federal plumbing codes, standard trade practice and as specified in this Specification.

- .3 Arrange piping within pipe spaces behind washroom fixtures to allow unimpeded access to piping for servicing.
- .4 Locate mains, risers and runouts concealed behind partition walls or above ceilings, except in service rooms and access spaces where piping shall be exposed.
- .5 Anchor, guide and support vertical and horizontal runs of piping to resist dead load and absorb thrust.
- .6 Generally, small diameter pipe runs from drips and drains, water cooling, and other services are not shown but must be provided.
- .7 If required by the authorities having jurisdiction, provide building traps complete with cleanout and fresh air inlet with special grilles as approved by the Consultant.
- .8 Air handling equipment drains
 - .1 Provide drains for fan casings, air handling equipment, and low points in ductwork and plenums in locations and in arrangements as indicated on the Drawings, or as required by the layout of the equipment and services.
 - .2 Drain piping shall be of material and type as specified in Section 22 13 16 - Sanitary Waste and Vent Piping, with deep seal trap.
 - .3 Install trap seal equivalent to not less than 1½ times the maximum static pressure in the air system at the drain point.
- .9 Electrical interconnection of controls and instruments: is generally not shown but shall be provided. This includes interconnection of sensors, transmitters, transducers, control devices, control and instrumentation panels, alarms, instruments and computer workstations.
- .10 Many plumbing systems interface with the HVAC control systems. Refer to Section 23 09 00 - Instrumentation and Control for HVAC and for the Division 25 – Building Automation Specifications for further details.

3.2 **PLUMBING DEMOLITION**

- .1 Refer to Division 01 – General Requirements, Division 02 – Existing Conditions and Section 20 00 23 – Work in Existing Buildings for general demolition requirements and procedures.
- .2 Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed.
 - .1 Piping to be removed: remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - .2 Piping to be abandoned in place: drain piping and cap or plug piping with same or compatible piping material.
 - .3 Equipment to be removed: disconnect and cap services and remove equipment.
 - .4 Equipment to be removed and reinstalled: disconnect and cap services; remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 - .5 Equipment to be removed and salvaged: disconnect and cap services; remove equipment and deliver to the Owner.

- .3 If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.3 **TRENCHING, BEDDING AND BACKFILL**

- .1 Extent
 - .1 For buried services inside building and up to 1.5m outside building wall.
- .2 Trench depth
 - .1 To (75mm)(150mm) below the correct elevation and slope established for the bottom of the pipe.
- .3 Bedding
 - .1 Refill the bottom elevation of the trench with hand-placed bedding materials.
 - .2 Thoroughly compact to the approval of the Consultant.
 - .3 At pipe hubs or couplings, remove bedding in the bottom of the trench as necessary to provide for even and constant support for each length of pipe.
- .4 Shoring
 - .1 Provide adequate shoring, bracing and sheeting in pipe trenches.
 - .2 Place barriers and temporary crossings as necessary to ensure support, safety and protection at all times.
- .5 Unstable soil conditions
 - .1 When encountered, advise the Consultant.
 - .2 Excavate pipe trenches to a depth as directed by the Consultant and then backfill to the correct grade with bedding material.
- .6 Backfill
 - .1 Where joints occur, do not backfill until joint testing has been approved by Consultant.
 - .2 Hand place backfill to 300mm above the top of the pipe in 100mm layers taking particular care to place and compact the backfill simultaneously on both sides of the pipe.
 - .3 From 300mm above the top of the pipe backfill in 150mm layers and mechanically compact.
- .7 Keep excavations dry at all times.
- .8 Compaction
 - .1 Mechanically tamp and thoroughly compact each layer of new granular bedding and backfill material to 95 percent Modified Proctor Density.
- .9 In fill areas, allow a minimum clearance of 100mm on all sides of the pipe passing under or through building grade beams to prevent possible damage from settling of building. If a greater settlement can be expected, increase the clearance to prevent possible damage.
- .10 Remove and dispose of excess excavated material off-site.

3.4 **SPECIAL WATER AND WASTE CONNECTIONS**

- .1 Provide hot and cold water, waste and vent connections to all equipment requiring plumbing services but not supplied under the scope of the Division 21, 22, 23 or 25 Contract.
- .2 Provide backflow prevention devices including vacuum breakers, backflow preventers and hose bibs on equipment and fixture connections without adequate air gap per CAN/CSA B64 requirements, based on the severity of the hazard level represented by the equipment or fixture.
- .3 Where hot and cold water supply pipes connect to a combination supply fitting with a shut-off valve on discharge; or where a combination supply fitting is equipped with a manual or thermostatic mixing valve, equip the hot and cold water supply pipes with composition disc swing check fittings.
- .4 Provide a shut-off valve on each service line close to the apparatus and a brass trap complete with cleanout on the waste connection unless the waste discharges directly into a floor drain or funnel drain.
- .5 Where specific sizes are not shown, valves and final connections to the equipment shall be one pipe size larger than the equipment tapping size, the trap and drain pipe shall be one pipe size larger than the waste connection on the equipment.
- .6 For equipment marked as not in Mechanical Contract, do not make final connections but provide required plumbing services.
- .7 For equipment marked as supplied by the Owner, make final connections and provide all necessary accessories including traps and screwdriver stops.

3.5 **CONNECTIONS TO LABORATORY FURNITURE**

- .1 Laboratory furniture will be set in place under the scope of the Division 11 – Equipment Contract, with furniture predrilled for service installation and with sinks fitted with tailpieces. Appurtenances (faucets, gas cocks, air and vacuum outlets) will be supplied per the laboratory equipment schedule.
- .2 Install appurtenances and connect to plumbing services providing the required piping, fittings, valves and traps. Provide shutoff valve on each service branch, except on waste, in accessible location above the floor or inside the furniture.
- .3 Install all services concealed in the furniture; provide the required supports and hangers.
- .4 Provide laboratory drainage piping and fittings, up to main drain or sanitary stack. Fit sink traps with removable dips for cleaning. Vent piping to be of the same material as the drainage piping.

3.6 **FLASHING**

- .1 Provide flashing for piping penetrations through roofs and other waterproofed areas. Leave flashing ready for the Contractor performing the roofing Work to make watertight connections.

3.7 **VENT TERMINATION (VTR)**

- .1 Fit vents passing through the roof with vent stack sleeves terminating not less than 150 mm above the finished roof level and above the flood level of the roof. Locate VTRs 900 mm above and 3500 mm horizontally from any air intake, door or operable window.

3.8 ESCUTCHEONS

- .1 Install escutcheons at finished surfaces where bare or insulated exposed piping passes through floors, walls, or ceilings in finished areas. Escutcheons shall be fastened securely to pipe or pipe covering. In wet or humid areas such as washrooms, housekeeping rooms, pool areas, seal pipe penetrations through unrated walls behind escutcheons using plumber's putty.

3.9 PAINTING

- .1 Coordinate the finish paint of plumbing piping with the Contractor performing the Work of Section 09 91 00 – Painting as follows:
 - .1 Concealed from view: not painted.
 - .2 Exposed to view: bare, uninsulated cast iron pipe and associated hangers exposed to view in finished areas shall be painted with one coat approved rust inhibiting primer.

3.10 TESTING

- .1 Execute plumbing systems and equipment tests in accordance with the requirements of municipal, provincial and federal plumbing codes, and as described under Section 22 08 00 - Commissioning of Plumbing. For testing procedures of specialty systems refer to the respective Sections of the Division 22 - Plumbing Specifications.
- .2 Furnish pumps, gauges and other equipment required to complete test.
- .3 Charge system with water only when there is no possibility of freeze-up.
- .4 Perform tests after plumbing pumps have been tested.
- .5 Prior to testing, ensure that shut-off valves, pressure reducing valves, balancing valves, backflow prevention and control devices are functioning.
- .6 Adjust setting of pressure reducing stations to the required setpoints.
- .7 Check horizontal pipe with an accurate level for any alterations in pitch. Inspect laterals, cross arms, and eliminate pockets. Correct any cases of water hammer.
- .8 Execute tests in the presence of the Consultant and Owner's authorized representative.
- .9 Test all water lines hydrostatically at 1-1/2 times the working pressure but at not less than 1,380 kPa, for a period of not less than four (4) hours without any drop in pressure. Do testing before piping is buried or furred in and before pressure sensitive devices are installed in the pipework.
- .10 Testing of sanitary drain, storm drain and vent piping:
 - .1 Securely close all openings on pipe ends throughout the systems by means of approved plugs and fill the entire piping system, including stacks, branches to fixtures and all horizontal runs with water, up to the highest opening. Let this water stand at this level for not less than two (2) hours. Perform another test after the fixtures are set, connected, and connections are made to all equipment. Test by running water into all pipes, fixtures, traps, and apparatus in order to detect any imperfect material or workmanship. Where it is impossible to test the whole system at one time, divide into parts. Perform a smoke or ball test or any other test required by authorities having jurisdiction.

- .11 Promptly repair defects which develop during tests, and then re-test system to complete satisfaction of authorized inspectors. Repairs to piping shall be made with new materials. Caulking of screwed joints or holes is not acceptable.
- .12 Connect fixtures and faucets with integral strainer only after the initial flushing out has been completed.

3.11 **FLUSHING AND STERILIZATION**

- .1 Inspect the systems, and remove any heavy debris and excessive oil and dirt.
- .2 Flush all completed systems with clear water at the highest obtainable pressure and velocity.
- .3 During flushing and cleaning, maintain all isolating and control valves in the open position.
- .4 Provide adequate personnel to monitor the flushing operation and to ensure that drain lines are unobstructed in order to prevent flooding of the building. The Division 22 – Plumbing Contractor shall be responsible for any flood damage resulting from flushing of the system.
- .5 Sterilize water piping connected to municipal water supply in accordance with local municipal requirements.
- .6 Flush each system after completion by allowing full flow of water through the system for a period of 15 minutes or longer when directed by the Consultant.
- .7 After the system flushing has been completed, drain down the system to remove the flushing water.
- .8 Adjust the hot water system for uniform circulation. Adjust flushing devices and automatic control systems for proper operation according to manufacturer's instructions.
- .9 After the flushing of the system has been completed, perform a 24-hour contact sterilization treatment by treating the water with an initial concentration of 50 mg/L of chlorine as per AWWA C651 requirements. At the end of the 24-hour period, arrange and pay for laboratory testing of the water samples taken from the newly disinfected pipe. If the residual chlorine level is below 25 mg/L, drain down the water and repeat the disinfection process for an additional 24 hours with lab testing until a residual chlorine level of minimum 25 mg/L is obtained.
- .10 Notify the Consultant at least two (2) days in advance of the date when the disinfecting operations are proposed, so that the Consultant may witness the procedure.
- .11 After the sterilization period has elapsed, flush system to reduce the chlorine content to an acceptable level, for not less than 30 minutes.
- .12 Remove and clean strainer screens after flushing operation has been completed. Repeat two weeks after the initial start-up of the plumbing systems, and again within two weeks after Substantial Completion.

3.12 **COMPLETION**

- .1 Provide chemical and bacteriological test data to prove that sterilization has been carried out. Provide written certification to the Owner that the plumbing systems were installed, flushed and tested in accordance with appropriate codes, approved plans and calculations, and confirming the following:
 - .1 Water pressure test performed and plumbing systems are leak free.

.2 Plumbing inspections completed. Issue the necessary certificates.

3.13

DEMONSTRATION

- .1 Prior to final acceptance of the Plumbing systems, the Division 22 - Plumbing Contractor shall provide operational training in all aspects of these systems to the Owner's key personnel. Training shall include emergency procedures, safety requirements, and demonstration of the systems, including all interfaces with the Control and Building Automation Systems.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
 - .2 Furnish and install general duty valves for plumbing systems, including shut-off and balancing services, and check stops.
- .2 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Sections 20 00 13 – Mechanical General Provisions and Section 22 05 00 - Common Works for Plumbing shall apply to and govern this Section.

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for plumbing valves.

1.3 REFERENCE STANDARDS

- .1 Manufacturers' Standardization Society of Valve and Fittings Industry (MSS) SP-70, 71, 80, 85, 110.
- .2 ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
- .3 ASTM A216 - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service.
- .4 ASTM B124 - Standard Specification for Copper and Copper Alloy Forging Rod, Bar, and Shapes.
- .5 ASTM A351/A351M - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts
- .6 ASTM A536 - Standard Specification for Ductile Iron Castings
- .7 ANSI/ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250
- .8 ANSI/ASME B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings, Classes 150 and 300
- .9 NSF/ANSI 61 - Drinking Water System Components

1.4 QUALITY ASSURANCE

- .1 Valves shall be rated for the maximum system working pressure to which they are exposed but shall not be rated at less than 1034 kPa.
- .2 Seats and seals used in potable water systems shall be ANSI classified in accordance with NSF/ANSI 61.

- .3 Standard of Acceptance
 - .1 Plumbing Valves
 - .1 Toyo
 - .2 Kitz
 - .3 Mueller
 - .4 Crane (not for ball valves)
 - .5 Nibco
 - .6 Apollo
 - .7 MAS
 - .8 Victaulic
 - .9 Jenkins (not for ball valves)
 - .10 FlowTek
 - .11 Apco
 - .12 Bray
 - .13 Bonney Forge
 - .14 Beric
 - .15 Powell
 - .16 Moygro
 - .17 WKM
 - .2 Circuit Balancing Valves
 - .1 S.A. Armstrong
 - .2 Xylem
 - .3 Nexus
 - .4 Victaulic
 - .5 Grundfos
 - .6 Hays
 - .7 Oventrop

PART - 2 PRODUCTS

2.1 PLUMBING VALVES

- .1 Approvals
 - .1 All valves shall have a CRN registration number and be certified to NSF/ANSI 61 for use in drinking water.
- .2 Selection criteria
 - .1 For shut-off or isolating service, valves to be:
 - .1 Gate;

- .2 Butterfly; or
 - .3 Ball.
- .2 For flow balancing and shut-off service valves to be:
 - .1 Double regulating
- .3 At the discharge of pumps check valves to be silent or spring assisted or combination check and flow control valves, or Triple Duty Valves.
- .4 On mains and risers, drain valves to be selected as follows
 - .1 On mains 100mm and under
 - .1 20mm brass threaded ball valve of appropriate pressure rating with hose thread, cap and chain.
 - .2 On mains 150mm and over
 - .1 25mm brass threaded ball valve of appropriate pressure rating with hose thread, cap and chain.
- .3 Gate valves up to 50mm
 - .1 Class 150 or Class 300, bronze body, solid wedge bronze disc, rising stem, screw in or union bonnet, soldered or threaded, to MSS SP-80.
 - .2 Class 150, Class 300 or Class 600 stainless steel Type 316L body, bolted bonnet, OS&Y, stainless steel trim, PTFE packing, socket weld, to ASTM A351/A351M.
- .4 Gate valves 65mm and over
 - .1 Class 125 or Class 250, Class B, fusion bonded epoxy coated cast iron body with flat face flanges, solid bronze wedge disc, bronze seat rings, rising stem, OS & Y, bolted bonnet, flanged or grooved, to ASTM A126 and MSS SP-70.
 - .2 Class 150, Class 300 or Class 600 stainless steel Type 316L body, bolted bonnet, OS&Y, stainless steel trim, graphite packing, flanged, to ASTM A351/A351M.
- .5 Globe valves up to 50mm
 - .1 300 CWP, bronze body, renewable composition PTFE disc, threaded over bonnet, lock shield handles, soldered, to MSS SP-80.
 - .2 Class 150 or Class 300 stainless steel Type 316L body, bolted bonnet, OS&Y, stainless steel trim, PTFE packing, socket weld, to ASTM A351/A351M.
- .6 Globe valves 65mm and over
 - .1 Class 150, bronze body, renewable composition PTFE disc, union bonnet, lock shield handles, threaded, to MSS SP-80.
 - .2 Class 150 or Class 300 stainless steel Type 316L body, bolted bonnet, OS&Y, stainless steel trim, graphite packing, flanged, to ASTM A351/A351M.
- .7 Ball Valves up to 50mm
 - .1 1034 kPa, two-piece bronze body, full port, solid chrome-plated bronze ball, stainless steel stem, PTFE seats, soldered, grooved or threaded, to ASTM B124.
 - .2 1034 kPa, 316L stainless steel body, full port, TFE seats, Teflon packing, stainless steel ball and stem, lever handle, socket weld, to ASTM A351/A351M.

- .8 Ball Valves 65mm and over
 - .1 1034 kPa, 316L stainless steel body, full port, PTFE seats, PTFE packing, 316L stainless steel ball and stem, locking lever handle or gear operated, flanged, to ASTM A351/A351M.
- .9 Butterfly valves 65mm and over, lug style
 - .1 Class 150 or Class 300, stainless steel Type 316L body, 17-4 stainless steel shaft and disc, RPTFE seats and packing. Valve shall have bubble tight shut-off to the full rating of the valve when downstream flange is removed. Locking lever operator up to 100mm; manual gear operator 150mm and over. To ASTM A351/A351M.
- .10 Butterfly valves 50mm to 300mm, grooved joint style
 - .1 Rated for 2068 kPa, fusion bonded epoxy coated cast iron body, grade E dual seal disc, lever handle up to 75mm and gear operators 100mm and over
- .11 Swing check valves up to 50mm
 - .1 Class 125 or Class 250, bronze body, bronze swing disc, regrindable seat, screw-in cap, soldered or threaded, to MSS SP-80.
 - .2 Class 150 or Class 300 stainless steel Type 316L body, bolted cover, stainless steel trim, socket weld, to ASTM A351/A351M.
- .12 Swing check valves 65mm and over, flanged
 - .1 Class 125 or Class 250, fusion bonded epoxy coated cast iron body with flat faced flanges, renewable bronze seat rings, bronze faced iron or bronze disc, bolted cap, to ASTM A216 class B and MSS SP-71.
 - .2 Class 150 or Class 300 stainless steel Type 316L body, bolted cover, stainless steel trim, graphite gasket, to ASTM A351/A351M.
- .13 Swing check valves 65mm and over, grooved joint style
 - .1 Rated up to 2517 kPa, to ASTM A-536, Grade 65-45-12, fusion bonded epoxy coated ductile iron body, non-slam aluminum bronze or elastomer coated ductile iron disc, stainless steel spring and shaft, PPS coated or welded-in nickel seat.
- .14 Wafer check valves 65mm and over, flanged
 - .1 Class 150 or Class 300 stainless steel Type 316L body, 316L stainless steel disc and trim, to ASTM A351/A351M.
- .15 Double door check valves 65mm and over, flanged
 - .1 Class 150 or Class 300 stainless steel Type 316L body, 316L stainless steel disc and trim, to ASTM A351/A351M.
- .16 Circuit balancing valves up to 50mm, soldered
 - .1 Brass body, stem and plug; high-strength resin hand wheel; 'Y' pattern; equal percentage globe-style with precision machined venturi built into the valve body; two threaded brass metering ports with check valves and gasketed caps located on the inlet side of the valve.
- .17 Circuit balancing valves 65mm and over
 - .1 Fusion bonded epoxy coated ductile or cast iron body with grooved, flanged or screwed ends as appropriate; metering ports with EPT check valves; 'Y' pattern modified equal percentage globe valve.

2.2 **VALVE IDENTIFICATION**

- .1 In accordance with Section 20 05 53 - Mechanical Identification.

PART - 3 EXECUTION

3.1 **GENERAL**

- .1 Valves, except circuit balancing valves, shall be the same size as the pipe in which installed.
- .2 Valves shall be located in such a manner that the top works, operators, and bonnets may be easily removed.
- .3 Install valves in upright position with stem above horizontal or as per manufacturer's instructions.
- .4 Arrange valve hand wheels and operating levers to be accessible.
- .5 Remove internal parts of valves before soldering, welding or brazing pipe to valve body.
- .6 Provide shut-off valves on all mains and sub-mains, and on each riser to allow for complete control, shut off and drainage the system.
- .7 Where two or more branches connect to a domestic hot water recirculating line, provide each return branch with a globe or circuit balancing valve.
- .8 Provide all necessary drips and drains to completely empty the system.
- .9 Install chain operators and chains on valves 1.8m or higher above floor. Keep chains out of working areas or ceilings. Provide chain wheels complete with guide, rustproof chain and of size recommended by the valve manufacturer for proper operation of the valve.
- .10 Install double regulating valves with five pipe diameters of straight pipe on inlet side and two pipe diameters on outlet side.
- .11 Install triple duty or throttling valves where shown in pump discharge piping with ten pipe diameters of straight pipe on the inlet side and two pipe diameters on outlet side.

3.2 **GATE VALVES**

- .1 Provide gate valves:
 - .1 Where indicated on the Drawings and in the Specification.
 - .2 On all branch lines.
 - .3 As isolation of each floor for all services.
 - .4 At the base of all risers.

3.3 **GLOBE VALVES**

- .1 Provide globe and/or eccentric plug valves:
 - .1 Where indicated on the Drawings and in the Specification.
 - .2 On all bypass systems.
 - .3 Where required for throttling control.

- .2 For balancing of domestic hot water recirculation system, provide thermostatic flow regulators in lieu of throttling valves. Refer to Section 22 11 19 – Domestic Water Piping Specialties.

3.4 **CHECK VALVES**

- .1 Provide check valves:
 - .1 Where indicated on the Drawings and in the Specification.
 - .2 On the discharge of all pumps.
 - .3 On the discharge of multiple equipment.

3.5 **BALL VALVES**

- .1 Install ball valves in the following locations:
 - .1 Where indicated on the Drawings and in the Specification.
 - .2 At each single plumbing fixture.
 - .3 At each single item of equipment.
- .2 For pipe sizes 50mm and smaller, ball valves may be substituted for gate and globe valves.

3.6 **CIRCUIT BALANCING VALVES**

- .1 Provide ball or globe valves for throttling or controlling flow where indicated on the Drawings and in the Specification except where circuit balancing valves are specified.
- .2 Provide circuit balancing valves as follows:
 - .1 Where indicated on the Drawings and in the Specification.
 - .2 In domestic hot water recirculation piping connections to supply mains.
- .3 Do not locate handwheel or measuring ports facing downward to prevent build-up of sedimentation.
- .4 Position handwheel scale and ports for easy access.
- .5 Install balancing valves with a minimum five pipe diameters of straight pipe on the inlet side. Maintain two pipe diameters downstream of any balancing valves free of any fitting.
- .6 Insulate balancing valves with preformed insulation provided by valve manufacturer.
- .7 Calibrated balancing valves and automatic flow-control valves shall not be used on equipment on pumps with variable speed control.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 22 05 00 - Common Works for Plumbing shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 Furnish and install cleanouts for buried and above grade sanitary and storm drain pipes.

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for cleanouts. Shop drawings shall indicate materials, finishes, method of anchorage, dimensions, construction and assembly details and accessories.

1.3 REFERENCE STANDARDS

- .1 CSA B79 - Commercial and Residential Drains and Cleanouts

PART - 2 PRODUCTS

2.1 CLEANOUTS

- .1 Floor cleanouts shall conform to CSA B79.
- .2 Cleanouts shall be the same size as the pipe up to 100 mm size, and not less than 100 mm size for larger pipe diameter. Cleanouts shall be easily accessible, gastight and watertight. Maintain a minimum clearance of 600 mm for clearing a clogged drain line.
- .3 Flush floor type: cast iron body and cast iron ferrule with inside caulked or spigot connection outlet, seal plug, nickel brass frame and cover suitable for floor finish. In finished areas provide nickel bronze top and internal seal plug. Cleanout shall be vertically adjustable for a minimum of 50 mm and include clamping collars when used on floors with a waterproof membrane.
 - .1 Resilient tile and sheet finish: round flange top with scoriated cover.
 - .2 Ceramic tile finish: square flange top with scoriated cover.
 - .3 Poured finish: round, wide-flange top with scoriated cover.
 - .4 Carpet finish: round top with standard top tapped for carpet-marker bolt.
 - .5 Terrazzo finish: round top with recessed-for-terrazzo cover.
 - .6 Quarry tile finish: square, heavy-duty top with heavy-duty scoriated cover.

- .7 Concrete finish (unfinished areas): heavy round frame, satin-bronze, scoriated tractor top, ANSI heavy duty load class.
- .4 In all areas with seamless plastic or linoleum flooring, and in terrazzo finish provide special flanges. These flanges shall be 100mm larger in diameter than the drain or cleanout top of sleeve diameter, and located approximately 5mm below the top flanges to be of the same material as the drain or cleanout finish.
- .5 Floating floors: isolation cleanouts with a lower and an upper flashing collar, flashing clamps with seepage openings, and adjustable ferrule with 100 mm diameter bronze top. Ferrule shall be tapped for cleanout plug. Seal ferrule to lower clamping collar with press-fit neoprene gasket. Seal cleanout plug with neoprene gasket.
- .6 Cast iron piping in exposed location or in accessible pipe chases: cast iron body with straight threaded, coated plug with a tapered shoulder that seats against a lead seal.
- .7 Copper stack piping in exposed locations or in accessible pipe chases: bronze cleanout tee, bronze ferrule and cover, secured to ferrule by bronze cap screws.
- .8 Urinal cleanout - wall access cleanout with bronze plug, stainless steel bolt and wingnut, and 100mm diameter polished stainless steel secured cover.
- .9 Access cover for concealed cleanouts:
 - .1 Public areas: type to suit wall surface and construction in accordance with Section 20 00 19 - Basic Materials and Methods.
 - .2 Service spaces:
 - .1 Face-of-wall access cover for openings in tile, masonry and plaster walls round, chrome plated bronze frame and secured cover.
 - .2 Flush-with-wall access cover for plaster and wet wall constructions: round, chrome plated bronze frame and secured cover
 - .3 Cover for cleanouts at the base of vertical sanitary stacks or rainwater leaders: bolted type, neoprene gasket, and brass cap screws or bolt studs.
- .10 Standard of Acceptance
 - .1 Watts
 - .2 Zurn
 - .3 MIFAB
 - .4 J.R.Smith
 - .5 Blücher

PART - 3 EXECUTION

3.1 INSTALLATION

- .1 Provide cleanouts on all drainage and waste systems where shown on the Drawings and as required by the applicable provincial or federal plumbing code, including the following:
 - .1 Where there is a change of direction of 45 degrees or more.
 - .2 Not more than 15m apart on straight runs for pipes 100mm and below; 30m for pipes 150mm and greater.

- .3 On sanitary drain stacks serving kitchen sinks, at every second floor.
- .4 At the base of every soil stack and rainwater leader.
- .5 Where main drains leave the building.
- .6 On footing drains where shown on the Drawings.
- .2 Bring cleanouts from below floor up to finished floor with a 'Y' and 1/8th bend. Locate all cleanouts for easy access and in areas of least traffic, as directed by the Consultant.
- .3 Cleanouts in furred ceiling spaces shall be extended up through the floor slab above, except where the Consultant gives specific approval to its location in the ceiling space.
- .4 Cleanouts on drains outside the building shall be brought up to grade with a 100mm 'Y' and 1/8th bend in medium weight soil pipe with solid brass recess plug-in top. Provide the necessary support for the soil pipe and set cleanout flush with grade in a 300mm by 300mm by 150mm concrete pad.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 22 05 00 - Common Works for Plumbing shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 This Section includes requirements for commissioning the plumbing systems, subsystems and equipment. This Section supplements the general requirements specified under Section 20 08 00 - Commissioning Requirements.

1.2 COMMISSIONED SYSTEMS

- .1 Automatic control related to plumbing systems, not covered under the Work of Division 25 – Building Automation;
- .2 Domestic hot water generation systems;
- .3 Domestic water distribution systems;
- .4 Non-potable water distribution systems;
- .5 Laboratory and process drainage treatment systems;

PART - 2 PRODUCTS

2.1 NOT APPLICABLE.

PART - 3 EXECUTION

3.1 TESTING OF PLUMBING SYSTEMS

- .1 Piping systems (applicable to domestic and non-potable water):
 - .1 Test all piping systems in accordance with all applicable provincial and federal plumbing codes and in accordance with Division 22 requirements. Remove fixtures, appliances, devices, vents and gauges and temporarily plug connections as required. Provide temporary by-pass when required. Protect equipment not capable of withstanding test pressure during testing.
 - .2 After completion of the testing, rough balance the water systems and ensure all systems are operating approximately at design conditions. Adjust the circuits by means of the balancing valves.
 - .3 Where multiple branch lines are installed, the flow in these shall be balanced to ensure water flow to all equipment.
 - .4 All tests for the systems shall be witnessed. Complete the testing forms and forward copies of the tests reports to the Consultant and the Commissioning Authority.

- .5 Coordinate with the TAB Contractor to ensure all necessary valves required for balancing the systems are installed. Notify the Consultant and the Commissioning Authority in writing that this co-ordination has taken place before installation begins.
- .6 Ensure that access is provided to all valves and equipment that requires servicing.
- .7 Operate all equipment at design conditions and trim impellers to provide the required conditions. Final verification of balancing shall be coordinated by the TAB Contractor and witnessed/verified by the Commissioning Authority.
- .8 Make qualified staff available as required by TAB Contractor, to correct any deficiency in the mechanical systems which prevents TAB Contractor from balancing the system.
- .9 Provide copies of all shop drawings requested by TAB Contractor.
- .2 TAB Contractor's balancing of plumbing systems:
 - .1 TAB Contractor shall balance the plumbing systems in accordance with Section 20 05 93 - Testing, Adjusting and Balancing.
 - .2 Coordinate with the TAB Contractor and provide assistance during the balancing process.
 - .3 Balancing shall not begin until all point-to-point and BAS component testing has been satisfactorily completed.
 - .4 TAB Contractor shall balance the plumbing system to ensure all equipment and systems are operating to design conditions. Adjust the circuits by means of the balancing valves and record their positions.
 - .5 TAB Contractor shall coordinate with the Mechanical Contractor to ensure all necessary devices and valves for control and balancing are installed in all necessary locations. Notify the Consultant and the Commissioning Authority in writing that this coordination has taken place. Include in this letter any recommendations made regarding valves, locations, installation.
 - .6 TAB Contractor shall not disconnect any direct digital control (DDC) device after it has been calibrated. BAS Contractor shall make all necessary adjustments through the BAS as requested by TAB Contractor.
 - .7 TAB Contractor shall coordinate with the BAS Contractor and receive instruction regarding set-up, calibration and operation of the BAS as it applies to the TAB Contractor work. The BAS Contractor shall provide the TAB Contractor with a portable operator's terminal for this work.
 - .8 The TAB Contractor is responsible for balancing the systems to obtain the design conditions and shall repeat the balancing until the required conditions have been met.
 - .9 At time of final inspection, recheck, in presence of the Consultant and the Commissioning Authority, random selections of data recorded in the certified report. Points or areas of recheck shall be selected by the Commissioning Authority and shall be a maximum of 50% of the report data.
 - .10 A measured deviation of more than 10% between the verification reading and the reported data will be considered as failing the verification procedure.
 - .11 A failure of more than 10% of the selected verification readings will be considered unacceptable and will result in rejection of the report.

- .12 In the event the report is rejected, rebalance all systems, submit new certified reports and perform a re-inspection, all at no additional cost to Owner.
- .13 Submit a copy of the final testing and balancing report to Commissioning Authority for review.
- .14 Include in the plumbing balancing report: types, serial numbers, dates, and calibration of all instruments used in during the TAB work.
- .3 Domestic hot water systems:
 - .1 The water heaters, heat exchangers and pumps shall be inspected and tested by the manufacturers' technicians. The technicians shall enter the test results on forms provided by manufacturers. The Commissioning Authority shall witness the final operational test.
 - .2 The technicians shall verify that the water heaters, heat exchangers and pumps have been installed according to manufacturers' recommendations, shop drawings and the Specification.
 - .3 Tests shall include the verification of safeties and controls.
- .4 Testing of plumbing specialty equipment and systems:
 - .1 Start-up and test procedures must be consistent with manufacturer's recommendations contained in the Operating and Maintenance Manual.
 - .2 The start-up report shall record all observations made during the start-up procedures including problems and their resolutions.
 - .3 Retain the services of the manufacturers' technicians to test the equipment and associated systems. Technicians shall record the results of the tests on the testing forms. The tests shall be witnessed by the Commissioning Authority. When the tests have been completed with satisfactory results, the technicians and the witnessing authority shall sign the forms. A copy of the forms shall be forwarded to the Consultant and the Commissioning Authority. The original shall be inserted into the Systems Operating Manual.
 - .4 Should equipment or systems fail a test, the test shall be repeated after repairs or adjustments have been made. The additional tests shall be witnessed by the Commissioning Authority.
 - .5 Tests which have not been witnessed shall not be accepted and shall be repeated.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 22 05 00 - Common Works for Plumbing shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 Design, supply, install, test and adjust all local control and monitoring systems specified under the diverse Sections of Division 22 – Plumbing.

1.2 RELATED WORK

- .1 The following work is provided under other Sections or Divisions of the Work:
 - .1 Centralized control and monitoring of plumbing systems and equipment: Division 25 – Building Automation.
 - .2 Power supply to Plumbing equipment and to associated control equipment: Division 26 – Electrical.

1.3 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for all control components including technical specification data sheets for each system component, sequence of operation, wiring diagrams, control device arrangements, control device locations on floor plans to scale.

1.4 REFERENCE STANDARDS

- .1 Ontario Electrical Safety Code

1.5 QUALITY ASSURANCE

- .1 Provide electrical and electronic equipment which is CSA approved where such approval is required by the authorities having jurisdiction.
- .2 Conduit and wiring materials and methods shall be in strict accordance with the requirements of Division 26 – Electrical and the applicable provincial and federal electrical codes and standards.

PART - 2 PRODUCTS

2.1 CONTROL AND INTERLOCK WIRING

- .1 Provide control and interlock wiring for Plumbing equipment with local control components supplied loose. Refer to specific requirements under the diverse Sections of Division 22 – Plumbing.

- .2 Wiring shall be in accordance with the requirements of Section 20 05 13 – Common Wiring Requirements and Division 26 – Electrical.

2.2 **ELECTRICAL CONTROL DEVICES**

- .1 Switches
 - .1 Provide switches for system monitoring, safety and operational interlocks.
- .2 Relays
 - .1 Provide electric switching relays, ULC listed, as required and where indicated. Unless otherwise indicated, install relays within control cabinet. Provide line voltage or low voltage general purpose type relays unless heavy duty type are indicated.
- .3 Control cabinets and panels
 - .1 Provide control cabinets and panels with mounting brackets sized to house all local control devices.

PART - 3 EXECUTION

3.1 **INSTALLATION**

- .1 Install all components and make interconnections.
- .2 Connect electric control equipment and interlocks in accordance with the requirements of Division 26 – Electrical.
- .3 Provide a conduit for future wiring between the municipal water meter and the location of the remote reader.
- .4 Post a control diagram of each local control system, as prepared by manufacturer, on the wall of the associated equipment rooms.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 22 05 00 - Common Works for Plumbing shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 Furnish and install domestic hot, cold and recirculation water pipe systems, including connections to all fixtures and equipment, capped connections.

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for domestic hot, cold and recirculation water piping, fittings, joints and related material.

1.3 REFERENCE STANDARDS

- .1 ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings
- .2 ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs 60,000PSI Tensile Strength
- .3 ASTM A312 - Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
- .4 ASTM A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment and Systems
- .5 ASTM A403/A403M - Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
- .6 ASTM A563 - Standard Specification for Carbon and Alloy Steel Nuts
- .7 ASTM B32 - Specification for Solder Metal
- .8 ASTM B88 - Standard Specification for Seamless Copper Water Tube
- .9 ASTM B828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
- .10 ASTM D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
- .11 ASME B16.9 - Factory-Made Wrought Butt welding Fittings
- .12 ASME B16.11 - Forged Steel Fittings, Socket-Welding and Threaded
- .13 ASME B16.15 - Cast Bronze Threaded Fittings, Classes 125 and 250

- .14 ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings
- .15 ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
- .16 ASME B16.24 - Cast Copper Alloy Pipe Flanges and Flanged Fittings; Class 150, 300, 400, 600, 900, 1500, & 2500.
- .17 ASME B16.25 - Buttwelding Ends
- .18 ASME B16.28 - Wrought Steel Buttwelding Short Radius Elbows and Returns
- .19 AWS A5.8 - Brazing Filler Metal.
- .20 AWWA C111 / ANSI A21.11 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
- .21 ANSI/AWWA C220 - Standard for Stainless-Steel Pipe, 1/2 In. (13 mm) and Larger
- .22 ANSI/AWWA C226 - Stainless-Steel Fittings for Waterworks Service
- .23 ANSI/AWWA C606 - Grooved and Shouldered Joints
- .24 CSA B137.3 - Rigid Polyvinylchloride (PVC) Pipe and Fittings for Pressure Applications
- .25 CSA B242 - Groove and Shouldered Type Mechanical Couplings

PART - 2 PRODUCTS

2.1 COPPER PIPING AND FITTINGS

- .1 Above grade – up to 100mm
 - .1 Pipe: type “K” or “L” hard drawn copper tubing to ASTM B88. Tube shall have certification markings made by a testing agency accredited by the Standards Council of Canada.
 - .2 Fittings:
 - .1 Brass or bronze flanges and flanged fittings, Class 150 and 300 to ASME B16.24;
 - .2 Brass or bronze threaded fittings, Class 125 and 250 to ASME B16.15;
 - .3 Solder/brazed fittings: cast bronze to ASME B16.18 or wrought copper and bronze to ASME B16.22;
 - .4 65mm and larger: roll groove to CSA B242, full flow standard radius cast bronze fittings to ANSI/ASME B16.18 or wrought copper fittings to ANSI/ASME B16.22;
 - .1 Standard of Acceptance
 - .1 Victaulic
 - .2 Gruvlock
 - .3 Shurjoint
 - .3 Joints:
 - .1 Rubber gaskets, latex-free, 1.6mm thick: to ANSI/AWWA C111.
 - .2 Bolts, nuts, hex head and washers to ASTM A307, heavy series.

- .3 95/5 tin copper alloy lead free solder.
- .4 Brazed with phosphorus based filler metal
- .5 Teflon tape for threaded joints.
- .6 Grooved couplings: designed with angle bolt pads to provide rigid joint, complete with EPDM flush seal gasket. Gasket shall be classified in accordance with ANSI/NSF 61 for potable water service. Couplings shall be manufactured to copper-tube dimensions. Flaring of tube or fitting ends to accommodate IPS sized couplings is not permitted.
- .4 Unions: all bronze construction with ground joint; solder joint or screwed ends as required.
- .2 Buried – up to 75mm
 - .1 Pipe: type “K” soft annealed seamless copper tubing to ASTM B88. Tube shall have certification markings made by a testing agency accredited by the Standards Council of Canada.
 - .2 Fittings:
 - .1 Wrought copper and bronze solder/brazed fitting to ASME B16.22;
 - .2 Cold flared fittings.
 - .1 Standard of Acceptance
 - .1 Mueller
 - .3 Joints:
 - .1 95/5 tin copper alloy lead free solder.
 - .2 Brazed with phosphorus based filler metal

PART - 3 EXECUTION

3.1 GENERAL

- .1 Install plumbing systems in accordance with the requirements of the applicable provincial or federal plumbing code.
- .2 Use pipes which conform to CSA and ASTM standards.
- .3 Arrange piping within pipe spaces behind washroom fixtures to allow unimpeded access to piping for servicing.

3.2 PIPING INSTALLATION

- .1 Consider the piping layout shown on the Drawings as diagrammatic, indicating the general runs and connections, and that the piping may, or may not, in all parts be shown in true position.
- .2 Ream all piping and keep plugged to prevent entry of dirt.
- .3 Accurately cut pipe to the established measurements and work into place without springing or forcing. In any situation where bending of the pipe is required, use a standard pipe-bending template. Pipe hangers, supports, restraint of system piping and seismic bracing shall be installed accordance with Sections 20 05 29 - Bases, Hangers and Supports, and 20 05 49 - Seismic Control.

- .4 All fittings shall be of same material or equal in quality and thickness to the pipe to which they are connected.
- .5 Anchor, guide and laterally support vertical and horizontal piping to support filled weight and absorb thrust under operating conditions.
- .6 Erect piping so that gravity forces and thrust from changes in direction do not stress connections to apparatus.
- .7 Thoroughly clean the inside of fittings and outside of pipe with steel wool and coat with flux, before soldering or brazing any copper pipe work joint. Remove the working parts of valves before soldering or brazing commences, and replace after soldering or brazing is complete. Solder or braze joints with blow torch or oxy-acetylene flame.
- .8 Grooved joint piping systems shall be installed in accordance with the manufacturer's guidelines and recommendations. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Grooved end shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove. Use a torque wrench for installation if required for the joint type. Required torque shall be in accordance with the manufacturer's recommendations. A factory trained field representative shall provide on-site training to contractor's field personnel in the installation of grooved piping products. Factory trained representative shall periodically review the product installation. Remove and replace any improperly installed joints.
- .9 Install drain valves at low points in water piping systems and in valved run-outs from risers so that system or isolated parts of system can be drained.
- .10 Underground piping:
 - .1 Provide proper facilities for lowering sections of pipe into trenches. Do not drop or dump pipe, fittings, valves, or any other water line material into trenches. Lay bell-and-spigot pipe with the bell end pointing in the direction of laying. Grade the pipeline in straight lines; avoid the formation of dips and low points. Support pipe at proper elevation and grade. Lay pipe so that the full length of each section of pipe and each fitting will rest solidly on the pipe bedding; excavate recesses to accommodate bells, joints, and couplings. Provide anchors and supports where necessary for fastening work into place. Make proper provision for expansion and contraction of pipelines. Provide concrete thrust blocks for pipe anchorage.
 - .2 Make flanged joints up tight; avoid undue strain on flanges, fittings, valves, and other equipment and accessories. Align bolt holes for each flanged joint. Use full size bolts for the bolt holes; the use of undersized bolts to make up for misalignment of bolt holes or for any other purpose will not be permitted.
 - .3 Install a continuous length of AWG 10 gauge copper tracer wire for the full length of each run of non-metallic pipe. Attach the wire to the top of the pipe in such manner that it will not be displaced during construction operations.
- .11 Copper Pipe – above grade
 - .1 Provide dielectric unions or couplings at all connections between copper tubing and ferrous piping.
- .12 Copper Pipe - buried
 - .1 Provide dielectric unions at connection between cast iron or ductile iron water main and copper tubing.

- .2 When required by the municipal authority, provide 900 mm long copper gooseneck after the corporation stop at the connection to water the main. Connection at the water main shall be at 45 degrees and gooseneck shall have a minimum 160 mm radius bend.

3.3 **LINES, GRADES AND SLOPES**

- .1 Install piping in conformity with elevations and grades indicated on the Drawings using axis lines and bench marks provided under General Construction.
 - .1 Verify such axis lines and bench marks.
 - .2 Lay out work and be responsible for lines, elevations, measurements required for the installation of the Work.
- .2 Slopes:
 - .1 Install plumbing piping free of pockets and pitch to drain at low points in the pipe with valves installed as required for the drainage of the pipes.
- .3 Minimum slopes:
 - .1 Pitch domestic water pipes to low points so that all pipes may be completely drained.
- .4 Where pipe slope causes a pipe to rise to the top of the ceiling space, or fall to the bottom of structural members, ceiling space or defined service space, provide drain valve at the bottom of low point, and provide riser to increase the elevation of the piping.
- .5 Piping connections to mains
 - .1 Make down feed piping connections to horizontal supply and return mains at the bottom quadrant of the mains.

3.4 **JOINTS, UNIONS, FLANGES AND COUPLINGS**

- .1 Pipe joints
 - .1 Preparation
 - .1 Ream pipe ends and thoroughly clean all dirt, cuttings and foreign matter from pipe after cutting and threading.
 - .2 Thoroughly clean all fittings, valves and equipment before connections are made.
 - .3 Cut copper tubing with a tube cutter and clean the joining surfaces of the tubing and fitting with fine emery cloth. Wipe clean with a dry cloth.
 - .2 Ductile iron bell and spigot joints
 - .1 Make joints using neoprene compression type preformed gaskets equivalent to Bibby-Ste-Croix Bi-seal, and caulk in such a manner to produce a permanently water-tight joint.
 - .2 Cold caulking compound in cord form may also be used.
 - .3 Assemble preformed neoprene gaskets per manufacturer's instructions.
 - .3 Mechanical joints:
 - .1 Assemble mechanical joint on ductile iron pressure pipe with cast iron gland, rubber sealing gasket and high strength malleable iron bolts in accordance with the manufacturer's recommendations.

- .4 Threaded joints:
 - .1 Use Teflon tape or Masters metallic compound with the compound applied to the male threads only and particular care taken to prevent the compound from reaching the interior of the pipe or fittings.
- .5 Carbon steel welded joints:
 - .1 To ANSI B31.1 Section IX for welding.
 - .2 Fusion welded joints made by electric arc welding, gas metal arc welding, or oxy-acetylene gas welding.
 - .3 Unless more stringent methods of inspections are specified, the Consultant will visually inspect welded joints for fusion of metal, icicles, alignment. Remove any defects and remake defective joints to the Consultant's satisfaction.
- .6 Grooved end piping systems:
 - .1 Install couplings and fittings in accordance with manufacturer's instructions.
- .2 Unions and flanges
 - .1 Provide unions or flanges in the following locations:
 - .1 For by-passes around equipment or control devices in piping systems.
 - .2 At connections to equipment.
 - .3 Couplings in grooved end pipe systems may serve as disconnect points.
 - .2 If unions are concealed in walls, partitions or ceilings, build access thereto.
 - .3 Provide dielectric unions or isolating type companion flanges at all connections between copper tubing and ferrous piping.
 - .1 Brass body valves between ferrous piping and copper tubing is acceptable as a dielectric union.
 - .4 Flange joints
 - .1 Assemble joints with appropriate flanges, gaskets and bolting.
 - .2 Allow clearance between flange faces such that the connections can be gasketed and bolted tight without undue strain on the piping system, with flange faces parallel and bores concentric.
 - .3 Centre gaskets on the flange faces so as not to project into the bore.
 - .4 Lubricate bolts before assembly and provide 2 hardened steel washers under the head of each unit to assure uniform bolt stressing.
 - .5 Machine off raised face flanges when joining to a flat companion flange and use a full face gasket.
 - .6 Follow gasket manufacturer's instructions for correct bolting procedure.
 - .7 Use calibrated torque wrench and tighten bolts in recommended sequence in four equal steps to required final torque value.
- .3 Couplings
 - .1 Minimize couplings on runs of pipes.
 - .2 Do not use running couplings in any pipeline.

- .4 Eccentric reducer fittings
 - .1 To provide proper drainage or venting of the lines.
 - .2 At change of pipe sizes.
 - .3 At connections to equipment and control valves.
 - .4 Do not use bushings.
- .5 Change of direction
 - .1 Use standard pipe fittings.
 - .2 Use long radius welded steel elbows unless short radius elbows are specifically authorized by the Consultant.
 - .3 Mitered joints or field fabricated pipe bends are not permitted.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 22 05 00 - Common Works for Plumbing shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 Furnish and install domestic water piping specialties, including:
 - .1 Backflow preventers
 - .2 Make-up water feed valves
 - .3 Shock absorbers
 - .4 Pressure reducing valves
 - .5 Hose bibs and wall hydrants

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for all products. Shop drawings shall indicate materials, finishes, method of anchorage, dimensions, construction and assembly details and accessories.
 - .3 Submit a pressure reducing, pressure regulating and relief valve schedule indicating the system served, location and setpoint for each valve.

1.3 REFERENCE STANDARDS

- .1 AWWA C510 - Double Check Valve Backflow Prevention Assembly Standard
- .2 AWWA C511 - Reduced-Pressure Principle Backflow-Prevention Assembly Standard
- .3 CSA B64.5 - Double check valve (DCVA) backflow preventers
- .4 CSA B64.4 - Reduced pressure principle (RP) backflow preventers
- .5 CSA B64.8 - Backflow Preventers, Dual Check Valve Type with Intermediate Vent (DuCV)
- .6 ASSE 1013 - Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Principle Fire Protection Backflow Preventers
- .7 ASSE 1015 - Performance Requirements for Double Check Backflow Prevention Assemblies and Double Check Fire Protection Backflow Prevention Assemblies
- .8 ANSI Z21.22/CSA 4.4 - Relief Valves for Hot Water Supply Systems

PART - 2 PRODUCTS

2.1 BACKFLOW PREVENTERS

- .1 Pressure vacuum breakers (PVB)
 - .1 Acetal bonnet with silicone rubber O-ring seal and silicone rubber seat disc, replaceable seats, stainless steel springs, lead-free cast copper silicone alloy body, quarter turn ball valve shutoff valves. Check assembly shall be guided over its full stroke by 'V' notched guides.
 - .2 Temperature range: 0.5°C to 60°C
 - .3 Maximum working pressure: 1034 kPa.
- .2 Double check valve assemblies (DCVA)
 - .1 12mm to 50mm: lead-free cast copper silicon alloy body, two positive-seating check modules with captured springs and rubber seat discs, replaceable check module seats and seat discs, two resilient seated isolation valves and four top mounted, resilient seated test cocks, quarter turn ball valve shutoff valves. Service of all internal components shall be through a single access cover secured with stainless steel bolts. The assembly shall meet the requirements of CSA B64.5, ASSE Std. 1015 and AWWA C510. Working temperature range: 0.5°C to 82°C
 - .2 65mm to 250mm: fused epoxy coated cast iron body, modular check assemblies with center stem guiding, captured spring, accessible through a bolted cover plate, stainless steel seats replaceable without special tools, tight-closing resilient seated shutoff valves, test cocks. The assembly shall meet the requirements of CSA B64.5, ASSE Std. 1015 and AWWA C510. Working temperature range: 0.5°C to 43°C
 - .3 Maximum working pressure: 1200 kPa.
- .3 Dual check valve with intermediate atmospheric vent (DCAP)
 - .1 Two independent check valves with intermediate vacuum breaker and relief vent.
 - .2 12mm to 20mm:
 - .1 Forge brass body, stainless steel internal parts, and tight seating rubber check valve assemblies, for laboratory applications only.
 - .2 Working temperature range: 0.5°C to 121°C
 - .3 Maximum working pressure: 1200 kPa
 - .3 10mm for laboratory faucets:
 - .1 Lead-free brass body with polished chrome plating, stainless steel working parts and durable rubber diaphragm and disc, primary check valve with soft disc seated against a soft rubber mating part, secondary check valve with soft disc-to-metal seating.
 - .2 Working temperature range: 0.5°C to 82°C
 - .3 Maximum working pressure: 1034 kPa
 - .4 6mm to 10mm for vending machine water supply:
 - .1 Lead-free stainless steel body and heavy duty rubber parts, dual check valve with a third ball check valve.
 - .2 Working temperature range: 0.5°C to 60°C

- .3 Maximum working pressure: 1034 kPa
- .4 Reduced pressure principle (RP)
 - .1 Two independent check valves with intermediate relief valve, shut-off valves and ball type test cocks.
 - .2 Maximum working pressure: 1200 kPa
 - .3 12mm to 50mm: lead-free cast copper silicon alloy body construction, silicone rubber disc material in the first and second check plus the relief valve, replaceable polymer check seats for first and second checks, removable stainless steel relief valve seat, and stainless steel cover bolts. Complete with quarter turn resiliently seated ball shut-off valves. Working temperature range: 0.5°C to 82°C
 - .4 65mm to 250mm: epoxy coated cast iron body, stainless steel seats and trim, lead-free copper silicon alloy pressure differential relief valve between two positive seating check valves and captured springs, air admittance directly into the reduced pressure zone via a separate channel from the water discharge channel, two tightly closing shutoff valves before and after the valve, and lead-free copper silicon alloy test cocks. Working temperature range: 0.5°C to 60°C
 - .5 RP valves shall be complete with air gap drain collector.
 - .6 Provide a backflow preventer test kit consisting of pressure gauge, colour coded needle valves and hose, adaptors, replaceable hose filters.
- .5 Standard of Acceptance
 - .1 Watts
 - .2 Beeco
 - .3 Febco
 - .4 Wilkins

2.2 **TEMPERATURE MIXING VALVES (TMV)**

- .1 Type: thermostatic mixing valve, adjustable limit stop, union angle strainer checkstops on inlets, inlet shut-off valves, integral wall support, metal lever handle, internal components of bronze, brass and stainless steel, rough bronze finish, outlet ball valve, dial thermometer.
- .2 Capacity: as shown on drawings, selected at 140 kPa pressure drop or as shown.
 - .1 Symmons "TempControl" 5-XXX series
 - .2 Powers Crane Hydroguard 43X
 - .3 Leonard TM-XX-E-RF

2.3 **WATER MAKE-UP ASSEMBLIES**

- .1 Iron body water pressure regulator with:
 - .1 Integral check,
 - .2 Stainless steel strainer,
 - .3 Fast fill /purge lever, and
 - .4 Iron body diaphragm operated relief valve

2.4 **WATER PRESSURE REDUCING VALVE**

- .1 Spring loaded, cast iron body, synthetic rubber diaphragm, solid bronze trim.
 - .1 Leslie "Hi-Flo" Class WK
 - .2 Singer
 - .3 Trerice

2.5 **SHOCK ABSORBERS**

- .1 Water hammer type, sized in accordance with P.D.I.-WH201
 - .1 Watts SG series
 - .2 Zurn "Shoktrols A-1700-75"
 - .3 S-M-S "P.P.P. Type II"
 - .4 Enpoco HWT series

2.6 **NON-FREEZE WALL HYDRANTS (WH)**

- .1 "WH-1": Non-freeze box type, flush mounting to wall, with NPS 3/4 hose connection, self-draining, integral hose end vacuum breaker, hinged locking cover, galvanized wall sleeve, ground joint union elbow adapter and operating key.
 - .1 Watts HY-725
 - .2 Zurn Z-1320
 - .3 Enpoco HY72
 - .4 MIFAB MHY-26
- .2 "WH-2": Non-freeze exposed type, with NPS 3/4 hose connection, self-draining, integral hose end vacuum breaker, hinged locking cover, galvanized wall sleeve, ground joint union elbow adapter and operating key.
 - .1 Watts HY-420
 - .2 Zurn Z-1321
 - .3 Enpoco HY42
 - .4 MIFAB

2.7 **HOSE BIBBS (HB)**

- .1 Rough brass construction with hose end spout, size as indicated.
 - .1 Cambridge Brass - 32W200 or 32W210
 - .2 Emco - 10740 or 10241
 - .3 MIFAB MHY-90

2.8 **COMBINED TEMPERATURE AND PRESSURE RELIEF VALVES**

- .1 Lead-free cast bronze body, test lever, thermostat, automatic re-seating with non-mechanical seat-to-disc alignment, tamper-resistant bonnet screws, designed to ANSI Z21.22 for temperature discharge capacity. Temperature relief factory set to 99°C. Pressure relief range 517 – 1034 kPa, standard setting 517, 689, 862 and 1034 kPa.

- .2 Standard of Acceptance
 - .1 Watts
 - .2 Zurn
 - .3 Conbraco

2.9 THERMOSTATIC FLOW REGULATOR

- .1 Flow regulator shall be equivalent to Circuit Solver as manufactured by Therm-Omega-Tech, Inc., NSF-61 certified for use in domestic water systems.
- .2 The flow regulator shall control the flow of recirculated domestic hot water based on water temperature entering the regulator regardless of system operating pressure.
- .3 Even when fully closed the flow regulator shall bypass a small amount hot water to maintain dynamic control of the recirculating loop.
- .4 The regulator shall be factory adjustable as required by project conditions.
- .5 The regulator shall be available in sizes ranging from 12mm to 50mm, with standard tapered female pipe thread connection, rated to 1,378 kPa maximum operating pressure and to 148.9°C maximum working temperature.
- .6 Body and all internal components shall be constructed of stainless steel with major components constructed of type 303 stainless steel.
- .7 Thermal actuator shall be spring loaded and self-cleaning, delivering closing thrust sufficient to keep orifice opening free of scale deposits.

PART - 3 EXECUTION

3.1 BACKFLOW PREVENTERS

- .1 Provide backflow preventers selected in conformance to CSA B64.10, where a connection is made between any system conveying potable water and a system carrying non-potable water or any other liquid.
- .2 Install backflow preventers where shown on drawings, in accordance with manufacturers recommendations, and as follows:
 - .1 Locate RPP devices at 1200mm above finished floor.
 - .2 Locate VB devices exposed as close to fixture connection as possible.
 - .3 Provide drain collector at relief valves and 20mm drain from DCAP and RPP devices and run drain to nearest floor drain.
- .3 Testing:
 - .1 Provide the services of an independent inspection agency to verify operation of all backflow prevention devices provided with testing ports.
 - .2 Provide inspection tag on each such device.
 - .3 Submit test results to Building Plumbing Inspector, Commissioning Agent and Consultant.

3.2 WATER PRESSURE REDUCING VALVES

- .1 Locate in domestic water lines as shown, with capacity and pressure reduction ratings as shown.
- .2 Provide pressure gauge on downstream side of PRV, complete with pet-cock.
- .3 Provide pressure relief valve suitably sized and pipe to drain.

3.3 SHOCK ABSORBERS

- .1 Locate shock absorbers in hot and cold water lines:
 - .1 At far ends of mains
 - .2 At branch lines to each flush valve and quick closing valve
 - .3 At dead ends of branch piping or to groups of plumbing fixtures
 - .4 At isolated individual plumbing fixtures

3.4 WALL HYDRANTS

- .1 Verify wall thickness at each hydrant to ensure correct hydrant length.

3.5 HOSE BIBBS

- .1 Mount 1050mm above finished floor.
- .2 Provide a line mounted vacuum breaker selected for continuous pressure.

3.6 COMBINED TEMPERATURE AND PRESSURE RELIEF VALVES

- .1 Install a relief valve on each tank type water heater, on each storage tank and on the discharge side of each heat exchanger.
- .2 Pipe relief to the nearest floor drain.

3.7 THERMOSTATIC FLOW REGULATOR

- .1 Install a thermostatic flow regulator in each domestic hot water recirculation riser/branch beyond the last hot water device in that branch. Provide suitable line size isolation valves and access panel as required in non-accessible ceilings and walls.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section for the following:
 - .1 Furnish and install sanitary waste and vent piping systems.
- .2 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Sections 20 00 13 – Mechanical General Provisions and 22 05 00 - Common Works for Plumbing shall apply to and govern this Section.

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit product data for waste and vent piping, fittings, joints and related material.

1.3 REFERENCE STANDARDS

- .1 CAN/CSA B70 - Cast Iron Soil Pipe, Fittings, and Means of Joining
- .2 CSA B158.1 - Cast Brass Solder Joint Drainage, Waste, and Vent Fittings
- .3 CAN/CSA-B181.1 - Acrylonitrile-Butadiene-Styrene (ABS) Drain, Waste, and Vent Pipe and Pipe Fittings
- .4 CAN/CSA-B181.2 - PVC Drain, Waste and Vent Pipe and Pipe Fittings
- .5 CAN/CSA B181.3 - Polyolefin and Polyvinylidene Fluoride (PVDF) Laboratory Drainage Systems
- .6 CAN/CSA B182.2 - PSM Type Polyvinylchloride (PVC) Sewer Pipe and Fittings
- .7 CSA B602 - Mechanical Couplings for Drain, Waste, and Vent Pipe and Sewer Pipe
- .8 ASTM A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
- .9 ASTM A74 - Standard Specification for Cast Iron Soil Pipe and Fittings
- .10 ASTM A518 / A518M - Standard Specification for Corrosion-Resistant High-Silicon Iron Castings
- .11 ASTM A861 - Standard Specification for High-Silicon Iron Pipe and Fittings
- .12 ASTM A888 - Standard Specification for Hubless Cast Iron Pipe and Fittings for Sanitary and Storm Drain, Waste and Vent Piping Applications
- .13 ASTM B32 - Specification for Solder Metal
- .14 ASTM B306 - Standard Specification for Copper Drainage Tube (DWV)
- .15 ASTM B828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings

- .16 ASTM C564- Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
- .17 ASTM C1053 - Standard Specification for Borosilicate Glass Pipe and Fittings for Drain, Waste, and Vent (DWV) Applications
- .18 ASTM C1540 - Standard Specification for Heavy Duty Shielded Couplings Joining Hubless Cast Iron Soil Pipe and Fittings
- .19 ASTM F2389 - Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems
- .20 ANSI/ASME 16.29 - Wrought Copper and Wrought Copper Alloy Solder-Joint Drainage Fittings – DWV
- .21 ULC S102.2 - Standard Method of Test for Surface Burning Characteristics of building Materials and Assemblies
- .22 Canadian Pipe Institute Standard Specification
- .23 Cast Iron Soil Pipe Institute (CISPI) Technical Manual

PART - 2 PRODUCTS

2.1 CAST IRON PIPING AND FITTINGS

- .1 Cast iron waste, drain, and vent pipe and fittings shall be used for the following applications:
 - .1 General service pipe buried in or in contact with earth.
 - .2 Sanitary pipe extensions to a distance of 1500 mm outside the building.
 - .3 General service interior waste and vent piping above grade.
- .2 Above grade
 - .1 Pipe: hubless (plain end or no-hub) cast iron to CAN/CSA-B70, ASTM A74 or ASTM A888.
 - .2 Mechanical sleeve joints: to CSA B602 and ASTM C1540, with neoprene or butyl rubber compression gaskets to ASTM C564, with stainless steel sleeve, and not less than four stainless steel drive clamps with stainless steel worm gears on sizes 150mm and larger.
- .3 Buried
 - .1 Pipe: hubless (plain end or no-hub) cast iron to CAN/CSA-B70, ASTM A74 or ASTM A888, with heavy bituminous coating.
 - .2 Mechanical sleeve joints: to CSA B602 and ASTM C1540, with neoprene or butyl rubber compression gaskets to ASTM C564, with stainless steel sleeve, and not less than four stainless steel drive clamps with stainless steel worm gears.
- .4 Tie rods
 - .1 Fabricated using double bolted riser clamps and 10mm carbon steel rods, with riser clamp placed on each side of joint; or pre-manufactured restraint system equivalent to Holdrite

2.2 **COPPER TUBE AND FITTINGS**

- .1 Copper tube sanitary waste, drain and vent pipe may be used for all above grade general service gravity drain application except for urinal drains, and pressure drains up to 50mm size.
- .2 Pipe: hard drawn copper drainage tube (DWV) to ASTM B306
- .3 Drainage fittings: wrought copper solder joint: to ANSI B16.29
- .4 Cast brass solder joint: to CSA B158.1 with 50/50 solder to ASTM B32.

2.3 **POLYVINYL CHLORIDE (PVC) PIPING AND FITTINGS**

- .1 PVC pipe and fittings are only permitted where the waste temperature is below 60°C for the following applications:
 - .1 General service pipe buried in or in contact with earth
 - .2 General service interior waste and vent piping above grade
 - .3 Dialysis, radioisotope and RO water drain and vent
 - .4 Process waste systems. Do not use PVC piping for process waste where solvents may be present.
- .2 Above grade
 - .1 Pipe: plain end DWV System 15 with solvent weld joints to CAN/CSA-B181.2
- .3 Above grade – plenum rated
 - .1 Pipe: Schedule 40 PVC to CSA B181.2, listed to ULC S102.2 to exhibit a Flame Spread Rating of not greater than 25 and a Smoke Developed Classification of not greater than 50.
 - .2 Fittings: fittings matching piping system to ensure compliance with Flame and Smoke listings.
 - .3 Joints: glued using solvent cement
- .4 Buried
 - .1 Up to 150mm:
 - .1 Plain end DWV System 15 pipe with solvent weld joints to CAN/CSA-B181.2, or
 - .2 SRD35 gasketed pipe and fittings to CSA B182.2, or
 - .3 SDR35 solvent weld pipe and fittings to CSA B182.2.
 - .2 200mm and above:
 - .1 SRD35 gasketed pipe and fittings to CSA B182.2.

2.4 **POLYPROPYLENE PIPE AND FITTINGS**

- .1 Schedule 40, flame retardant polypropylene pipe to CSA B181.3 for buried and above grade laboratory drainage.
- .2 Joints: heat fusion using manufacturer's standard heat fusion tool system, with threaded adaptors for equipment connection.

- .3 Maximum operating temperature: 149°C

2.5 **POLYETHYLENE PIPE AND FITTINGS**

- .1 Schedule 40 polyethylene pipe to CSA B181.3 for above grade laboratory drainage.
- .2 Joints: heat fusion using manufacturer's standard heat fusion tool system, with threaded adaptors for equipment connection.
- .3 Maximum operating temperature: 60°C

2.6 **BOROSILICATE GLASS PIPE AND FITTINGS**

- .1 Tempered, low expansion sodium borosilicate, plain or beaded end, acid waste pipe and fittings for above grade corrosive drainage to ASTM C1053.
- .2 Spigot end polypropylene fittings, or fire retardant polypropylene fittings and bolted type band couplings.
- .3 Couplings: stainless steel outer band and bolt, with poly fin coupling and stainless steel retainer rings.
- .4 Joints: gear or screw type band coupling with compressible rubber liner and Teflon gasket.
- .5 Maximum operating temperature: 232°C for beaded end, 149°C for plain end.

2.7 **GALVANIZED STEEL PRESSURE PIPE AND FITTINGS**

- .1 Schedule 40 galvanized steel pipe; stretch reduced continuous weld, ASTM A53, for pressure drains 65mm and above.
- .2 Fittings: Class 125, gray-iron threaded fittings to ASME B16.4.
- .3 Unions: Class 150 hexagonal-stock body with ball and socket, metal to metal, bronze seating surface, malleable iron conforming to ASME B16.39 with female threaded ends.
- .4 Flanges: Class 125 cast iron conforming to ASME B16.1.
- .5 Flange gaskets: full face, flat non-metallic, asbestos free conforming to ASME B16.21.
- .6 Flange nuts and bolts: carbon steel conforming to ASME B18.2.1

PART - 3 EXECUTION

3.1 **GENERAL**

- .1 Install drainage and vent systems in accordance with the requirements of the applicable provincial or federal plumbing code.
- .2 Size vent lines based on developed pipe length and hydraulic load.
- .3 All vent piping serving corrosion resistant drainage piping distribution system to be corrosion resistant up to and through the roof penetrations.
- .4 Arrange piping within pipe spaces behind washroom fixtures to allow unimpeded access to piping for servicing.
- .5 All traps and fittings shall be of same material or equal in quality and thickness to the pipe to which they are connected.

3.2 PIPE INSTALLATION

- .1 Consider the piping layout shown on the Drawings as diagrammatic, indicating the general runs and connections, and that the piping may, or may not, in all parts be shown in true position.
- .2 Ream all piping and keep plugged to prevent entry of dirt.
- .3 Accurately cut pipe to the established measurements and work into place without springing or forcing. In any situation where bending of the pipe is required, use a standard pipe-bending template. Pipe hangers, supports, restraint of system piping and seismic bracing shall be installed accordance with Sections 20 05 29 - Bases, Hangers and Supports, and 20 05 49 - Seismic Control.
- .4 Anchor, guide and laterally support vertical and horizontal piping to support filled weight and absorb thrust under operating conditions.
- .5 Erect piping so that gravity forces and thrust from changes in direction do not stress connections to apparatus.
- .6 Grooved joint piping systems shall be installed in accordance with the manufacturer's guidelines and recommendations. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Grooved end shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove. Use a torque wrench for installation if required for the joint type. Required torque shall be in accordance with the manufacturer's recommendations. A factory trained field representative shall provide on-site training to contractor's field personnel in the installation of grooved piping products. Factory trained representative shall periodically review the product installation. Remove and replace any improperly installed joints.
- .7 Changes in direction for soil and waste drainage and vent piping shall be made using appropriate branches, bends and long sweep bends. Sanitary tees and short sweep quarter bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Long turn double wye branch and eighth bend fittings shall be used if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Proper size of standard increaser and reducers shall be used if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- .8 Underground piping:
 - .1 Provide proper facilities for lowering sections of pipe into trenches. Do not drop or dump pipe, fittings, valves, or any other water line material into trenches. Lay bell-and-spigot pipe with the bell end pointing in the direction of laying. Buried soil and waste drainage and vent piping shall be laid beginning at the low point of each system. Piping shall be installed true to grades and alignment indicated with unbroken continuity of invert. Hub ends shall be placed upstream. Required gaskets shall be installed according to manufacturer's written instruction for use of lubricants, cements, and other installation requirements. Grade the pipeline in straight lines; avoid the formation of dips and low points. Support pipe at proper elevation and grade. Lay pipe so that the full length of each section of pipe and each fitting will rest solidly on the pipe bedding; excavate recesses to accommodate bells, joints, and couplings. Provide anchors and supports where necessary for fastening work into place. Make proper provision for expansion and contraction of pipelines. Provide concrete thrust blocks for pipe anchorage.

- .2 Make flanged joints up tight; avoid undue strain on flanges, fittings, valves, and other equipment and accessories. Align bolt holes for each flanged joint. Use full size bolts for the bolt holes; the use of undersized bolts to make up for misalignment of bolt holes or for any other purpose will not be permitted.
- .3 Install a continuous length of AWG 10 gauge copper tracer wire for the full length of each run of non-metallic pipe. Attach the wire to the top of the pipe in such manner that it will not be displaced during construction operations.
- .9 Cast iron
 - .1 Install in accordance with the requirements of CISPI Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings".
- .10 PVC - buried
 - .1 Install in accordance with the requirements of CSA B182.1, and manufacturer's recommendations.
 - .2 Provide a tracer wire directly over PVC pipe.
- .11 PVC – above grade
 - .1 Install in accordance with the requirements of CSA B181.12 and manufacturer's recommendations.
 - .2 Provide fire stop seals on all fire separation penetrations, except at connections through concrete floor slabs to non-combustible water closets. Fire stopping used for plenum rated piping shall be a listed system as supplied by the pipe manufacturer.
 - .3 Do not use combustible piping in return air ceiling plenums or in vertical riser shafts.
- .12 Polypropylene
 - .1 Install in accordance with the requirements of CSA B182.13 and manufacturer's recommendations.
 - .2 Make heat fusion joints in accordance with manufacturer's written instructions.
 - .3 Install fittings and joints using socket-fusion, electrofusion, or butt-fusion as applicable for the fitting or joint type.
 - .4 Prior to joining, the pipe and fittings shall be prepared in accordance with the requirements of ASTM F2389 and the manufacturer's specifications.
- .13 Polyethylene
 - .1 Install in accordance with the requirements of CSA B182.6 and manufacturer's recommendations.
 - .2 Make heat fusion joints in accordance with manufacturer's written instructions.
- .14 Borosilicate glass
 - .1 Install and support piping system to manufacturer's written instructions.
 - .2 Provide pipe hangers with padding material between hanger and glass pipe.

3.3 **LINES, GRADES AND SLOPES**

- .1 Install piping in conformity with elevations and grades indicated on the Drawings using axis lines and bench marks provided under General Construction.
 - .1 Verify such axis lines and bench marks.
 - .2 Lay out work and be responsible for lines, elevations, measurements, etc., required for installation of the Work.
- .2 Slopes:
 - .1 Slope piping drains and sewers as indicated on the Drawings.
 - .2 Install so that slope between elevations shown on the Drawings is even and constant.
- .3 Minimum slopes:
 - .1 As shown on the Drawings. If not shown, then as follows:
 - .1 Drainage piping, 75mm and less: 1:50.
 - .2 Drainage piping, 100mm and larger: 1:100.
 - .1 In special circumstances as provided for under the applicable plumbing code, and at the express approval of the Consultant, drains of 100mm size and larger may be laid at a lesser slope.

3.4 **JOINTS, UNIONS, FLANGES AND COUPLINGS**

- .1 Pipe joints
 - .1 Preparation
 - .1 Ream pipe ends and thoroughly clean all dirt, cuttings and foreign matter from pipe after cutting and threading.
 - .2 Thoroughly clean all fittings, valves and equipment before connections are made.
 - .3 Cut copper tubing with a tube cutter and clean the joining surfaces of the tubing and fitting with fine emery cloth. Wipe clean with a dry cloth.
 - .2 Cast iron pipe sleeve joints
 - .1 For cast iron plain end soil pipe, install sleeve type couplings in strict accordance with manufacturer's instructions.
 - .3 Mechanical joints:
 - .1 Assemble mechanical joint on ductile iron pressure pipe with cast iron gland, rubber sealing gasket and high strength malleable iron bolts in accordance with the manufacturer's recommendations.
 - .4 Threaded joints:
 - .1 Use Teflon tape or Masters metallic compound with the compound applied to the male threads only and particular care taken to prevent the compound from reaching the interior of the pipe or fittings.
- .2 Unions and flanges
 - .1 Provide unions or flanges in the following locations:
 - .1 At connections to equipment.

- .2 In screwed or solder joint drainage tubing at inlet side of trap.
- .2 If unions are concealed in walls, partitions or ceilings, build access thereto.
- .3 Provide dielectric unions or isolating type companion flanges at all connections between copper tubing and ferrous piping.
- .4 Flange joints
 - .1 Assemble joints with appropriate flanges, gaskets and bolting.
 - .2 Allow clearance between flange faces such that the connections can be gasketed and bolted tight without undue strain on the piping system, with flange faces parallel and bores concentric.
 - .3 Centre gaskets on the flange faces so as not to project into the bore.
 - .4 Lubricate bolts before assembly and provide 2 hardened steel washers under the head of each unit to assure uniform bolt stressing.
 - .5 Machine off raised face flanges when joining to a flat companion flange and use a full face gasket.
 - .6 Follow gasket manufacturer's instructions for correct bolting procedure.
 - .7 Use calibrated torque wrench and tighten bolts in recommended sequence in four equal steps to required final torque value.
- .3 Couplings
 - .1 Minimize couplings on runs of pipes.
 - .2 Do not use running couplings in any pipeline.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 22 05 00 - Common Works for Plumbing shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 Furnish and install sanitary waste drainage products, backwater valves and primers.

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for all products. Shop drawings shall indicate materials, finishes, method of anchorage, dimensions, construction and assembly details and accessories.

1.3 REFERENCE STANDARDS

- .1 CSA B79 - Commercial and Residential Drains and Cleanouts

PART - 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- .1 Drainage products shall conform to CSA B79.
- .2 Drains installed in waterproofed floors or shower pans shall be equipped with bolted-type device to securely clamp flashing.
- .3 The designation allocated to the following list of drainage products identifies that particular drain type on the Drawings.
- .4 Standard of Acceptance
 - .1 Watts
 - .2 Zurn
 - .3 MIFAB
 - .4 J.R.Smith
 - .5 Blücher

2.2 FLOOR DRAINS – ‘FD’

- .1 Epoxy coated cast iron body unless otherwise specified, double drainage pattern for embedding in the floor construction, flashing clamp with seepage openings, trap primer

- connection. Adjustable grate/strainer to suit floor thickness. Outlet connection type to suit drain pipe. Outlet connection size as shown on the Drawings.
- .2 Mechanical, electrical and service rooms, plenums, other unfinished areas
 - .1 203 mm diameter, heavy duty, heel proof nickel bronze anti-tilting strainer.
 - .2 For electrical rooms, transformer vault, UPS and switchgear rooms, include backwater valve.
 - .3 Mechanical, electrical and service rooms, plenums, other unfinished areas – floating floors
 - .1 203 mm diameter, heavy duty cast iron anti-tilting strainer with movement compensator and vibration isolator.
 - .4 Finished areas – nickel bronze
 - .1 125mm diameter, nickel bronze, 6mm thick strainer secured with stainless steel screws, full 100mm throat opening.
 - .2 For quarry and mosaic tiles areas, use 125mm x 125mm square nickel bronze strainer.
 - .5 Finished areas – stainless steel
 - .1 125mm diameter, stainless steel strainer with no. 4 satin finish, secured with stainless steel screws, full 100mm throat opening.
 - .2 For quarry and mosaic tiles areas, use 125mm x 125mm square stainless steel strainer with no. 4 satin finish.
 - .3 Provide lug in drain body for grounding wire connection for pool deck drains.
 - .6 Finished areas – vinyl flooring
 - .1 178mm diameter, nickel bronze strainer with 2-piece surface membrane clamp.
 - .7 Finished areas – heavy duty
 - .1 125mm diameter, nickel bronze, 12mm thick secured strainer, full 100mm throat opening.
 - .8 Garbage rooms, loading docks
 - .1 280mm x 280mm hinged, vandal-proof, cast iron bar grate, and 100mm deep, slotted sediment bucket.
 - .9 Cooling tower drain
 - .1 Combined flashing clamp and gravel stop, under deck clamp, sump receiver, solid extension, cast iron dome and 50mm overflow dam.
 - .10 Flushing rim drain for dialysis, morgue, cystoscopy and animal rooms
 - .1 Epoxy coated, acid resistant drain body interior, 20mm flushing connection, 241mm diameter nickel bronze, hinged, vandal-proof secured strainer.
 - .11 Acid-resistant laboratory floor drains
 - .1 Flame retardant, fiber-filled polypropylene or PVDF body, grate, flange, flashing clamp, shall be supplied by the laboratory drain pipe system manufacturer. Outlet connection size as shown on the Drawings.

2.3 **FUNNEL FLOOR DRAINS – ‘FFD’**

- .1 Epoxy coated cast iron body, double drainage pattern for embedding in the floor construction, flashing clamp with seepage openings, trap primer connection. Adjustable top to suit floor thickness. Outlet connection type to suit drain pipe. Outlet connection size as shown on the Drawings.
- .2 127mm diameter, nickel bronze 6mm thick strainer with 102mm x 229mm integral, nickel bronze funnel (no bars at funnel throat), full 100mm throat opening.

2.4 **HUB DRAINS – ‘HD’**

- .1 Epoxy coated cast iron body, double drainage pattern for embedding in the floor construction, flashing clamp with seepage openings, trap primer connection. Adjustable top to suit floor thickness. Outlet connection type to suit drain pipe. Outlet connection size as shown on the Drawings.
- .2 125mm diameter nickel bronze above-floor hub.

2.5 **TRAPS PRIMERS**

- .1 Mechanical trap seal primer valve
 - .1 Pressure drop activated brass trap seal primer of lead-free construction, 12mm male inlet and female outlet openings. Complete with four view holes and removable filter screen. Primer requires no adjustments and no air pre-charge; or
 - .2 Flow activated, cast brass body trap seal primer, integral vacuum breaker and 12mm inlet and outlet sweat connections.
 - .3 Provide trap seal primer distribution unit with four 12mm brass compression outlet connections, ABS body and HDPE lid with top 12mm connection. Unit shall be complete with a four-wall internal body design that aligns with the slots in the underside of the lid to distribute water evenly and to only the desired number of ports.
- .2 Electronic trap primer systems for remote floor drains
 - .1 For traps located on parking levels, in mechanical rooms and in any other area without an appropriate water source where a mechanical primer valve cannot be used, provide an enclosed electronic trap seal primer system with timer, 12mm plastic ball valve, lead-free bronze vacuum breaker, 12mm solenoid valve and plastic manifold with distribution ports with 12mm compression connections. Electrical components to include a single point power connection at 120V/1Ph/60Hz, manual override switch, a minimum 5 Amp breaker, 24-hour timer with relay and adjustable delay. All components to be factory assembled and installed into a satin coated 1.5mm steel box for surface mounted installation. The entire assembly shall be tested and certified to ASSE 1044 Standard.

2.6 **BACKWATER VALVES – ‘BWV’**

- .1 Cast iron body backwater valve, bolted access cover with gasket, bronze seat, revolving double fulcrum flapper, and stainless steel hardware. For extended floor access provide PVC extension and cover.

PART - 3 EXECUTION

3.1 DRAINAGE PRODUCTS

- .1 Provide each drain with a deep seal "P" trap unless otherwise shown, complete with trap primer connection tapping for drains without a direct primer connection, to conform to applicable provincial and federal plumbing code requirements.
- .2 Install floor drains with top strainer set flush with the finished surface. Surrounding surface shall match with floor drain top for proper drainage.
- .3 Install drain flashing collar or flange so that no leakage occurs between the drain and the adjoining flooring. Maintain the integrity of waterproof membranes where penetrated.
- .4 Provide floor drains in air plenums on the suction and discharge side of fans.
- .5 Provide a primed running trap with cleanout for each drain where an integral trap cannot be installed.
- .6 Coordinate trench drain layout with the General Contractor for elevation, slab slope at trench drain location, and support requirements. Adjacent surface shall be finished to convey drainage into trench drain without pooling

3.2 TRAP PRIMERS

- .1 Provide each trapped drain and running trap with a trap seal primer.
 - .1 Exception: floor drains located in shower stalls, group showers and other locations where the drain is exposed to water on a daily basis, as approved by the Consultant.
- .2 Use trap seal primer valves where a domestic cold water line serving a washroom fixture (preferably a water closet) is within 15m of the floor drains.
- .3 Primer connections:
 - .1 Above ground floor drains: 12mm Type K copper pipe to primer connection on drain body.
 - .2 Buried floor drains: 12mm Type K copper pipe to within 300mm of the floor line. Provide 9mm soft copper tubing from this point and connect to drain body.
- .4 Install trap primers in ceiling space or in other accessible location, or as directed by the Consultant. Provide isolation valve on the supply side of the primers.

3.3 BACKWATER VALVES

- .1 When the pipe invert is more than 457mm from the finished floor, the backwater valve shall be installed in an access pit with cover. Coordinate with the Contractor performing the Work of Division 03 – Concrete.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 22 05 00 - Common Works for Plumbing shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 Provide electric domestic hot water heaters, booster heaters and associated controls.

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for all products. Shop drawings shall include, but not be limited to: data sheets, dimensions showing required clearances and connection entries, complete description of control panel, with wiring diagram, sequencing data, instrumentation and alarms.
 - .3 Submit a certification for compliance with the requirements of ASHRAE 90.1 or NECB for efficiency and stand-by loss ratings, as applicable.

1.3 REFERENCE STANDARDS

- .1 ASHRAE 90.1 – Energy Standard for Buildings
- .2 National Energy Code of Canada for Buildings
- .3 ANSI Z21.22/CSA 4.4 - Relief valves for hot water supply systems
- .4 CAN/CSA C22.2 No. 110 - Construction and Test of Electric Storage-Tank Water Heaters
- .5 CAN/CSA C191 - Performance of Electric Storage Tank Water Heaters for Domestic Hot Water Service
- .6 CAN/CSA C745 - Energy Efficiency of Electric Storage Tank Water Heaters and Heat Pump Water Heaters
- .7 NSF/ANSI 61 - Drinking Water System Components
- .8 NSF 372 - Drinking Water System Components - Lead Content

1.4 QUALITY ASSURANCE

- .1 Domestic water heater efficiency and stand-by loss ratings shall meet or exceed the requirements of ASHRAE 90.1 or NECB, as applicable.
- .2 Domestic water heaters shall be certified to CAN/CSA C22.2 No. 110, CAN/CSA C191 and CAN/CSA C745.

- .3 Tank lining shall comply with the requirements of NSF 61 and NSF 372 for barrier materials for potable water.

PART - 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- .1 Connections up to 75mm shall be threaded, and 100mm and over shall be flanged.
- .2 Water heaters shall be factory pre-piped and pre-wired, except where devices are specified as shipped loose to be field installed.

2.2 STORAGE TYPE WATER HEATER

- .1 Steel tank shell with an inner liner, extended into the openings, and with access for cleaning and disinfection. Heater constructed for a working pressure of 1034 kPa.
- .2 Screw-in or bolt-on immersion type, thermostatically adjustable elements. Heater shall be capable of raising the discharge temperature to 77 to 82°C for thermal eradication.
- .3 Tapping (openings) shall be factory fabricated of materials compatible with the tank for piping connections, pressure and temperature relief valve, pressure gauge, thermometer, drain valve, anode rods and controls as required.
- .4 Tank insulation shall comply with the requirements of ASHRAE 90.1 or NECB as applicable.
- .5 For domestic water heater sizes greater than 9 kW, the heating element shall be arranged in multiples of three elements. For heaters less than 9 kW, the heater elements shall be arranged in single or double elements.
- .6 Tank capacity and size as indicated on the Drawings.

2.3 TRIM AND INSTRUMENTATION

- .1 Drain valve: 20mm or 25mm, to suit water heater's pipe connections, with hose end.
- .2 Thermometer: in accordance with Section 20 05 19 - Meters and Gauges.
- .3 Temperature and pressure relief valve sized for the full capacity of the heater: in accordance with Section 22 11 19 - Domestic Water Piping Specialties.
- .4 Magnesium anodes adequate for 20 years of operation and located for easy replacement.

PART - 3 EXECUTION

3.1 GENERAL

- .1 Install heaters level, on concrete housekeeping pad, or suspended using threaded rods and steel frame platform anchored to the building structure, per manufacturer's installation instructions.
- .2 Pipe relief valve to the nearest funnel or hub drain.
- .3 Connect cold water supply line and domestic hot water distribution piping to heaters with isolation valves and unions.

- .4 Install heat traps on piping in accordance with ASHRAE 90.1 unless provided integrally with the heater.
- .5 Provide a thermometer on the outlet piping from each heater and where shown on the Drawings.
- .6 Provide field control wiring of local safeties and interlocks in accordance with Section 22 09 00 - Instrumentation and Control for Plumbing.
- .7 Flush and clean water heaters on completion of installation, according to manufacturer's installation instructions.
- .8 At the completion of installation, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes including chips, scratches, and abrasions.
- .9 Allow and pay for one (1) site visit during installation performed by a service technician trained by the manufacturer, with written reports forwarded to the Consultant.
- .10 Set thermostatic control to maintain design domestic hot water temperature in accordance with Section 22 05 00 - Common Works for Plumbing.
- .11 Provide a complete start up service to set all controls. Include both initial start-up as well as follow-up. Recalibrate all controls as required.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 22 05 00 - Common Works for Plumbing shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 Furnish and install emergency plumbing fixtures, faucets and associated trim.

1.2 QUALITY ASSURANCE

- .1 Fixtures and trim of the same type shall be the product of one manufacturer unless specified otherwise.
- .2 Finished surfaces shall be clear, smooth and bright, and guaranteed not to craze, discolour or scale.

1.3 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for plumbing fixtures, faucets, rough stops, risers, traps and all other accessories.

1.4 RELATED WORK

- .1 The following work is provided under other Sections or Divisions of the Work:
 - .1 Caulking of fixtures: Division 07 - Thermal and Moisture Protection.

1.5 REFERENCE STANDARDS

- .1 ANSI Z358.1 - American National Standard for Emergency Eyewash and Shower Equipment

1.6 FIXTURE COUNT

- .1 Determine the number and location of fixtures from the Architectural or Interior Design Drawings. In the absence of such drawings, refer to Mechanical Drawings.

PART - 2 PRODUCTS

2.1 SAFETY STATIONS

- .1 Combination Eyewash/Safety Shower - Type ESE1
 - .1 250 mm diameter ABS plastic shower head, quick opening stay open ball valve with lever and rigid pull rod, stainless steel receptor with two chrome plate aerator heads, separate flow control for each head and push-to-operate ball valve. Mount

shower fitting, valves and eye wash fountain on a common NPS 1¼ pipe standard with NPS 1¼ supply and NPS 1¼ drain connections, and floor flange.

.1 Water Saver SS 950

PART - 3 EXECUTION

3.1 TRAPS

- .1 Provide every fixture with trap in accordance with the applicable plumbing code. Provide each trap with its own brass plug and ferrule cleanout.

3.2 UNIONS, FLANGES

- .1 Provide unions or flanges at each connection to fixtures requiring servicing or replacing.
- .2 In copper pipes, provide wrought copper unions with soldered joints for pipes up to and including 50mm and 1034 kPa cast brass flanges for pipes 65mm and larger.

3.3 FIXTURES

- .1 Supply and install all hangers, supports, brackets, reinforcement, steel back-up plates, and all other accessories for the proper installation of fixtures and supply fittings.
- .2 Install all components in strict accordance with manufacturer's recommendations.
- .3 Fixtures mounted on outside walls shall have water supplies connected from the floor; all other fixtures shall be served from walls.
- .4 Mounting heights for wall hung fixtures and emergency showers shall be measured from the finished floor.
- .5 Fixtures shall be installed symmetrical with wall tile pattern, unless otherwise dimensioned on the Architectural or Interior Design Drawings.
- .6 Conceal vertical supports and baseplates in wall construction.
- .7 Where plumbing fixtures contact walls and/or the floor, the joints shall be made watertight using mould resistant sealant. Coordinate with the Contractor performing the work of Division 07 - Thermal and Moisture Protection.
- .8 Vent fixtures and traps in accordance with Section 22 13 16 – Sanitary Waste and Vent Piping.
- .9 Install chrome plated angle on straightaway type screwdriver compression stops, as required, on all hot and cold water service connections to fixtures.
- .10 Install escutcheon plates where service connections to fixtures pass through walls or floors. Refer to Section 22 05 00 - Common Works for Plumbing for requirements.

3.4 EMERGENCY EYEWASH AND SHOWER STATIONS

- .1 Install eyewash and shower stations in accordance with manufacturers instructions.
- .2 On pipe standards, plug spare Tee branches if not used.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

.1 Section includes:

- .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .2 This Section supplements all Sections of Division 23 – HVAC.
- .3 The intent of the Division 23 – HVAC Specifications and the accompanying Drawings is to provide complete and workable heating, ventilation and air conditioning (HVAC) systems as shown, specified and required by applicable codes. Include all work specified under Division 23 - HVAC and shown on the accompanying Drawings.
- .4 The Drawings that accompany the Division 23 – HVAC Specifications are diagrammatic. It is the responsibility of this Contractor to ensure that adequate and appropriately sized air distribution and hydronic systems are provided. The Contract Drawings do not show each offset, bend, tee, or elbow which may be required to install the HVAC Work in the space provided and to avoid conflicts. Follow the Drawings as closely as is practical to do so and install additional bends, offsets and elbows where required by local conditions from measurements taken at the Site, subject to approval, and without additional cost to the Owner.
- .5 Major aspects of the HVAC Work shall include but not necessarily be limited to, the following items:
 - .1 Research and Development Labs, Wet Lab and Analytic Lab, will be provided with one(1) x dedicated split heat pump system respectively for space heating and cooling, to meet the required room temperature control (between 20~23°C).
 - .2 Also, one (1) x gas-fired and DX cooling dedicated outdoor air system (DOAS) unit air unit will be installed on roof to compensate for exhaust air from the proposed fume hoods in Wet Lab, and two(2) x ducted-mounted electric heaters and one (1) x electric steam humidifier will be supplied to raise makeup air temperature and humidity to set up points if required.
 - .3 One(1) ceiling mounted electric heating fresh air unit will work with one(1) x roof exhaust fan to serve Analytic Lab.
 - .4 Natural gas supply system and equipment;
 - .5 Refer to the following Sections of the Division 23 – HVAC Specification for further details:
 - .1 Commissioning of HVAC – Section 23 08 00
 - .2 Instrumentation and Control for HVAC – Section 23 09 00
 - .3 Natural-Gas Piping – Section 23 11 23
 - .4 Refrigerant Piping – Section 23 23 00
 - .5 Ducts and Casings – Section 23 31 00
 - .6 Duct Cleaning – Section 23 31 31
 - .7 Duct Accessories – Section 23 33 00

- .8 Fans – Section 23 34 00
- .9 Diffusers, Registers and Grilles – Section 23 37 13
- .10 Split-System Air-Conditioners – Section 23 81 26
- .11 Air Coils – Section 23 82 16
- .12 Humidifiers – Section 23 84 13

.2 Related Requirements:

- .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
- .2 Section 20 00 13 – Mechanical General Provisions shall apply to and govern this Section.

1.2 **RELATED WORK**

.1 The following Work is provided under other Sections or Divisions of the Work:

- .1 Finish painting: Section 09 91 00 – Painting.
- .2 Electrical wiring: Division 26 - Electrical.

1.3 **QUALITY ASSURANCE**

.1 Manufacturer Qualifications:

- .1 Companies specialized in manufacturing heating, ventilation, air conditioning, natural gas, and fuel oil products specified under the Sections of Division 23 – HVAC with minimum three years of documented experience.

.2 Installer Qualifications:

- .1 Companies specialized in performing work of the type specified under the Sections of Division 23 – HVAC:
 - .1 Minimum three years of experience, or
 - .2 Approved by product manufacturers.
- .2 Contractors performing work on natural gas or propane systems shall be licensed as a gas and propane installer under O.Reg. 215, by the Technical Standards and Safety Authority.
- .3 Contractors performing work on fuel oil systems shall be licensed as a fuel system installer under O.Reg. 213, by the Technical Standards and Safety Authority.
- .4 Contractors performing work on refrigerant systems shall be licensed as a refrigerant installer under O.Reg. 75, by the Technical Standards and Safety Authority.

.3 Equipment certification

- .1 Equipment and fittings designated as pressure vessels or Class “H” fittings as per CSA B51, Part 1 shall:
 - .1 Be ASME stamped, and
 - .2 Have CRN registration.

- .4 Registration
 - .1 Register the following pressure vessel and pressure piping systems:
 - .1 Building heating and cooling water systems operating at pressures exceeding 1100 kPa; or temperatures exceeding 121°C;
 - .2 Steam and condensate systems.
- .5 Conform to CSA, municipal, provincial and federal building codes', Owner's HVAC Standard requirements as applicable for this project.
- .6 Layout drawings:
 - .1 HVAC 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 23 – HVAC 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.
 - .2 Prepare complete HVAC 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 23 Specification.
 - .3 HVAC systems layout drawings shall take into consideration architectural, structural, mechanical and electrical layouts of the building. Piping and ductwork mains and branches must be arranged to not interfere with any of the aforementioned systems and equipment.

1.4 DESIGN CRITERIA

- .1 Noise and vibration
 - .1 Noise levels due to equipment and ductwork shall permit attaining sound pressure levels in all eight (8) octave bands in occupied spaces conforming to (room criteria (RC)) (noise criteria (NC)) levels listed (in Table 1 in 'Sound and Vibration Control' Chapter of the ASHRAE HVAC Applications Handbook) (in the acoustical Consultant's Noise and Vibration Report attached to this Section) (in the below table).

Noise Criteria	
Space Usage	Max. Noise Level (NC)
Open Plan Office, Lab	35-40

- .2 Install equipment, piping and ductwork in accordance with good noise and vibration control engineering practices in order to meet the requirements specified in this Section.
- .3 If noise or vibration levels created by any mechanical equipment and systems transmitted to the occupied portion of the building or to other mechanical work, are over the maximum allowable levels, make all necessary changes to reduce the noise and vibration levels without any additional cost to the Owner.

1.5 **SUBMITTALS**

.1 Shop Drawings

- .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Submit product data for flashing system.

1.6 **PERMITS AND INSPECTIONS**

- .1 Submit layout drawings to the municipal Building Department; apply for and obtain permits required for HVAC Work and pay all costs levied for permits and inspections.

1.7 **REFERENCE STANDARDS**

- .1 CSA B51 - Boiler, Pressure Vessel, and Pressure Piping Code
- .2 CSA B272 - Pre-Fabricated Self Sealing Roof Vent Flashings
- .3 O. Reg. 75 –Refrigeration and Air Conditioning Mechanic
- .4 O. Reg. 213 – Fuel Oil
- .5 O. Reg. 215 - Fuel Industry Certificates
- .6 Technical Standards and Safety Authority (TSSA), Pressure Vessels Safety Division, inspection requirements for registered systems.

PART - 2 PRODUCTS

2.1 **HANGERS AND SUPPORTS**

- .1 In accordance with Section 20 05 29 - Bases, Hangers and Supports.

2.2 **THERMAL INSULATION**

- .1 In accordance with Section 20 07 00 - Mechanical Insulation.

2.3 **IDENTIFICATION FOR EQUIPMENT, VALVES AND PIPING**

- .1 In accordance with Section 20 05 53 - Mechanical Identification.

2.4 **GAUGES**

- .1 In accordance with Section 20 05 19 - Meters and Gauges.

2.5 **ELECTRIC MOTORS**

- .1 In accordance with Section 20 05 12 - Common Motor Requirements.

2.6 **ELECTRIC WIRING**

- .1 In accordance with Section 20 05 13 - Common Wiring Requirements.

2.7 **EXPANSION COMPENSATION**

- .1 In accordance with Section 20 05 16 - Expansion Control.

2.8 VIBRATION ISOLATION

- .1 In accordance with Section 20 05 48 - Vibration Control.

2.9 SEISMIC RESTRAINING

- .1 In accordance with Section 20 05 49 - Seismic Control.

2.10 VARIABLE FREQUENCY DRIVES

- .1 In accordance with Section 20 29 23 - Variable Frequency Drives.

2.11 ESCUTCHEONS

- .1 Escutcheons shall be satin-finish, corrosion-resisting steel, polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Obtain Interior Designer's approval for the required finish. Escutcheons shall be either one-piece or split-pattern, held in place by internal spring tension or setscrew.

2.12 FLASHING

- .1 Flashing for through-roof penetration and other waterproofed areas:
 - .1 Manufactured from composite material;
 - .2 Minimum dimensions of 500 mm x 500 mm;
 - .3 With sleeve extending at least 150 mm above roof.

PART - 3 EXECUTION

3.1 GENERAL

- .1 Execute the HVAC Work in accordance with requirements specified in the various Sections of Division 23 – HVAC.
- .2 Install complete HVAC ductwork and piping in accordance with the municipal, provincial and federal building codes, standard trade practice and as specified in this Specification.
- .3 Locate mains, risers and runouts concealed behind partition walls or above ceilings, except in service rooms and access spaces where piping shall be exposed.
- .4 Anchor, guide and support vertical and horizontal runs of piping to resist dead load and absorb thrust.
- .5 Generally, small diameter pipe runs from terminal units, reheat coils, radiant panels, and other services are not shown but must be provided.
- .6 Electrical interconnection of controls and instruments: is generally not shown but shall be provided. This includes interconnection of sensors, transmitters, transducers, control devices, control and instrumentation panels, alarms, instruments and computer workstations.

3.2 HVAC DEMOLITION

- .1 Refer to Division 01 – General Requirements, Division 02 – Existing Conditions and Section 20 00 23 – Work in Existing Buildings for general demolition requirements and procedures.

- .2 Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.
 - .1 Piping to be removed: remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - .2 Piping to be abandoned in place: drain piping and cap or plug piping with same or compatible piping material.
 - .3 Equipment to be removed: disconnect and cap services and remove equipment.
 - .4 Equipment to be removed and reinstalled: disconnect and cap services; remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 - .5 Equipment to be removed and salvaged: disconnect and cap services; remove equipment and deliver to the Owner.
- .3 If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.3 **SPECIAL SERVICE CONNECTIONS**

- .1 Provide natural gas and/or process piping connections to all equipment requiring these services but not supplied under the scope of the Division 21, 22, 23 or 25 Contract.
- .2 Provide a shut-off valve on each service line close to the apparatus.
- .3 Where specific sizes are not shown, valves and final connections to the equipment shall be the same or one pipe size larger than the equipment tapping size, per manufacturer's installation instruction.
- .4 For equipment marked as not in Mechanical Contract, do not make final connections but provide the required HVAC services.
- .5 For equipment marked as supplied by the Owner, make final connections and provide all necessary accessories.

3.4 **FLASHING**

- .1 Provide flashing for piping penetrations through roofs and other waterproofed areas. Leave flashing ready for the Contractor performing the roofing Work to make watertight connections.

3.5 **ESCUTCHEONS**

- .1 Install escutcheons at finished surfaces where bare or insulated exposed piping passes through floors, walls, or ceilings in finished areas. Escutcheons shall be fastened securely to pipe or pipe covering. In wet or humid areas such as washrooms, housekeeping rooms, pool areas, seal pipe penetrations through unrated walls behind escutcheons using plumber's putty.

3.6 **PAINTING**

- .1 Coordinate the finish paint of HVAC piping with the Contractor performing the Work of Section 09 91 00 – Painting as follows:
 - .1 Concealed from view: not painted.

- .2 Exposed to view: bare, uninsulated bare steel pipe, fittings and associated hangers exposed to view in finished areas shall be painted with one coat approved rust inhibiting primer.

3.7 **TESTING**

- .1 Execute HVAC systems and equipment tests in accordance with the requirements of municipal, provincial and federal codes, and as described under Section 23 08 00 - Commissioning of HVAC. For testing procedures of specialty systems refer to the respective Sections of the Division 23 - HVAC Specifications.
- .2 Furnish pumps, gauges and other equipment required to complete test.
- .3 Charge system with water only when there is no possibility of freeze-up.
- .4 Perform tests after HVAC pumps have been tested.
- .5 Prior to testing, ensure that shut-off valves, pressure reducing valves, balancing valves, and control devices are functioning.
- .6 Adjust setting of pressure reducing stations to the required setpoints.
- .7 Check horizontal pipe with an accurate level for any alterations in pitch. Inspect laterals, cross arms, and eliminate pockets. Correct any cases of water hammer.
- .8 Execute tests in the presence of the Consultant and Owner's authorized representative.
- .9 Test all water and steam lines hydrostatically at 1-1/2 times the working pressure but at not less than 1,380 kPa, for a period of not less than four (4) hours without any drop in pressure. For systems with operating pressures in excess of 1723 kPa, perform the pressure test at 345 kPa above the maximum operating pressure. Do testing before piping is buried or furred in and before pressure sensitive devices are installed in the pipework.
- .10 Test natural and propane gas piping, and exhaust flues from gas-fired equipment in accordance with the requirements of CSA B149.1. Test pipe joints with a soap solution while the piping is under pressure. Purge piping after the pressure test in accordance with CSA B149.1.
- .11 Test ductwork following the procedure described under Section 23 31 00 - HVAC Ducts and Casings.
- .12 Promptly repair defects which develop during tests, and then re-test system to complete satisfaction of authorized inspectors. Repairs to piping shall be made with new materials. Caulking of screwed joints or holes is not acceptable.

3.8 **FLUSHING**

- .1 Inspect the systems, and remove any heavy debris and excessive oil and dirt. Thoroughly clean, insofar as possible, welded joints by swabbing interior of pipe with swabs soaked with a caustic solution.
- .2 Flush all completed systems with clear water at the highest obtainable pressure and velocity. Flush water piping with water flowing at a velocity of not less than 1.8m/sec, for a period of 15 minutes or longer as required to remove all dirt, scale, and cuttings from the entire length of the piping.
- .3 During flushing and cleaning, maintain all isolating and control valves in the open position.

- .4 Provide adequate personnel to monitor the flushing operation and to ensure that drain lines are unobstructed in order to prevent flooding of the building. The Division 23 – HVAC Contractor shall be responsible for any flood damage resulting from flushing of the system.
- .5 After the system flushing has been completed, drain down the system to remove the flushing water.
- .6 Remove and clean strainer screens after flushing operation has been completed.

3.9 **COMPLETION**

- .1 Provide written certification to the Owner that the HVAC pipe systems were installed, flushed and tested in accordance with appropriate codes, approved plans and calculations, and confirming the following:
 - .1 Water pressure test performed and HVAC pipe systems are leak free.
 - .2 HVAC inspections completed. Issue the necessary certificates.

3.10 **DEMONSTRATION**

- .1 Prior to final acceptance of the HVAC systems, the Division 23 - HVAC Contractor shall provide operational training in all aspects of these systems to the Owner's key personnel. Training shall include emergency procedures, safety requirements, and demonstration of the systems, including all interfaces with the Control and Building Automation Systems.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 23 05 00 - Common Works for HVAC shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 This Section includes requirements for commissioning the HVAC systems, subsystems and equipment. This Section supplements the general requirements specified under Section 20 08 00 - Commissioning Requirements.

1.2 COMMISSIONED SYSTEMS

- .1 Automatic control related to HVAC systems, not covered under the Work of Division 25 – Building Automation;
- .2 Air handling systems;
- .3 Steam generation and distribution systems;
- .4 Electric heating systems;
- .5 Air distribution and exhaust systems;
- .6 Fire and smoke dampers;
- .7 Variable frequency drives serving HVAC equipment;
- .8 Indoor air quality (IAQ) control systems;
- .9 Laboratory hood exhaust and treatment systems;
- .10 Natural gas and propane supply systems;
- .11 Refrigeration systems installed under the Work of Division 23 – HVAC;
- .12 Unitary heating and cooling systems.

PART - 2 PRODUCTS

2.1 NOT APPLICABLE.

PART - 3 EXECUTION

3.1 TESTING OF HVAC SYSTEMS

- .1 Testing of air distribution systems:
 - .1 Test for air leakage in accordance with the SMACNA manuals, all ductwork with the exception of ductwork downstream of air terminal units or other pressure reducing devices. Seal ducts at all equipment connections and pressurize with a

- smaller blower. Test the system as a whole or in parts, provided all ductwork is accessible for inspection at the time of the test. Provide test blower, calibrated orifice tube and all test equipment. Block off the inlet opening of the test blower before the test blower is started. Then open the inlet opening slowly to prevent over-pressurizing the system. Refer to the Specification for the criteria for leakage evaluation and for the definition of acceptable test results.
- .2 Test the entire system for noise, tightness of joints and proper functioning of the system. Noise tests shall be made under minimum system pressure drop conditions (highest air velocities and clean filter conditions). Make all necessary alterations and repeat the tests until satisfactory operation is achieved.
 - .3 Perform all tests in the presence of the Commissioning Authority. Complete the testing forms and forward to the Consultant and the Commissioning Authority.
 - .4 Adjust minimum outside air controller and adjust return air and exhaust air damper linkages to approximately design air quantities, for both maximum and minimum conditions where required, to ensure freezing conditions will not occur.
 - .5 Coordinate with the TAB Contractor to ensure all necessary manual dampers and splitter dampers for balancing the system are installed. Notify the Consultant in writing that this coordination has taken place before installation begins.
 - .6 Ensure that access is provided to all fire dampers and equipment that require servicing. Fire damper operation will be verified by the Commissioning Authority in coordination with the Contractor.
 - .7 Operate all equipment at design conditions and change fan sheaves if required to provide the required conditions.
 - .8 Make qualified staff available as required by the TAB Contractor, to correct any deficiency in air distribution systems which prevents the TAB Contractor from balancing the systems.
 - .9 Provide copies of all shop drawings requested by the TAB Contractor.
 - .10 Provide access ports for balancing as requested by the TAB Contractor.
- .2 TAB Contractor's balancing of air distribution systems:
- .1 The TAB Contractor shall balance the air systems in accordance with Section 20 05 93 - Testing, Adjusting and Balancing.
 - .2 Coordinate with the TAB Contractor and provide assistance during the balancing process.
 - .3 Balancing Work shall not commence until all point-to-point component testing has been satisfactorily completed.
 - .4 The TAB Contractor shall take air measurements, make final adjustments, report the air volume at each air terminal unit, diffuser, register and grille, and measure the static pressure upstream and downstream of the fan, the fan speed and the motor current. The return and supply air flows shall be measured when mixing dampers are set for full outside air and minimum outside air positions.
 - .5 Set the minimum position for the mixing dampers. Provide new filters when the final balancing has been completed.
 - .6 Repair the insulation or vapour barrier in an approved manner, if damaged.
 - .7 Adjust each supply outlet to provide proper throw and distribution in accordance with architectural requirements.

- .8 Set up fans on all systems to give the minimum discharge pressure required to overcome the resistance of the terminal unit, discharge ductwork and diffusers.
- .9 TAB Contractor shall not disconnect any control device after it has been calibrated.
- .10 The TAB Contractor is responsible for balancing the systems to obtain the design conditions and shall repeat the balancing until the required conditions have been met.
- .11 At the time of final inspection, recheck in the presence of the Commissioning Authority random selections of air quantities and fan data recorded in the certified report. Points or areas for recheck will be selected by the Commissioning Authority and shall be a maximum of 50% of the report data.
- .12 At the time of verification, measure space temperatures and relative humidity in a representative number of rooms to verify performance. Tabulate these results and include in the certified report as an appendix.
- .13 A measured flow deviation of more than 10% between the verification reading and the reported data will be considered as failing the verification procedure.
- .14 A failure of more than 10% of the selected verification readings will be considered unacceptable and will result in rejection of the report.
- .15 In the event the report is rejected, rebalance all systems, submit new certified reports and re-inspect, at no additional cost to the Owner.
- .16 Submit a copy of the final test and balance report to the Commissioning Authority for review.
- .3 Air handling systems:
 - .1 Air handling units shall be inspected and tested by manufacturer's technician. Technician shall enter the test results on the forms provided by manufacturer. The Commissioning Authority shall witness the final operational test.
 - .2 The technician shall verify that the air handling units have been installed according to manufacturer's recommendations, shop drawings and the Specification.
 - .3 Tests shall include verification of electrical power, electrical interlocks, safeties, control, coils, plenums, fans and dampers.
 - .4 The technician shall start-up the air handling units and monitor the operation for a minimum of 4 hours of running time after all tests have been completed. The technician shall revisit the site after 1 month of operation and monitor the operation of the system for a minimum period of 4 hours running time. The technician shall issue a report to Consultant after each visit.
 - .5 Rectify any deficiency identified by the TAB Contractor.
- .4 Fire dampers:
 - .1 All fire dampers, combination fire/smoke dampers and smoke dampers shall be inspected and tested by the Contractor and the Commissioning Authority. Verify the operation of each fire damper by removing the fusible link and extending the damper the fully closed and back to the fully open position.
- .5 Piping systems (applicable to natural gas, steam and condensate):
 - .1 Test natural gas and propane piping systems in accordance with CSA B149.1.
 - .2 Test all other systems over a period of 24 hours using a hydrostatic test in accordance with Division 23 requirements. Remove devices, vents and gauges

- and temporarily plug connections as required. Provide temporary by-pass when required. Protect equipment not capable of withstanding test pressure during testing.
- .3 After completion of the testing, rough balance the water systems and ensure all coils, heat exchangers, are operating approximately at design conditions to ensure freezing conditions will not occur anywhere. Adjust the circuits by means of the balancing valves.
 - .4 Where multiple branch lines are installed, the flow in these shall be balanced to ensure water flow to all equipment.
 - .5 All tests for the systems shall be witnessed. Complete the testing forms and forward copies of the tests reports to the Consultant and the Commissioning Authority.
 - .6 Coordinate with the TAB Contractor to ensure all necessary valves required for balancing the systems are installed. Notify the Consultant and the Commissioning Authority in writing that this co-ordination has taken place before installation begins.
 - .7 Ensure that access is provided to all valves and equipment that requires servicing.
 - .8 Operate all equipment at design conditions and trim impellers to provide the required conditions. Final verification of balancing shall be coordinated by the TAB Contractor and witnessed/verified by the Commissioning Authority.
 - .9 Make qualified staff available as required by TAB Contractor, to correct any deficiency in the mechanical systems which prevents TAB Contractor from balancing the system.
 - .10 Provide copies of all shop drawings requested by TAB Contractor.
- .6 Humidification systems:
- .1 Humidifiers shall be inspected and tested by manufacturer's technician. The technician shall enter the test results on the forms provided by manufacturer. The Commissioning Authority shall witness the final operational test.
 - .2 The technician shall verify that the humidifiers have been installed according to manufacturer's recommendations, shop drawings and the Specification.
 - .3 Tests shall include the verification of safeties and controls, a review of drains, steam piping and insulation, steam nozzles and distribution.
 - .4 The technician shall start-up the humidifiers, monitor and record their operation for a minimum of 4 hours running time after the tests have been completed. The technician shall revisit the site after 1 month of operation and monitor the operation of the humidifiers for a minimum period of 4 hours running time. Reports shall be forwarded to Consultant after each visit.
- .7 Steam system:
- .1 Have the installation of all steam devices such as steam traps, steam trap monitors, vacuum breakers, pressure reducing valve, safety relief valve, steam relief valves and steam separators inspected and tested by the manufacturers. Manufacturers shall complete the testing forms and submit a report to the Consultant.
 - .2 Have the installation of all steam to steam generators, heat exchangers, condensate receivers, tanks and pumps inspected and tested by the

manufacturers. Manufacturers shall complete the testing forms and submit a report to the Consultant.

- .8 Testing of HVAC specialty equipment and systems:
 - .1 Start-up and test procedures must be consistent with manufacturer's recommendations contained in the Operating and Maintenance Manual.
 - .2 The start-up report shall record all observations made during the start-up procedures including problems and their resolutions.
 - .3 Retain the services of the manufacturers' technicians to test the equipment and associated systems. Technicians shall record the results of the tests on the testing forms. The tests shall be witnessed by the Commissioning Authority. When the tests have been completed with satisfactory results, the technicians and the witnessing authority shall sign the forms. A copy of the forms shall be forwarded to the Consultant and the Commissioning Authority. The original shall be inserted into the Systems Operating Manual.
 - .4 Should equipment or systems fail a test, the test shall be repeated after repairs or adjustments have been made. The additional tests shall be witnessed by the Commissioning Authority.
 - .5 Tests which have not been witnessed shall not be accepted and shall be repeated.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 23 05 00 - Common Works for HVAC shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 Design, supply, install, test and adjust all local control and monitoring systems specified under the diverse Sections of Division 23 – HVAC.

1.2 RELATED WORK

- .1 The following work is provided under other Sections or Divisions of the Work:
 - .1 Centralized control and monitoring of HVAC systems and equipment: Division 25 – Building Automation.
 - .2 Power supply to HVAC equipment and to associated control equipment: Division 26 – Electrical.

1.3 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for all control components including technical specification data sheets for each system component, sequence of operation, wiring diagrams, control device arrangements, control device locations on floor plans to scale.

1.4 REFERENCE STANDARDS

- .1 Ontario Electrical Safety Code

1.5 QUALITY ASSURANCE

- .1 Provide electrical and electronic equipment which is CSA approved where such approval is required by the authorities having jurisdiction.
- .2 Conduit and wiring materials and methods shall be in strict accordance with the requirements of Division 26 – Electrical and the applicable provincial and federal electrical codes and standards.

PART - 2 PRODUCTS

2.1 CONTROL AND INTERLOCK WIRING

- .1 Provide control and interlock wiring for HVAC equipment with local control components supplied loose. Refer to specific requirements under the diverse Sections of Division 23 – HVAC.

- .2 Wiring shall be in accordance with the requirements of Section 20 05 13 – Common Wiring Requirements and Division 26 – Electrical.

2.2 **ELECTRICAL CONTROL DEVICES**

- .1 Switches
 - .1 Provide switches for system monitoring, safety and operational interlocks.
- .2 Relays
 - .1 Provide electric switching relays, ULC listed, as required and where indicated. Unless otherwise indicated, install relays within control cabinet. Provide line voltage or low voltage general purpose type relays unless heavy duty type are indicated.
- .3 Control cabinets and panels
 - .1 Provide control cabinets and panels with mounting brackets sized to house all local control devices.

PART - 3 EXECUTION

3.1 **INSTALLATION**

- .1 Install all components and make interconnections.
- .2 Connect electric control equipment and interlocks in accordance with the requirements of Division 26 – Electrical.
- .3 Post a control diagram of each local control system, as prepared by manufacturer, on the wall of the associated equipment rooms.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 23 05 00 - Common Works for HVAC shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 Supply and install natural gas distribution system.

1.2 SUBMITTALS

- .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Submit product data for natural gas piping system components.

1.3 CODES AND REGULATIONS; PERMITS, COSTS AND FEES

- .1 Install, test and purge to current:
 - .1 Natural Gas Installation Code CAN/CGA-B149.1.

PART - 2 PRODUCTS

2.1 SPECIALTIES

- .1 Pressure Reducing Regulating Valves
 - .1 Spring loaded, quick response regulator with stabilizer vent, partial internal relief, suitable for service with downstream solenoid valves.
 - .1 Fisher CS800
 - .2 or Leslie equivalent
- .2 Safety Relief Valves
 - .1 Throttling type relief valve.
 - .2 Size valves so that combined capacity of relief port of gas regulator and of relief valve will provide relief capacity equal to total capacity of pressure reducing station.
 - .1 Fisher 289 series
 - .2 or Leslie equivalent
- .3 Blocking (Shut-Off) Solenoid Valves
 - .1 Approvals
 - .1 CGA listed to CAN. 1-6.5-78
 - .2 CGA listed to CAN/CGA-3.9-M87
 - .3 CSA listed to CSA C22.2, No. 139

- .2 Brass or aluminum body, normally closed (NC) solenoid natural gas valve, 120 VAC, to NPS 2.
 - .1 Ascoelectric Ltd
- .4 Bleed (Vent) Solenoid Valves
 - .1 Approvals
 - .1 CSA listed to CSA C22.2, No. 139
 - .2 Brass or aluminum body, normally open (NO) solenoid natural gas valve, 120 VAC, to NPS 2½.
 - .1 Ascoelectric Ltd
- .5 Safety Shut-Off Valves
 - .1 Approvals
 - .1 CGA 3.9
 - .2 FM listed
 - .3 IRI listed for block/bleed/vent
 - .2 Gray iron body, normally closed (NC), rising stem valve, solenoid actuated control, DPDT switch to indicate valve closed position. Valve to only open when power is supplied to the solenoid. (Automatic) (or) (Manual) opening (as shown on drawings). NPS ¾ to NPS 6.
 - .1 Maxon 5000-CP (automatic opening)
 - .2 Asco General H117A (automatic opening)
 - .3 Maxon 808-CP (manual opening)
 - .4 Ascoelectric 8044 (manual opening)

PART - 3 EXECUTION

3.1 INSTALLATION - GENERAL PIPING

- .1 Piping
 - .1 Exposed piping:
 - .1 NPS 2 and smaller: screwed
 - .2 NPS 2½ and larger: welded with butt weld fittings
 - .2 Concealed piping:
 - .1 NPS 2 and smaller: welded with socket weld fittings
 - .2 NPS 2½ and larger: welded with butt weld fittings
 - .3 Equipment connections:
 - .1 NPS 2 and smaller: screwed unions
 - .2 NPS 2½ and larger: flanges
 - .4 Branch connections:
 - .1 May be welded directly into main provided main is more than NPS 4 and branch is at least 2 pipe sizes smaller than main

- .2 Cut openings in main true and bevelled
 - .3 Do not project branch pipes inside main pipe
 - .4 Size openings to prevent entry of welding metal and slag into pipes
 - .5 Saddle type branch welding fittings used on mains:
 - .1 Hole saw or drill and ream main to maintain full inside diameter of branch line prior to welding
 - .6 Make-up joints in screwed pipe with joint compound.
 - .7 Provide clearance for maintenance of equipment, valves and fittings.
 - .8 Ream pipe after cutting to length, clean off scale and dirt inside and outside of pipe.
 - .9 Cap ends during construction to prevent entry of foreign matter.
 - .10 Slope piping down in direction of flow to low points.
 - .11 Use eccentric reducers at pipe size change installed FOB to provide positive drainage.
 - .2 Valves
 - .1 Install valves with stems upright or horizontal.
 - .2 Install valves at branch take-offs to isolate each piece of equipment.
- 3.2 **INSTALLATION - REGULATING AND CONTROL DEVICES**
- .1 Pressure Reducing Stations
 - .1 Provide, where shown, pressure reducing stations consisting of pressure regulating valve, relief valve, isolating valves and pressure gauges on both sides of pressure reducing station.
 - .2 Pressure Reducing Regulators
 - .1 Provide regulator control lines, where required, and connect to downstream piping a minimum of 8 to 10 pipe diameters from the regulator and any elbows.
 - .3 Relief Valves
 - .1 Select relief valves based on wide open (valve failure condition) flow rates and not on regulated flow rate.
 - .4 Vents
 - .1 Run vent piping from relief connection on gas regulator and relief valves up through roof. Provide roof sleeves and flashing. Terminate pipe with turn down bend, and protect opening with stainless steel insect screen, to approval of authorities having jurisdiction.
 - .2 Individual vent line sizes:
 - .1 Equal to relief port connection size where total length of vent is less than 15 metres
 - .2 One size larger than port connection size where total length of vent is between 15 m and 30 m
 - .3 One additional size larger for each additional 15 m of pipe length

- .3 Combined vent line sizes:
 - .1 Individual vent lines can be combined into common vents, where the variance between the inlet pressures of all relief devices is less than 10%, and the variance between the outlet pressures of all relief devices is less than 10%
 - .2 Size the combined vent to have a cross sectional area equal to the largest relief device opening, plus 50% of the total area openings of all other devices.
- .5 Safety, Blocking and Vent Solenoid Valves
 - .1 Install valves in accordance with manufacturers recommendations.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 23 05 00 - Common Works for HVAC shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 Provide refrigerant pipe systems, including valves, fittings, accessories and connections to all equipment.

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for refrigerant systems piping, fittings, joints, valves and related material.

1.3 REFERENCE STANDARDS

- .1 ASTM B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
- .2 ANSI B31.5 - Code for Pressure Piping
- .3 CSA B52-M - Mechanical Refrigeration Code
- .4 ASHRAE 15 - Safety Standard for Refrigeration Systems

PART - 2 PRODUCTS

2.1 GENERAL

- .1 Refrigerant piping, valves, fittings, and accessories shall be in accordance with ASHRAE 15 and ASME B31.5, except as specified herein. Refrigerant piping, valves, fittings, and accessories shall be compatible with the fluids used and capable of withstanding the pressures and temperatures of the service. Refrigerant piping, valves, and accessories used for refrigerant service shall be cleaned, dehydrated, and sealed (capped or plugged) prior to shipment from the manufacturer's plant.

2.2 REFRIGERANT PIPING

- .1 Pipe - Copper
 - .1 Type ACR copper tubing, soft annealed or hard drawn
 - .2 Type ACR copper tubing, hard drawn: to ASTM B280
 - .3 Deoxidized and dehydrated, with ends factory sealed and identified by the manufacturer as being suitable for refrigeration service

- .2 Pipe – Steel
 - .1 Schedule 40 steel pipe for refrigerant service to ASTM A 53/A 53M, or
 - .2 Cold-rolled, electric-forged, welded-steel tubing to ASTM A 334/A 334M, Grade 1.
- .3 Fittings - Copper
 - .1 Heavy wrought copper, solder joint type
 - .2 Adapter fittings at screwed connections
 - .3 On NPS 5/8 and less, flareless compression type
- .4 Fittings – Steel
 - .1 Butt- or socket-welded;
 - .2 Threaded, or
 - .3 Flanged fittings and connections.
- .5 Unions
 - .1 Rating: 150°C maximum temperature rating, 2760 kPa working pressure.
 - .2 Brass tail piece adaptors for copper tubing, forged steel flanges, steel bolts, bronze nuts and asbestos-free fibre gasket.
 - .3 Acceptable Manufacturers: Henry Valve Company Type P30.
- .6 Flanges
 - .1 Class 150 with non-asbestos compressed gaskets, 1.59 mm (1/16 inch) thickness, full face or self-centering flat ring type.
 - .2 Gaskets shall contain aramid fibers bonded with styrene butadiene rubber (SBR) or nitrile butadiene rubber (NBR).
 - .3 Bolts shall be high or intermediate strength material.
- .7 Flexible Hose
 - .1 Bronze construction with braided wire exterior jacket and union connection on one end.
 - .2 Minimum length: 6 times the diameter of the hose.
 - .3 Rating: suitable for 150°C maximum temperature and 2760 kPa working pressure.
 - .4 Acceptable Manufacturers: Flexonics or Anaconda.
 - .5 Coiled section of soft annealed tubing may be used instead of hose on lines not larger than NPS 5/8.

2.3 **PIPING ACCESSORIES**

- .1 Filter Driers
 - .1 Driers shall conform to ARI 710. Sizes 15 mm (5/8 inch) and larger shall be the full flow, replaceable core type. Sizes 15 mm (1/2 inch) and smaller shall be the sealed type. Cores shall be of suitable desiccant that will not plug, cake, dust, channel, or break down, and shall remove water, acid, and foreign material from the refrigerant. Filter driers shall be constructed so that none of the desiccant will pass into the refrigerant lines. Minimum bursting pressure shall be 10.3 MPa (1,500 psi).

- .2 Sight Glass and Liquid Level Indicator
 - .1 Assembly and Components
 - .1 Assembly shall be pressure- and temperature-rated and constructed of materials suitable for the service. Glass shall be borosilicate type. Ferrous components subject to condensation shall be electro-galvanized.
 - .2 Gauge Glass
 - .1 Gauge glass shall include top and bottom isolation valves fitted with automatic checks, and packing followers; red-line or green-line gauge glass; elastomer or polymer packing to suit the service; and gauge glass guard.
 - .3 Bull's-Eye and Inline Sight Glass Reflex Lens
 - .1 Bull's-eye and inline sight glass reflex lens shall be provided for dead-end liquid service. For pipe line mounting, two plain lenses in one body suitable for backlighting viewing shall be provided.
 - .4 Moisture Indicator
 - .1 Indicator shall be a self-reversible action, moisture reactive, color changing media. Indicator shall be furnished with full-color-printing tag containing color, moisture and temperature criteria. Unless otherwise indicated, the moisture indicator shall be an integral part of each corresponding sight glass.
- .3 Vibration Dampeners
 - .1 Dampeners shall be of the all-metallic bellows and woven-wire type.
- .4 Flexible Pipe Connectors
 - .1 Connector shall be a composite of interior corrugated phosphor bronze or Type 300 Series stainless steel, as required for fluid service, with exterior reinforcement of bronze, stainless steel or monel wire braid. Assembly shall be constructed with a safety factor of not less than 4 at 150°C (300°F). Unless otherwise indicated, the length of a flexible connector shall be as recommended by the manufacturer for the service intended.
- .5 Strainers
 - .1 Strainers used in refrigerant service shall have brass or cast iron body, Y-or angle-pattern, cleanable, not less than 60-mesh noncorroding screen of an area to provide net free area not less than ten times the pipe diameter with pressure rating compatible with the refrigerant service. Screens shall be stainless steel or monel and reinforced spring-loaded where necessary for bypass-proof construction.

2.4 VALVES

- .1 Valves shall be designed, manufactured, and tested specifically for refrigerant service. Valve bodies shall be of brass, bronze, steel, or ductile iron construction. Valves 25 mm (1 inch) and smaller shall have brazed or socket welded connections. Valves larger than 25 mm (1 inch) shall have butt welded end connections. Threaded end connections shall not be used, except in pilot pressure or gauge lines where maintenance disassembly is required and welded flanges cannot be used. Internal parts shall be removable for inspection or replacement without applying heat or breaking pipe connections. Valve stems exposed to the atmosphere shall be stainless steel or corrosion resistant metal plated carbon steel. Direction of flow shall be legibly and permanently indicated on the valve

body. Control valve inlets shall be fitted with integral or adapted strainer or filter where recommended or required by the manufacturer. Purge, charge and receiver valves shall be of manufacturer's standard configuration.

.2 Refrigerant Stop Valves

- .1 Valve shall be the globe or full-port ball type with a back-seating stem especially packed for refrigerant service. Valve packing shall be replaceable under line pressure. Valve shall be provided with a handwheel operator and a seal cap. Valve shall be the straight or angle pattern design as indicated.

.3 Check Valves

- .1 Valve shall be the swing or lift type as required to provide positive shutoff at the differential pressure indicated. Valve shall be provided with resilient seat.

.4 Liquid Solenoid Valves

- .1 Valves shall comply with ARI 760 and be suitable for continuous duty with applied voltages 15 percent under and 5 percent over nominal rated voltage at maximum and minimum encountered pressure and temperature service conditions. Valves shall be direct-acting or pilot-operating type, packless, except that packed stem, seal capped, manual lifting provisions shall be furnished. Solenoid coils shall be moisture-proof, UL approved, totally encapsulated or encapsulated and metal jacketed as required. Valves shall have safe working pressure of 2,760 kPa (400 psi) and a maximum operating pressure differential of at least 1,375 kPa (200 psi) at 85 percent rated voltage. Valves shall have an operating pressure differential suitable for the refrigerant used.

.5 Expansion Valves

- .1 Valve shall conform to ARI 750 and ASHRAE 17. Valve shall be the diaphragm and spring-loaded type with internal or external equalizers, and bulb and capillary tubing. Valve shall be provided with an external superheat adjustment along with a seal cap. Internal equalizers may be utilized where flowing refrigerant pressure drop between outlet of the valve and inlet to the evaporator coil is negligible and pressure drop across the evaporator is less than the pressure difference corresponding to 1°C (2°F) of saturated suction temperature at evaporator conditions. Bulb charge shall be determined by the manufacturer for the application and such that liquid will remain in the bulb at all operating conditions. Gas limited liquid charged valves and other valve devices for limiting evaporator pressure shall not be used without a distributor or discharge tube or effective means to prevent loss of control when bulb becomes warmer than valve body. Pilot-operated valves shall have a characterized plug to provide required modulating control. A de-energized solenoid valve may be used in the pilot line to close the main valve in lieu of a solenoid valve in the main liquid line. An isolatable pressure gauge shall be provided in the pilot line, at the main valve. Automatic pressure reducing or constant pressure regulating expansion valves may be used only where indicated or for constant evaporator loads.

.6 Safety Relief Valves

- .1 Valve shall be the two-way type, unless indicated otherwise. Valve shall bear the ASME code symbol. Valve capacity shall be certified by the National Board of Boiler and Pressure Vessel Inspectors. Valve shall be of an automatically reseating design after activation.

- .7 Evaporator Pressure Regulators, Direct-Acting
 - .1 Valve shall include a diaphragm/spring assembly, external pressure adjustment with seal cap, and pressure gauge port. Valve shall maintain a constant inlet pressure by balancing inlet pressure on diaphragm against an adjustable spring load. Pressure drop at system design load shall not exceed the pressure difference corresponding to a 1°C (2°F) change in saturated refrigerant temperature at evaporator operating suction temperature. Spring shall be selected for indicated maximum allowable suction pressure range.
- .8 Refrigerant Access Valves
 - .1 Refrigerant access valves and hose connections shall be in accordance with ARI 720.

PART - 3 EXECUTION

3.1 GENERAL

- .1 Use pipes which conform to CSA and ASTM standards.

3.2 PIPING INSTALLATION

- .1 Consider the piping layout shown on the Drawings as diagrammatic, indicating the general runs and connections, and that the piping may, or may not, in all parts be shown in true position.
- .2 Ream all piping and keep plugged to prevent entry of dirt.
- .3 Accurately cut pipe to the established measurements and work into place without springing or forcing. In any situation where bending of the pipe is required, use a standard pipe-bending template. Pipe hangers, supports, restraint of system piping and seismic bracing shall be installed accordance with Sections 20 05 29 - Bases, Hangers and Supports, and 20 05 49 - Seismic Control.
- .4 All fittings shall be of same material or equal in quality and thickness to the pipe to which they are connected.
- .5 Anchor, guide and laterally support vertical and horizontal piping to support filled weight and absorb thrust under operating conditions.
- .6 Erect piping so that gravity forces and thrust from changes in direction do not stress connections to apparatus.
- .7 Thoroughly clean the inside of fittings and outside of pipe with steel wool and coat with flux, before soldering or brazing any copper pipe work joint. Remove the working parts of valves before soldering or brazing commences, and replace after soldering or brazing is complete. Solder or braze joints with blow torch or oxy-acetylene flame.
- .8 Copper Pipe – above grade
 - .1 Provide dielectric unions or couplings at all connections between copper tubing and ferrous piping.

3.3 JOINTS, UNIONS, FLANGES AND COUPLINGS

- .1 Pipe joints
 - .1 Preparation
 - .1 Ream pipe ends and thoroughly clean all dirt, cuttings and foreign matter from pipe after cutting.
 - .2 Thoroughly clean all fittings, valves and equipment before connections are made.
 - .3 Cut copper tubing with a tube cutter and clean the joining surfaces of the tubing and fitting with fine emery cloth. Wipe clean with a dry cloth.
 - .2 Carbon steel welded joints:
 - .1 To ANSI B31.1 Section IX for welding.
 - .2 Fusion welded joints made by electric arc welding, gas metal arc welding, or oxy-acetylene gas welding.
 - .3 Unless more stringent methods of inspections are specified, the Consultant will visually inspect welded joints for fusion of metal, icicles, alignment. Remove any defects and remake defective joints to the Consultant's satisfaction.
- .2 Change of direction
 - .1 Use standard pipe fittings.
 - .2 Use long radius welded steel elbows unless short radius elbows are specifically authorized by the Consultant.
 - .3 Mitered joints or field fabricated pipe bends are not permitted.

3.4 REFRIGERANT PIPING

- .1 Install piping to conform to applicable requirements of ANSI B31.5 Code for Pressure Piping Section 5 "Refrigeration Piping" and CSA B52-M "Mechanical Refrigeration Code" latest issue.
- .2 Make solder type joints with "sil-fos" silver solder or similar high melting point solder having a melting point of at least 538°C. Remove all interior parts of refrigerant specialties and valves before applying heat to the joint.
- .3 Provide refrigerant hoses on refrigerant line connections to equipment with reciprocating or rotating elements.
- .4 Test procedure and evacuation procedures: conform to ANSI B31.5.
- .5 Test pressure: in accordance with CSA Code B52-M.
- .6 Provide all refrigerant required for testing and charging of the system.
- .7 Purge refrigerant piping with anhydrous nitrogen prior to making connection to pre-evacuated equipment to ensure removal of all moisture and non-condensable gases.
- .8 Completely evacuate to 0.5 torr (500 micron), seal and leave for 24 hours, re-evacuate to 0.5 torr, and charge all components of refrigeration system not evacuated by manufacturer, in accordance with manufacturer's printed recommendations.

- .9 Do not use the refrigeration compressor to evacuate the system under any circumstances. Evacuation the system using a vacuum pump at an ambient temperature not less than 2°C to ensure removal of all moisture and non-condensable gases.
- .10 After testing, evacuation and charging is completed, allow system to operate under normal conditions for a minimum period of 24 hours, at which time, moisture indicator should indicate a dry system. If it does not so indicate, change dryer and operate unit for another 24 hours. Repeat this procedure until moisture indicator indicates a thoroughly dry system.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
 - .2 Supply and install HVAC duct systems including:
 - .1 Supply air, return air, outside air, exhaust, make-up air, transfer air and relief systems.
 - .2 Exhaust duct for chemical fume hoods.
- .2 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Section 20 00 13 – Mechanical General Provisions and 23 05 00 - Common Works for HVAC shall apply to and govern this Section.
- .3 Definitions
 - .1 SMACNA Standards as used in this Section: 'HVAC Duct Construction Standards, Metal and Flexible', latest edition.
 - .2 Seal or sealing: the use of liquid or mastic sealant, with or without compatible tape overlay, or gasketing of flanged joints, to keep air leakage at duct joints, seams and connections to an acceptable minimum.
 - .3 Exposed duct: exposed to view in a finished room.

1.2 RELATED WORK

- .1 Fire stopping: Section 07 84 00 – Fire Stopping and Smoke Seals
- .2 Seismic restraints: Section 20 05 49 - Seismic Control
- .3 Access doors, turning vanes, site fabricated dampers: Section 23 33 00 – Duct Accessories

1.3 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for rigid and flexible ductwork, and all related materials, including:
 - .1 Rectangular ducts:
 - .1 Schedules of duct systems, materials and selected SMACNA construction alternatives for joints, sealing, thickness and reinforcement.
 - .2 Sealants, tapes and gaskets.
 - .2 Round and flat oval duct construction details:
 - .1 Manufacturer's details for duct fittings.

- .2 Sealants, tapes and gaskets.
- .3 Installation instructions.
- .3 Plenums and casings:
 - .1 Construction details, materials.
 - .2 Dimensioned assembly drawings.
 - .3 Installation hardware and instructions.

1.4 **REFERENCE STANDARDS**

- .1 SMACNA HVAC Duct Construction Standards - Metal and Flexible
- .2 SMACNA HVAC Air Duct Leakage Test Manual
- .3 SMACNA HVAC Systems Testing, Adjusting and Balancing guidelines.
- .4 SMACNA Duct Cleanliness for New Construction guidelines.
- .5 ASHARE 62.1 - Ventilation for Acceptable Indoor Air Quality
- .6 ASHRAE 154 - Ventilation of Commercial Cooking
- .7 ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
- .8 ASTM A480/A480M - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
- .9 ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
- .10 ASTM A635/A635M - Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Alloy, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, General Requirements for
- .11 ASTM A36/A36M - Standard Specification for Carbon Structural Steel
- .12 ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- .13 ASTM B32 - Standard Specification for Solder Metal
- .14 ASTM C582 – Standard Specification for Contact-Molded Reinforced Thermosetting Plastic Laminates for Corrosion Resistant Equipment
- .15 ASTM D3982 – Standard Specification for Contact-Molded Fiberglass Ducts and Hoods
- .16 ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials
- .17 NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems
- .18 NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
- .19 NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

.20 NPS 15-69 - Standards specification for Custom Contact-Molded Reinforced - Polyester Chemical - Resistant Process Equipment

.21 ULC-S110 – Standard Methods of Test for Air Ducts

1.5 **QUALITY ASSURANCE**

.1 Duct system construction and installation:

.1 SMACNA Standards are the minimum acceptable quality.

.2 Manufacturer:

.1 Ductwork systems to be provided by firm having an established reputation in this field.

PART - 2 PRODUCTS

2.1 **MATERIALS**

.1 Galvanized steel:

.1 Lock forming quality: to ASTM A653/A653M, G90 zinc coating for unpainted indoor duct work and for outdoor duct work;

.2 A25 zinc coating to ASTM A653/A653M for painted duct work.

.3 Thickness, fabrication and reinforcement: to SMACNA except as noted in this Section.

.2 Stainless steel:

.1 Type 304L / Type 316L to ASTM A480/A480M.

.2 Finish: No 4. finish for exposed ducts in finished areas, No. 2B finish for concealed ductwork and for exposed ductwork in unfinished areas.

.3 Thickness, fabrication and reinforcement: to SMACNA except as noted in this Section.

.3 Aluminum:

.1 ASTM B209, alloy 3003 H-14 or 5052-H32 for sheet material, alloy 6061-T6 for plate material, alloy 6061-T4 or T6 for shapes material.

.2 Thickness, fabrication and reinforcement: to SMACNA except as noted in this Section.

.4 Black steel:

.1 To ASTM A635/A635M.

.2 Thickness: as noted in this Section for the specific application.

.3 Fabrication: ducts and fittings or SMACNA.

.5 Fiberglass reinforced plastic (FRP):

.1 Buried ductwork:

.1 FRP shall be of filament wound construction with a smooth resin rich interior layer and a 'C' veil resin rich exterior with a silane finish and a styrene soluble binder.

- .2 Thermoset FRP acrylic resin to ASTM E84, Class 1, with a maximum flame spread rating of 25 and maximum smoke development index of 50. The use of liners to achieve the indicated smoke and flame spread development will not be accepted.
- .3 Chopped strand mat shall be Type E glass with a minimum 0.46 kg per sq.m with silane finish and styrene soluble binder. Woven roving shall be Type E glass minimum 0.82 kg per sq.m. Continuous roving for a filament binding shall be Type E glass with a silane finish.
- .4 Standard of Acceptance:
 - .1 Monoxivent
 - .2 Perry Fiberglass Products
 - .3 Spunstrand
- .2 Corrosion resistant exhaust:
 - .1 FRP shall be of filament wound construction with a PS 15-69 corrosion barrier. Cast duct with no reinforced internal corrosion barrier or press molded fittings will not be accepted.
 - .2 Premium grade fire retardant vinyl ester resin to ASTM E84, Class 1, with a maximum flame spread rating of less than 25.
 - .3 Surfacing veil shall be Type C glass veil with a silane finish and a soluble binder. Chopped strand mat shall be Type ECR glass minimum 0.46 kg per sq.m with silane finish and styrene soluble binder. Continuous roving for chopper gun spray up shall be Type E glass. Woven roving shall be Type E glass minimum 0.82 kg per sq.m. Continuous roving for filament winding shall be Type E glass with silane finish.
 - .4 Standard of Acceptance:
 - .1 Monoxivent
 - .2 Perry Fiberglass Products
 - .3 Spunstrand
- .6 Gaskets in flanged joints:
 - .1 Soft neoprene
- .7 Solder for water-proof and buried ductwork:
 - .1 To ASTM Standard B32
- .8 Sealant:
 - .1 Elastomeric compound, gun or brush grade, maximum 25 flame spread and 50 smoke developed (dry state) compounded specifically for sealing ductwork as recommended by the manufacturer. Generally provide liquid sealant, with or without compatible tape, for low clearance slip joints and heavy, permanently elastic, mastic type where clearances are larger. Oil base caulking and glazing compounds are not acceptable. Use only non-solvent based (low VOC) type sealant.
 - .2 Standard of Acceptance:
 - .1 3M

- .2 Foster
- .3 Hardcast
- .4 Duro-Dyne
- .5 Transcontinental Equipment
- .6 Bakor
- .7 DuctMate
- .9 Tape:
 - .1 Polyvinyl treated open weave glass fibre tape, 50mm wide. Use only tape specifically designated by the sealant manufacturer and apply only over wet sealant. Pressure sensitive tape shall not be used on bare metal or on dry sealant.
- .10 Reinforcing and supporting material
 - .1 Mill-rolled structural steel conforming to ASTM A36/A36M. Whenever in contact with sheet metal ducting, provide galvanized steel in accordance with ASTM A123/A123M.

2.2 DUCT CONSTRUCTION AND FABRICATION

- .1 Regardless of the pressure and seal classifications outlined in the SMACNA Standards, fabricate and seal the ductwork in accordance with the following pressure classifications:

Duct Pressure and Seal Classification		
System	Pressure Class	Seal Class
Constant volume supply	+500 Pa	A
Variable volume supply, upstream of terminal units	+750 Pa	A
Variable volume supply, downstream of terminal units	+250 Pa	A
Supply and return for fan coil and heat pump units	+250 Pa	A
Central return air	-500 Pa	A
Central exhaust (sanitary, general)	-500 Pa	A
Fire rated supply and exhaust, smoke exhaust	+/-750 Pa	A
Laboratory exhaust	-2500 Pa	A
Wet exhaust (dishwasher, shower, swimming pool)	-500 Pa	A
All other ductwork and plenums	+/-500 Pa	A

- .2 Rectangular ductwork
 - .1 Make up longitudinal seams with Pittsburgh lock, with sealant applied prior to hammering of joint.
 - .2 Seal transverse joints as required to suit seal classification.
 - .3 Cross-break flat surfaces of uninsulated duct between joints, or between joints and intermediate reinforcements, to prevent vibration or buckling.

- .3 Round and flat-oval ductwork
 - .1 Furnish duct and fittings made by the same manufacturer to ensure good fit of slip joints. When submitted and approved in advance, round and flat oval duct, with size converted on the basis of equal pressure drop, may be furnished in lieu of rectangular duct design shown on the Drawings.
 - .2 Elbows: Diameters 80mm through 200mm shall be two sections die stamped, all others shall be gored construction, maximum 18 degree angle, with all seams continuously welded or standing seam. Coat galvanized areas of fittings damaged by welding with corrosion resistant aluminum paint or galvanized repair compound.
 - .3 Provide bell mouth, conical tees or taps, laterals, reducers, and other low loss fittings per SMACNA Standards.
 - .4 Ribbed duct option: Lighter thickness round/oval duct and fittings may be furnished provided certified tests indicating that the rigidity and performance is equivalent to SMACNA's standard gauge ducts are submitted.
 - .1 Ducts: Manufacturer's published standard gauge, G90 coating, spiral lock seam construction with an intermediate standing rib.
 - .2 Fittings: May be manufacturer's standard as shown in published catalogues, fabricated by spot welding and bonding with neoprene base cement or machine formed seam in lieu of continuous welded seams.
 - .5 Provide flat side reinforcement of oval ducts as recommended by the manufacturer and SMACNA Standards. Because of high pressure loss, do not use internal tie rod reinforcement unless approved by the Consultant.
- .4 Flexible ductwork:
 - .1 Return air plenums: single ply aluminium flex duct manufactured by using a dead soft aluminum strip which is spirally wound and mechanically joined together forming an air tight and leakproof triple lock seam, to ULC-S110.
 - .2 Return and Non-return air plenums: insulated aluminum flex duct with a polyethylene vapour barrier manufactured by using a dead soft aluminum strip, spirally wound and mechanically joined together with an inner duct that is covered with a thick fiberglass insulation and a flame retardant, non-toxic polyethylene vapour barrier, to ULC-S110.
 - .3 Acoustic flex duct: manufactured by using a dead soft aluminum strip which is perforated, spirally wound and mechanically joined together. The inner duct is covered with thick fiberglass insulation and sleeved by a triple-lock aluminum jacket. The acoustic flex duct includes a perforated core with an open area of 20-25%.
 - .4 Standard of Acceptance:
 - .1 Thermoflex
 - .2 Flexmaster
 - .3 Hart Cooley
- .5 Water-proof exhaust ducts
 - .1 Ducts serving dishwashers, pool return and exhaust, shower exhaust, scullery hood, cart washers, cage washers, steam sterilizer hoods and orthotics hoods shall be 1.3 mm 304L stainless steel made liquid tight with continuous external weld for

all seams and joints. Ductwork serving pools operating with salt water shall be made of 316L stainless steel.

- .6 Humidifier plenums
 - .1 Provide 304L welded stainless steel duct section to house duct-mounted terminal humidifiers. Ductwork shall be at least 0.9 m long on the upstream side and 1.8 m long on the downstream side. Slope the ductwork against the direction of airflow and provide drain connection. Install inside turned flange at the connection point to regular ductwork. Provide access door on side of duct.
- .7 Laboratory hood exhaust, fume hood, radioisotope exhaust, biosafety cabinet exhaust:
 - .1 1.3 mm 304L stainless steel, all welded.

2.3 **FITTINGS**

- .1 Fabrication: to SMACNA Standards.
- .2 Radiused elbows:
 - .1 Rectangular: Centreline radius: 1.5 times width of duct.
 - .2 Round: smooth radius or five piece. Centreline radius: 1.5 times diameter.
- .3 Mitred elbows, rectangular:
 - .1 Up to 400 mm: with single thickness turning vanes.
 - .2 Over 400 mm: with double thickness turning vanes.
- .4 Branches:
 - .1 Rectangular main and branch: with radius on branch 1.5 times width of duct or 45° entry on branch.
 - .2 Round main and branch: enter main duct at 45° with conical connection.
 - .3 Provide volume control damper in branch duct near connection to main duct.
 - .4 Main duct branches: with volume control damper.
- .5 Transitions:
 - .1 Diverging: 20° maximum included angle.
 - .2 Converging: 30° maximum included angle.
- .6 Offsets:
 - .1 Full short radiused elbows as indicated.
- .7 Obstruction deflectors: maintain full cross-sectional area. Maximum included angles: as for transitions.
- .8 FRP ductwork:
 - .1 Made out of the same resin and having the same strength as the FRP ductwork.
 - .2 The internal diameter of all fittings shall be equal to the adjacent duct.
 - .3 Elbows centreline radius shall be 1-½ times the diameter.
 - .4 Buried ductwork: Elbows 45 degrees or less shall be at least one (1) miter/two (2) gore. Elbows greater than 45 degrees shall be at least two (2) miter/three (3) gore.

- .5 Fume exhaust: Elbows 610mm diameter and smaller shall be smooth radius. Elbows larger than 610mm diameter shall be mitered. Elbows 45 degrees or less shall be at least two (2) miter/three (3) gore. Elbows greater than 45 degrees shall be at least four (4) miter/five (5) gore.

2.4 **PLENUMS AND CASINGS**

- .1 Construct plenums and casings in accordance with SMACNA Standards Chapter 6.
- .2 Provide built up system enclosures constructed of prefabricated acoustic panels complete with access doors in the configurations and dimensions shown on the Drawings.
 - .1 Side and top panels: 100 mm nominal thickness consisting of 72 kg/m density insulation packed between 1.3 mm galvanized steel outer shell and 0.85 mm galvanized perforated steel inner shell, reinforced by 3.5 mm galvanized steel channels spot welded or riveted in place. Panel joints shall be interlocking tongue and groove design. Trim angles shall be 1.6 mm galvanized steel.
 - .2 Doors shall be 600 mm x 1500 mm located as shown on the Drawings constructed in the same manner as the panels except with solid sheets both sides, and complete with two butt hinges, two camlocking latches operable from inside and outside with single air seal gasket. Door shall swing open against plenum pressure.

PART - 3 EXECUTION

3.1 **GENERAL**

- .1 Production and site delivery
 - .1 Self-adhesive labels for part identification of duct system components manufactured offsite shall be applied to external surfaces only.
 - .2 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.
- .2 Environmental requirements
 - .1 Maintain a space work temperature not less than the minimum ambient working temperature required by the duct sealant manufacturer requirements. Any ductwork sealant installed at lower space temperature shall be removed and replaced.
- .3 Protection
 - .1 Temporarily cap-off duct work openings while plastering, drywall and other finishing operations are in progress to protect against dirt accumulation inside the ductwork.
 - .2 Cover open ends or registers of active exhaust/return ducts with 25 mm thick filter media secured with tape. Maintain media until dust producing finishing operations are completed.
 - .3 Protect ductwork during installation as per (LEED) (CSA Z317.2) (SMACNA Advanced Duct Cleanliness Level) requirements. All sealed ends shall be visually examined and if damaged resealed with an appropriate material.

.4 Installation

- .1 Install ductwork in a clean and dry work area, protected from elements. Remove protective covering from duct ends only immediately before installation. Wipe internal surfaces of unprotected ductwork without internal lining to remove excess dust.
- .2 Install ductwork in locations and at elevations appropriate to ceiling heights shown on Drawings. Where required to be concealed, install ductwork in furred spaces provided in walls and ceilings. Where there is no provision for concealment install duct as close as possible to walls, partitions and overhead structures to attain maximum headroom and clearance.
- .3 Wherever ductwork is required at locations where sprayed fireproofing is applied to the building structure, install ductwork only after fireproofing work is complete. Do not compromise fire rating of sprayed fireproofing.

3.2 **DUCTWORK**

.1 General

- .1 Fabricate and install ductwork and accessories in accordance with the requirements of the SMACNA Standards, NFPA-90A and NFPA-90B.
- .2 Drawings show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts to equipment, terminal units, diffusers, grilles, and to coordinate with other trades. Fabricate ductwork based on field measurements. Provide all necessary fittings and offsets at no additional cost to the Owner. Coordinate with other trades for space available and relative location of HVAC equipment and accessories on ceiling grid.
- .3 Where ductwork is to be run within or through open web steel joists, ductwork shall be altered as required to suit final steel joist configuration, spacing, panel points, and cross-bridging at no additional cost.
- .4 Duct sizes on the drawings are inside dimensions which shall be altered by Contractor to other dimensions with the same air handling characteristics where necessary to avoid interferences and clearance difficulties. Where rectangular ductwork is shown, round or flat oval ductwork of equivalent cross-sectional area is acceptable.
- .5 Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA Standards, Chapter 2. Provide streamliner, when an obstruction cannot be avoided and must be taken in by a duct. Repair galvanized areas with galvanizing repair compound.
- .6 Where shape of duct changes, install transition piece so that angle of side of transition piece does not exceed 15 degrees from straight run of duct being connected, unless shown otherwise on Drawings.
- .7 Provide bolted construction and tie rod reinforcement in accordance with SMACNA Standards.
- .8 Where flanged duct joints are used, do not locate joints in wall or slab openings, or immediately at wall or slab openings. Do not use flanged joints for exposed uninsulated ducts in finished areas.
- .9 Hammer edges and slips to leave smooth finished surface inside duct.

- .10 Fabricate duct work free from vibration, rattle or drumming under operating conditions; reinforce, brace, frame, place gaskets as required to comply with the acoustical performance criteria.
- .11 Connections such as spin-in taps and other branch fittings inserted into cut openings in duct, access door frames, insertion type control elements and duct joints at equipment are to be treated as transverse joints.
- .12 Construct casings, eliminators, and pipe penetrations in accordance with SMACNA Standards, Chapter 6. Design casing access doors to swing against air pressure so that pressure helps to maintain a tight seal.
- .13 Place galvanized screens of 13 mm x 13 mm mesh x 2.7 mm diameter wire for air intakes, exhausts and open ends of duct work.
- .14 Where dissimilar metal ducts are to be connected, isolate ducts by means of flexible duct connection material. Wherever bare aluminum ductwork comes in contact with ferrous metal or copper, paint ferrous metal or copper surface with a heavy, 100% covering coat of zinc chromate paint, asphalt paint or otherwise isolate direct contact with the bare aluminum.
- .2 Sealant Application
 - .1 Store duct sealant at room temperature for 24 hours before use.
 - .2 Seal all ductwork to SMACNA Class A, except for round duct with self-sealing gasketed fittings and couplings which does not require site applied sealant.
 - .3 Apply sealants by brush or gun to cleaned metal surfaces. Where bare ductwork is exposed apply neat uniform lines of sealant. Randomly brushed, sloppy looking sealant applications will be rejected and must be repaired or replaced with a neat application of sealant.
 - .4 On bell and spigot style joints apply sealant on male section with caulking gun and spread sealant evenly on mating surface with brush.
 - .1 Insert fitting and secure with sheet metal screws;
 - .2 Brush sealant onto outside of assembled joints in 50 mm wide band covering fastener heads.
 - .5 Allow for 40 hours of curing time before pressure testing.

3.3 SPECIALTY DUCTWORK SYSTEMS

- .1 Flexible Type Round Ducts
 - .1 Install flexible ducts in accordance with SMACNA Standards, Chapter 3. Ducts shall be continuous, single pieces less than 3.0 m long, as straight and short as feasible. Utilize rigid ductwork for longer runs as required to meet this requirement. Centerline radius of bends shall be not less than two duct diameters.
 - .2 Flexible ducts shall not penetrate floors, or any chase or partition designated as a fire or smoke barrier. Install flexible ductwork clear of ceiling assemblies, light fixtures.
 - .3 Support flexible ducts using 25 mm wide, 0.85 mm galvanized steel straps at 1.5 m on centre.
 - .4 Seal joints between flexible duct and rigid duct work or equipment with non-flammable high velocity duct sealer, applied in accordance with duct manufacturer's recommendations. Make connections with stainless steel worm

drive clamps as recommended by SMACNA. Clamp with one clamp on the core duct and one on the insulation jacket.

.2 Waterproof Ductwork

- .1 Slope fresh air intake ducts down at 1:100 to permit moisture induced by air intake to be drained. Slope exhaust ducts back to source.
- .2 Continuously solder or seal joints in waterproof duct to prevent moisture entrainment through joints. Provide neoprene gaskets at flanged connections.
- .3 Where ducts are not self-draining back to the equipment, provide low point drain pocket with drain pipe and deep seal trap discharging to the nearest funnel drain or service sink. Provide access door in side of duct at drain pockets.
- .4 In areas having high humidity, fabricate exhaust ductwork without seams in bottom of duct for at least 3 m of duct run behind grille/register and slope duct up away from grille/register.

.3 Laboratory Hood Exhaust, Fume Hood, Radioisotope Exhaust, Biosafety Cabinet Exhaust

- .1 Cross-break flat surfaces of galvanized steel ducts between joints to prevent vibration and oil-canning.

3.4 **DUCT HANGERS AND SUPPORTS**

- .1 Install duct hangers and supports in accordance with SMACNA Standards Chapter 4.
- .2 Support vertical ducts with angles screwed or bolted to duct and bearing on building structure.
- .3 Strap hangers:
 - .1 Support rectangular ducts up to 750 mm width using strap-type hangers attached at not less than three places to not less than two duct surfaces in different planes.
 - .2 Perforated strap hangers are not acceptable.
 - .3 Maximum spacing of straps shall be 2.4 m on centre.
- .4 Trapeze hangers:
 - .1 Support rectangular ducting at 750 mm width and larger using trapeze hangers. Support ducts situated in unconditioned areas and required to have insulation with a vapor-sealed facing on trapeze hangers.
 - .2 Space hangers far enough out from the side of the duct to permit the duct insulation to be placed on the duct inside the trapeze. Do not penetrate the vapor-sealed facing with duct hangers.
 - .3 Maximum hanger spacing shall be 3.0 m on centre up to 1500 mm width and 2.4 m on centre for ducts over 1500 mm.
 - .4 Support the bottom of the duct on angles sized as follows:

Trapeze hanger angle sizing		
Width of duct mm	Min. bottom angle size mm	Rod size mm
Up to 750	25 x 25 x 3.2	6
750 to 1200	38 x 38 x 3.2	6

1225 to 1800	38 x 38 x 4.8	10
1825 to 2400	50 x 50 x 6.4	10
2425 and wider	80 x 80 x 6.4	10

.5 Round and flat oval ductwork

- .1 Support round and flat oval ducts in accordance with the SMACNA Standards.
- .2 Hang uninsulated and insulated ducts exposed in finished areas using pre-manufactured round duct strap bracket secured at top of duct to a hanger rod. For insulated ducts, size strap bracket to suit diameter of insulated assembly.
- .3 For uninsulated ductwork, as an alternative, at the contractor's discretion except within pool enclosures, the use of Gripple type wire hanger system is permitted.
- .6 Unless otherwise specified, duct support hardware for metal duct shall be constructed of the same material as the duct. Duct strap shall be one material thickness heavier than the duct it supports.
- .7 Where ductwork system contains heavy equipment, excluding air-diffusion devices and single-leaf dampers, hang such equipment independently of the ductwork by means of rods or angles of adequate size to support the load.
- .8 Support roof mounted ductwork using pre-fabricated roof support system. Refer to Article 2.4.3 of Section 20 05 29 - Bases, Hangers and Supports for requirements.

3.5 **PAINT FINISH AND TOUCH-UP**

- .1 In finished areas, where diffusers, registers and grilles cannot be installed to avoid seeing inside the duct, paint the inside of the duct with flat black paint to reduce visibility.
- .2 Touch-up galvanized steel damaged as a result of fabrication, including welding, with zinc dust galvanized primer.
- .3 In finished areas, paint all ductwork (insulated and uninsulated) exposed to view; colour to be determined by Interior Designer.

3.6 **PLENUMS AND CASINGS**

- .1 Install prefabricated plenum panels, fasteners, washers and any required sealant in accordance with the approved shop drawings. Comply with panel manufacturer's general instructions for installation to ensure weather-tight performance of the wall panel system.
- .2 Construct plenums to resist deflection and seal sufficiently to avoid air leakage when subjected to a pressure differential between inside and outside of up to 2,490 Pa
- .3 Provide access doors suitable for personnel pass through.
- .4 Provide 304L stainless steel drain pans with welded joints and accessible trapped drains for fresh air intake plenums, and where shown on the Drawings. Run drain line to the nearest funnel floor drain.

3.7 **CLEANING**

- .1 Clean all new horizontal and vertical ducts (supply, return, exhaust, transfer), as well as, existing supply and return ductwork connected to new fan systems.

- .2 Prior to start-up of fans, blow out complete systems of ductwork with high velocity air for not less than two hours using where possible the installed air handling equipment at full capacity and by blanking off duct sections to achieve the required velocity. Do not install air filters prior to blow-out of duct work systems. Use auxiliary portable blowers for cleaning where installed fan systems are not adequate to blow out the complete system free from dust and dirt.
- .3 After duct systems have been blown out, clean interior of plenums, coils, and register, grille or diffuser outlet collars with industrial type vacuum cleaner. On completion of cleaning process, install filters before placing systems in final operation.
- .4 Perform additional cleaning of duct system in accordance with Section 23 31 31 – Duct Cleaning.
- .5 Reset balancing dampers to original settings if moved during cleaning work. Have the TAB Contractor confirm the damper settings.

3.8 **TESTING**

- .1 Pressure test the following duct systems:
 - .1 Buried ductwork, any operating pressure;
 - .2 All ductwork located outside the building, any operating pressure;
 - .3 Ductwork that is designed to operate at or in excess of +/- 750 Pa static pressures;
 - .4 Fume exhaust ductwork, any operating pressure.
- .2 Conduct tests in accordance with the SMACNA HVAC Air Duct Leakage Test Manual.
- .3 Representative sections totalling no less than 25% of the total installed duct area shall be tested. Identify all sections selected for testing and submit to the Consultant for review prior to the commencement of the test. Pressure test buried and fume exhaust ducts in their entire length.
- .4 Positive pressure leakage testing is acceptable for negative pressure ductwork.
- .5 Where audible air noise is detected during test, remove test, pressure apply sealant to leaking joints and seams, and retest after 48 hours. Continue testing and sealing until leaks are inaudible.
- .6 Test duct systems before they are insulated, painted or concealed.
- .7 Test pressure: equal to ductwork pressure class, except fume exhaust ducts shall be tested at 1.5 times of the maximum operating pressure.
- .8 Allowable leakage shall be $F = C_L \times P^{0.65}$, where
 - .1 F = leakage rate l/s / 10 sq.m of duct surface area;
 - .2 P = duct design static pressure, Pa;
 - .3 C_L = leakage class based on pressure class as follows:

Duct Construction Class	
Duct Static Pressure	Any pressure
Seal Class	A

Leakage Class, C _L	
Rectangular Metal	0.08
Round Metal	0.04

- .9 Immediately correct defects discovered during tests and retest systems using minimum 50% of the total installed duct area. On a repeated failed test, retest the entire duct area (100%) after the required repair work has been completed.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
 - .2 Ductwork accessories, including balancing, backdraft, control, fire and smoke dampers; flexible duct connections; turning vanes; internal sound attenuation; cross talk silencers; duct access doors; test ports; airflow measurement stations.
- .2 Related requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Sections 20 00 13 – Mechanical General Provisions and 23 05 00 - Common Works for HVAC shall apply to and govern this Section.

1.2 RELATED WORK

- .1 The following work is provided under other Sections or Divisions of the Work:
 - .1 Ductwork and plenums: Section 23 31 00 - Ducts and Casings.
 - .2 Automatic control damper operators: provided under the scope of the Division 25 – Building Automation Contract.
 - .3 Automatic control dampers: supplied by the Contractor performing the work of Division 25 - Building Automation, installed by this Contractor.

1.3 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for all duct accessories. Shop drawings shall indicate dimensions, weights, required clearances, construction details. In addition:
 - .1 For operating dampers: damper schedule showing dimensions, service, type, leakage class and location of each damper, performance charts, pressure drop vs approach velocity for range of blade angles from 0 to 90 deg, torque requirements.
 - .2 For fire and smoke dampers: manufacturer's installation instruction, wiring diagram, pressure drop and maximum velocity, verification of conformance to NFPA 90A, UL 555, and applicable building code.
 - .3 For airflow measurement stations: manufacturer's installation details showing minimum upstream and downstream clearances to obstructions in the ductwork.

1.4 REFERENCE STANDARDS

- .1 SMACNA HVAC Duct Construction Standards - Metal and Flexible
- .2 SMACNA HVAC Systems Testing, Adjusting and Balancing guidelines.
- .3 ASHRAE 62.1 - Ventilation for Acceptable Indoor Air Quality

- .4 ANSI/ASHRAE 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems
- .5 ASHRAE 154 - Ventilation of Commercial Cooking
- .6 Thermal Insulation Association of Canada (TIAC) National Insulation Standard, excluding Section 12
- .7 Midwest Insulation Contractors Association (MICA) Standards Manual
- .8 NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems
- .9 NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
- .10 NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
- .11 NPS 15-69 - Standards specification for Custom Contact-Molded Reinforced - Polyester Chemical - Resistant Process Equipment
- .12 AMCA 500-D - Laboratory Methods of Testing Dampers for Ratings
- .13 AMCA 503 - Fire Ceiling (Radiation), Smoke, and Fire/Smoke Dampers Application Manual.
- .14 AMCA 511 - Certified Ratings Program Product Rating Manual for Air Control Devices
- .15 ANSI/AMCA 610 - Laboratory Methods of Testing Airflow Measurement Stations for Performance Rating
- .16 ASTM C423 - Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method
- .17 ASTM C916 - Standard Specification for Adhesives for Duct Thermal Insulation
- .18 ASTM C1071 - Standard specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
- .19 ASTM C1338 - Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings
- .20 ASTM C1534 - Standard Specification for Flexible Polymeric Foam Sheet Insulation Used as a Thermal and Sound Absorbing Liner for Duct Systems
- .21 ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi
- .22 UL 555 - Standard for Fire Dampers
- .23 UL 555S - Standard for Smoke Dampers
- .24 UL 181 - Standard for Factory-Made Air Ducts and Air Connectors
- .25 CAN/ULC S109 – Standard Method for Flame Tests for Flame-Resistant Fabrics and Films
- .26 CAN/ULC S112 - Standard Method of Fire Test of Fire Damper Assemblies

1.5 **QUALITY ASSURANCE**

- .1 Duct accessories construction and installation:
 - .1 SMACNA Standards are the minimum acceptable quality.

PART - 2 PRODUCTS

2.1 **FLEXIBLE DUCT CONNECTIONS**

- .1 Frame: 76 mm wide, 0.66 mm galvanized sheet metal, 0.4 mm 316 stainless steel or 0.81 mm aluminium frame to match duct material, with 76 mm wide fabric clenched by means of double locked seams.
- .2 Indoor equipment up to 500 Pa fan external static pressure:
 - .1 Fabric material: Polyester scrim base fabric with PVC coating, min. 750 g/m² mass, 0.66 mm thickness.
 - .2 Operating temperature range: -35° to 93°C.
 - .3 Fire resistance: Self-extinguishing, meets requirements of NFPA 90A and 90B, and CAN/ULC S109.
- .3 Indoor equipment above 500 Pa fan external static pressure:
 - .1 Fabric material: Woven fiberglass fabric with neoprene coating, min. 1,017 g/m² mass, 0.68 mm thickness.
 - .2 Operating temperature range: -40° to 93°C.
 - .3 Fire resistance: Self-extinguishing, meets requirements of NFPA 90A and 90B, and CAN/ULC S109.
- .4 Outdoor equipment:
 - .1 Fabric material: Woven fiberglass fabric with Hypalon coating, min. 814 g/m² mass, 0.61 mm thickness.
 - .2 Operating temperature range: -40° to 121°C.
- .5 Systems with operating temperatures in excess of 100°C:
 - .1 Fabric material: Woven fiberglass fabric with silicone rubber coating, min. 576 g/m² mass, 0.50 mm thickness.
 - .2 Operating temperature range: -50° to 260°C.
 - .3 Fire resistance: Flame proof, will not support combustion, meets requirements of NFPA 90A and 90B.
- .6 Standard of Acceptance:
 - .1 Duro-Dyne
 - .2 Hardcast DynAir
 - .3 Ductmate Industries
 - .4 Climtech International

2.2 **TURNING VANES**

- .1 Double wall hollow airfoil type, factory or shop fabricated to SMACNA of the same material as the duct in which they are installed, with extended leading and trailing edges. Holding rails shall be securely set in the duct so that they cannot loosen.
- .2 Standard of Acceptance:
 - .1 Duro-Dyne
 - .2 Ductmate Industries
 - .3 Aero-Dyne

2.3 **ACCESS DOORS IN DUCT WORK AND PLENUMS**

- .1 Hand Doors:
 - .1 For regular service – rectangular ducts installed concealed or exposed in unfinished areas:
 - .1 Up to 2,000 Pa static pressure: Double panel rectangular door made of the same material as the ductwork filled with 50 mm thick fiberglass insulation, matching mounting frame with notched knock over tabs, neoprene gasketing, self-tightening hand-operated cam latch and piano hinge. Provide cylinder lock and key where noted on the Drawings. Material thickness, hinge and latch arrangement per SMACNA Standard Figures 2-12 and 2-13. Select door type to suit duct operating pressure.
 - .2 For regular service – rectangular ducts installed exposed in finished areas and all round ducts:
 - .1 Up to 2,500 Pa static pressure: Frameless, rounded corner rectangular or oval sandwich panel construction made of the same material as the ductwork, complete with insulation and backing plate for insulated ducts, neoprene gasket, polypropylene moulded knobs, zinc plated bolts and spring.
 - .3 For FRP ducts:
 - .1 Up to 750 Pa static pressure: Double panel rectangular door made of 0.63 mm thick stainless steel filled with 50 mm fiberglass insulation, riveted flange stainless steel mounting frame, neoprene gasketing, self-tightening hand-operated cam latch and piano hinge. Hinge and latch arrangement per SMACNA Standard Figures 2-10 and 2-10M.
- .2 Equipment and Plenum Doors:
 - .1 0.85 mm thick galvanized steel double panel construction with 25 mm thick fiberglass insulation, mounted in 2.05 mm thick extruded aluminium frame, neoprene gasket.
 - .2 Continuous stainless steel piano hinge opening 180°.
 - .3 Dual-acting heavy duty compression handles operable from both sides. Up to 1,219 mm height 2 handles, higher 3 handles. Provide key operated handle where shown on the Drawings.
 - .4 Provide viewing panel, minimum 300 mm x 300 mm for all 1,829 mm high doors and for all equipment doors.

.3 Standard of Acceptance

- .1 Acudor
- .2 Duro-Dyne
- .3 Ductmate Industries
- .4 Nailor
- .5 Ruskin
- .6 Greenheck

2.4 **INSTRUMENT TEST PORTS**

.1 1.6 mm thick zinc plated steel body, chain secured neoprene expansion plug with cam lock handle or HD polyethylene twist plug with neoprene O-ring, 28 mm minimum inside diameter, length to suit insulation thickness. Neoprene mounting gasket: flat for rectangular duct and moulded for round duct.

.2 Standard of Acceptance

- .1 Duro-Dyne
- .2 Hardcast
- .3 Climtech International
- .4 Ventfabrics

2.5 **BALANCING DAMPERS**

.1 Splitter dampers

- .1 Single thickness construction, of same material as duct, one sheet metal thickness heavier where both dimensions of damper blade are less than 300 mm.
- .2 Double thickness construction, one metal thickness lighter than duct, where either dimension of damper blade is 300 mm or larger.
- .3 Of height equal to full depth of branch duct and length 1-½ times branch duct width.
- .4 Fitted with piano hinge pivot, control rod, and locking device accessible from outside fitting.
- .5 Folded leading edge.

.2 Single blade dampers in rectangular ductwork

- .1 Shop fabricated of the same material and sheet metal thickness as the duct, stiffened with longitudinal V-grooves.
- .2 Maximum aspect ratio: 3:1.
- .3 Maximum blade height: 300 mm
- .4 Fitted with locking quadrant, inside and outside nylon or bronze end bearings, and shaft extension to suit insulation thickness.
- .5 Channel frame of same material as adjacent duct, complete with angle stop.
- .6 Fabrication shall follow SMACNA Standard Figure 2-12.

- .3 Multi-blade dampers in rectangular ductwork
 - .1 Shop fabricated or factory manufactured of the same material and sheet metal thickness as duct, stiffened with longitudinal V-grooves.
 - .2 Opposed blade configuration
 - .3 Channel frame with angle blade stop.
 - .4 Maximum blade height: 100 mm.
 - .5 Maximum blade length: 1,200 mm.
 - .6 Bearings with bronze bushings.
 - .7 Shaft extension to suit insulation thickness with locking quadrant.
 - .8 Channel frame of same material as adjacent duct, complete with angle stop.
 - .9 Fabrication shall follow SMACNA Standard Figure 2-13.
 - .10 Maximum leakage: 2 % at 500 Pa
- .4 Single blade dampers in round ductwork
 - .1 Shop fabricated butterfly type with round edged 3.5 mm disk set in round sheet metal housing, fitting snugly when closed, 10 degrees from vertical.
 - .2 Fitted with rubber packing glands, shaft extension, wing nuts, and indexing device to indicate disk position.
 - .3 Fabrication shall follow SMACNA Standard Figure 2-12.
- .5 FRP butterfly dampers in round ductwork
 - .1 Frame and blade: premium vinyl ester. Blade shall fully encapsulate shaft. Blades that bolt to a single side of the shaft will not be accepted.
 - .2 Shaft: Pultruded vinyl ester
 - .3 Bearings: EPDM/Neoprene
 - .4 Pins and hardware: Type 316 stainless steel.
 - .5 Shaft seals: EPDM/Neoprene
 - .6 Isolation dampers shall have full circumference EPDM/Neoprene seals.
 - .7 Dampers shall have flanged ends or plain ends. Provide Type 316 stainless steel bolts, nuts and washers for flanged connections.
 - .8 Balancing / volume dampers shall have a fully adjustable slot with an extra hole drilled in the handle to "drill-and-pin in-place" once the system is balanced so handle cannot vibrate loose.
- .6 Remote damper control
 - .1 Low-voltage battery operated damper drive system to manually control dampers from a remote location. The damper drive shall have universal mounting capabilities to accommodate damper shafts ranging in size from 6 mm – 9 mm square and 6 mm – 13 mm.
 - .2 The system shall consist of a battery powered damper drive pre-wired with plenum rated cable and female over-molded connector, wall or ceiling connector termination fixtures, and a hand held control module (only one required per jobsite). A 9V DC motor shall be factory mounted to the damper drive and compliance tested prior to shipment. The damper drive unit shall operate at static

pressure up to 625 Pa. Over-molded cable shall fit into surface termination plates, mechanical closet box, or recessed diffuser mount clip without requiring any tools. Plastic surface termination plates shall be UL94-V0 flammability rated. The damper drive shall be operated by a hand held remote control module powered by a 9V battery. Hand held remote control module features shall include an LED open circuit indicator for field verification of proper installation, a 2-color LED array damper position indicator, and an automatic motor shut-off feature at full open and full closed positions.

.3 Standard of Acceptance

.1 Metropolitan Air Technology

.7 Cable operated dampers

.1 Minimum 0.85 mm thick galvanized steel frame; 0.85 mm thick galvanized steel single round or rectangular butterfly, or 1.6 mm thick galvanized steel multiple blades; zinc plated steel shaft with nylon or stainless steel bushing; control arm/screw-drive assembly mounted on stand-off bracket. Maximum air velocity 7.62 m/s.

.2 Flexible stainless steel cable in a galvanized steel outer sleeve with up to 3.05 m length; Allan drive head adjustable using nut driver or hex socket wrench; adjusting head secured to a mounting bracket complete with steel sleeve and plastic finishing plug. Provide a concealed regulator box where shown.

.3 Standard of Acceptance:

.1 Air Managers

.2 Ruskin

.3 Metropolitan Air Technology

.4 Duro-Dyne

2.6 **OPERATING DAMPERS**

.1 Automatic control dampers

.1 General

.1 For dampers located near fan outlets, provide dampers rated for fan outlet velocity and close-off pressure, and recommended by damper manufacturer for fan discharge damper service.

.2 Control dampers used as smoke dampers shall comply with UL 555S. Control dampers used as fire dampers shall comply with UL 555.

.3 Modulating control dampers: opposed blades; parallel blades when directional mixing is desired (e.g. inside AHUs)

.4 Two-position control dampers: parallel blades

.2 Construction:

.1 Structurally formed steel or extruded aluminium, interlocking minimum 140 mm wide air-foil blades, complete with extruded, mechanically fastened EPDM or silicone seals, extruded silicone or spring stainless steel frame seals, structurally formed and welded galvanized steel or extruded aluminum frame.

.2 Dampers used in contact with outdoor air (intake and exhaust): Blades shall be internally insulated with expanded polyurethane foam and shall be

- thermally broken complete with silicone seals. Complete blade assembly shall have a thermal resistance of RSI-0.41. The entire frame shall be thermally broken by means of polyurethane resin pockets complete with thermal cuts.
- .3 Pressure fit self-lubricated bronze or Celcon bearings rotating within a polycarbonate outer bearing inserted into the frame. Single axle bearing, rotating in an extruded or punched hole is not acceptable.
 - .4 Linkage: galvanized steel tie rods, brass pivots and galvanized steel brackets, complete with galvanized steel control rod, outside the air stream and concealed within the frame.
 - .5 Dampers used in aluminium and stainless steel ductwork: Frame shall be aluminium or 304 stainless steel, axle and linkage shall be 316 stainless steel.
 - .6 Dampers in fume hood exhaust: shall be made of the same material as the ductwork, or be finished with baked enamel, epoxy or polyester coating as applicable for the type of fumes exhausted.
 - .7 Damper operator: in accordance with Section 25 35 00 - Instrumentation and Terminal Devices for Mechanical Systems.
- .3 Performance:
 - .1 Dampers shall be AMCA rated for leakage class 1A at 250 Pa static pressure differential and class 1 at 1,000 Pa.
 - .2 Maximum pressure drop: 12.5 Pa at 5.1 m/s.
 - .4 Standard of Acceptance:
 - .1 Tamco Series 1000; 9000BF for outdoor air
 - .2 Ruskin CD50; TED50 for outdoor air
 - .3 Nailor 2010 / 2020; IBF for outdoor air
 - .4 Greenheck VCD-42; ICD-45 for outdoor air
 - .5 Alumavent 3165SI; 3965ELT for outdoor air
- .2 Backdraft dampers
 - .1 Construction:
 - .1 Extruded aluminium, maximum 140 mm wide blades, complete with mechanically fastened extruded vinyl, extruded PVC or silicone seals, extruded aluminum frame, with or without flange as required.
 - .2 Linkage: aluminium, concealed in jamb.
 - .3 Bearings: synthetic sleeve type.
 - .2 Performance:
 - .1 Tested in accordance with AMCA 500-D.
 - .2 Maximum pressure drop: 75 Pa at 5.1 m/s.
 - .3 Standard of Acceptance:
 - .1 Tamco Series 7000
 - .2 Ruskin BD2A2

- .3 Nailor 1370
 - .4 Greenheck ES-30 Series
 - .5 Ventex 1200 Series
 - .6 Price BDD-2X
 - .3 Relief dampers
 - .1 Construction:
 - .1 Extruded aluminium, maximum 140 mm wide blades, complete with mechanically fastened extruded vinyl, extruded PVC or silicone seals, extruded aluminum frame, with or without flange as required.
 - .2 Linkage: aluminium, concealed in jamb.
 - .3 Bearings: synthetic sleeve type.
 - .4 Counter-balance: adjustable zinc plated steel weights mounted internally (in the airstream).
 - .2 Performance:
 - .1 Tested in accordance with AMCA 500-D.
 - .2 Maximum pressure drop: 63 Pa at 5.1 m/s.
 - .3 Standard of Acceptance:
 - .1 Tamco Series 7000CW
 - .2 Ruskin CBD2
 - .3 Nailor 1370CB
 - .4 Greenheck BR-30 Series
 - .5 Ventex 1200 Series
- 2.7 **FIRE AND SMOKE DAMPERS**
- .1 General
 - .1 Type:
 - .1 Dynamic dampers: designed to close while the system fans are operating.
 - .2 Static dampers: designed to close with no airflow through damper.
 - .2 Style as per SMACNA:
 - .1 Type B: blades out of airstream, for rectangular or square ductwork.
 - .2 Type C: blades and frame out of airstream, for round and flat oval ductwork.
 - .3 Rating of dynamic dampers:
 - .1 Air velocity, maximum: 10 m/s
 - .2 Differential pressure, maximum: 1,000 Pa
 - .4 Standard of Acceptance:
 - .1 Nailor
 - .2 Ruskin

- .3 Price
- .4 Alumavent
- .5 Tamco – smoke dampers only
- .2 Fire dampers - curtain type
 - .1 Construction:
 - .1 Frame: G60 roll formed galvanized steel frame,
 - .2 Blades: curtain type, interlocking blades, G60 galvanized steel,
 - .3 Sleeve: same material as damper frame, length to suit application with steel enclosure and transition collars, and retaining angles. For type B dampers, top of sleeve is formed closely around top of damper; sleeve construction that leaves the blade pack in the airstream is not permitted.
 - .4 Damper enclosure: type B and C.
 - .5 Fusible link: 74°C unless otherwise shown.
 - .6 Frame, sleeve, and blades to be stainless steel where damper is installed in a duct system which is stainless steel.
 - .2 Dynamic dampers:
 - .1 As above, and
 - .2 Fitted with stainless steel closure spring.
 - .3 Static dampers:
 - .1 As above, and
 - .2 Mounting in horizontal plane: fitted with stainless steel closure spring.
- .3 Fire dampers - airfoil multiblade type
 - .1 Construction:
 - .1 Type: dynamic.
 - .2 Frame: G60 galvanized steel hat channel.
 - .3 Blades: airfoil multiblade type, opposed or parallel action, interlocking blades, G60 galvanized steel.
 - .4 Linkage: concealed in frame (out of airstream).
 - .5 Jackshaft: with internal locking quadrant, for use as a balancing damper.
 - .6 Sleeve: same material as damper frame, length to suit application with steel enclosure and transition collars, and retaining angles.
 - .7 Enclosure: type B
 - .8 Fusible link: high torque spring/fusible link, 74°C unless otherwise shown.
 - .9 Frame, sleeve, and blades to be stainless steel where damper is installed in a duct system which is stainless steel.
 - .2 Operator, electric:
 - .1 Where required by listing, for multiple damper installations.
 - .2 Factory installed electric two position, fail close, operator, 120 VAC motor.

- .3 Electric resettable link: 121°C, with manual reset button.
 - .4 Controlled rate spring closure.
 - .4 Smoke dampers
 - .1 Construction:
 - .1 Type: dynamic.
 - .2 Frame: G60 galvanized steel hat channel, with stainless steel jamb seals.
 - .3 Blades: airfoil multiblade type, parallel action, interlocking blades, extruded aluminum, with silicone blade seals.
 - .4 Linkage: exterior side of frame (out of airstream).
 - .5 Sleeve: same material as damper frame, length to suit application with steel enclosure and transition collars, caulked joints, and retaining angles.
 - .6 Enclosure: type B.
 - .7 Fusible link: high torque spring/fusible link, 74°C unless otherwise shown.
 - .8 Frame, sleeve, and blades to be stainless steel where damper is installed in a duct system which is stainless steel.
 - .2 Operator, electric:
 - .1 Factory installed electric two position, fail close, operator, 120 VAC motor.
 - .2 Electric resettable link: 121°C, with manual reset button.
 - .3 Controlled rate spring closure.
 - .4 Maximum power: 25 VA opening, 12 VA holding.
 - .3 Damper position switch:
 - .1 Factory installed, damper position contact switches:
 - .1 Prove damper open;
 - .2 Prove damper closed.
- .5 Combination smoke and fire dampers
 - .1 Construction:
 - .1 Type: dynamic.
 - .2 Frame: G60 galvanized steel hat channel, with stainless steel jamb seals.
 - .3 Blades: airfoil multiblade type, opposed action, interlocking blades, G60 galvanized steel.
 - .4 Linkage: concealed in frame (out of airstream).
 - .5 Sleeve: same material as damper frame, length to suit application with steel enclosure and transition collars, caulked joints, and retaining angles.
 - .6 Enclosure: type B up to 191mm duct height, type A for larger duct height.
 - .7 Frame, sleeve, and blades to be stainless steel where damper is installed in a duct system which is stainless steel.

- .2 Operator, electric, re-openable:
 - .1 Factory installed, electric two position, fail close, operator, 120 VAC motor:
 - .1 Re-opens damper control system,
 - .2 "Low" primary fusible link at 74°C, with electric override from remote fire alarm system contact.
 - .2 "High" secondary fusible link at 176°C.
 - .3 Maximum power: 25 VA opening, 12 VA holding.
- .3 Damper position switch:
 - .1 Factory installed, damper position contact switches:
 - .1 Prove damper open;
 - .2 Prove damper closed.

2.8 **ACOUSTIC TREATMENT**

- .1 Acoustic duct lining
 - .1 General
 - .1 Mineral fibre duct liner: air surface coated mat facing, or
 - .2 Soft elastomeric foam: closed cell fibre-free, low VOC, with antimicrobial protection.
 - .3 Fungi resistance: to ASTM C1338, ASTM G21.
 - .2 Rigid fibreglass:
 - .1 Use on flat surfaces where indicated
 - .2 25 mm thick, to ASTM C1071, Type 2, fibrous glass rigid board duct liner.
 - .3 Density: 48 kg/m³ minimum.
 - .4 Thermal resistance to be minimum RSI-0.76 for 25 mm thickness when tested in accordance with ASTM C177, at 24°C mean temperature.
 - .5 Maximum velocity on faced air side: 20.3 m/s.
 - .6 Minimum NRC of 0.70 at 25 mm thickness based on Type A mounting to ASTM C423.
 - .3 Flexible fibreglass:
 - .1 Use on round or oval surfaces.
 - .2 25 mm thick, to ASTM C1071 Type 1, fibrous glass blanket duct liner.
 - .3 Density: 24 kg/m³ minimum.
 - .4 Thermal resistance to be minimum RSI-0.74 for 25 mm thickness, when tested in accordance with ASTM C177, at 24°C mean temperature.
 - .5 Maximum velocity on coated air side: 25.4 m/s.
 - .6 Minimum NRC of 0.65 at 25 mm thickness based on Type A mounting to ASTM C423.
 - .4 Soft elastomeric foam:
 - .1 For all surfaces, at the contractor's choice.

- .2 25 mm thick, to ASTM C1534, elastomeric, thermal and acoustical duct liner.
- .3 Thermal conductivity (k) shall be maximum 0.036 W/m K for 25 mm thickness, when tested in accordance with ASTM C177, at 24°C mean temperature.
- .4 Maximum velocity on air side: 50.8 m/s.
- .5 Minimum NRC of 0.6 at 25 mm thickness based on Type A mounting to ASTM C423.
- .5 Adhesive:
 - .1 Fibreglass lining: water-based fire retardant type.
 - .2 Elastomeric lining: low VOC adhesive.
- .6 Fasteners:
 - .1 Weld pins 2.0 mm diameter, length to suit thickness of insulation. Metal retaining clips, 32 mm square.
- .7 Joint tape:
 - .1 Poly-vinyl treated open weave fiberglass membrane 50 mm wide.
- .8 Standard of Acceptance:
 - .1 Owens Corning
 - .2 Johns Manville
 - .3 Knauf Fibreglass
 - .4 Manson
 - .5 Armaflex (for elastomeric)
- .2 Crosstalk silencers
 - .1 Pre-manufactured or field fabricated as shown on the Drawings.
 - .2 Pre-manufactured:
 - .1 0.76 mm solid galvanized steel casing;
 - .2 0.45 mm solid galvanized steel internal noses at inlet and outlet;
 - .3 20 mm dual density absorptive fiberglass media. Acoustic media shall be shot-free inorganic glass fiber with long, resilient fibers, bonded with thermosetting resin. Glass fiber shall be in accordance with erosion requirements of UL 181, and shall conform to the physical properties and requirements of ASTM C1071.
 - .4 Cross talk silencers shall be fastened with the use of button lock, Pittsburgh lock, and welds. Screws and other types of mechanical fasteners shall not be acceptable.
 - .5 Standard of Acceptance:
 - .1 Price
 - .2 Vibro-Acoustics
 - .3 Kinetics
 - .4 Ruskin

- .3 Field fabricated:
 - .1 Housing: galvanized steel, to SMACNA pressure class 250 Pa standard.
 - .2 Liner: rigid coated fibreglass or closed cell elastomeric duct liner.
 - .3 Size: as shown on the Drawings.
 - .4 Shape: as shown on the Drawings.
 - .5 Provide a sheet metal nosing at the open ends of duct to close off the cut edge of liner.

2.9 **EXPANSION JOINTS FOR FRP DUCT**

- .1 W-design configuration with integral flanges suitable for service with FRP duct.
- .2 Material: EPDM
- .3 Backing rings: 10mm thick, 51mm wide, type 316 stainless steel where flanged expansion joints or flex connectors are noted.
- .4 Extensions: 76mm
- .5 Compression: 64mm
- .6 Lateral offset: 64mm
- .7 Thickness: 6.4mm minimum
- .8 Bolts, nuts and washers: Type 316 stainless steel.
- .9 Expansion joints shall be flanged where connecting ductwork to equipment, slip-type may be used for all other location.

PART - 3 EXECUTION

3.1 **GENERAL**

- .1 Install miscellaneous steel framing, supports, and braces as required to hang or support equipment and duct accessories as specified herein, and as shown on the Drawings.

3.2 **FLEXIBLE DUCT CONNECTIONS**

- .1 Use flexible duct connections at ductwork connections to all fans, air handling units and convection heating/cooling units such as fan coils and heat pumps, between air handling unit components, in ducts at building expansion joints, and in other locations as shown on the Drawings, including at air handling units with internal vibration isolation. Flexible connection is not to be installed at air terminal units, in kitchen exhaust systems and other specialty duct systems such as laboratory hood exhaust, fume exhaust and exhaust system operating above 260°C.
- .2 Install flexible connectors with fabric in folds, not drawn tight, to maintain a minimum distance of 25mm between metal parts when the system is in operation.
- .3 Install internal guides to prevent flexible connection from collapsing on suction side of fans.
- .4 For installation between sections of air handling units, install flexible connectors suitable for connecting to flanges of casings where so provided.

- .5 Apply duct sealant on frames of flexible connector and fasten using sheet metal screws at maximum 50mm on centre to rectangular ducts and stainless steel draw bands with worm gear fastener to round ducts. Cover edges of each frame with tape.

3.3 **TURNING VANES**

- .1 Install in all 90 degree square duct elbows, in radius elbows with an inside radius larger than the depth of the duct, at the inlet of air handling units with an offset or side plenum connection, and where shown on the Drawings, in accordance with the SMACNA Standard and as indicated.

3.4 **ACCESS DOORS**

- .1 Provide access doors in ductwork, equipment and for plenums to allow servicing, maintenance, and inspection of:
 - .1 Inlet side of heating and cooling coils,
 - .2 Humidifiers,
 - .3 Control dampers,
 - .4 Volume dampers,
 - .5 Fire dampers,
 - .6 Smoke dampers,
 - .7 Fire/smoke detectors,
 - .8 Control elements,
 - .9 Sprinkler heads mounted in ductwork,
 - .10 Motors,
 - .11 Bearings,
 - .12 And where shown on the Drawings.
 - .13 Provide additional access doors on runs of kitchen exhaust, fume exhaust and OR supply ducts to facilitate cleaning as required by applicable codes and standards. Refer to Section 23 31 00 - Ducts and Casings for additional requirements.

- .2 Provide hand doors in ductwork of sizes as follows:

Access Type	Duct Dimension	Access Door Size
One hand and sight	Less than 400 mm	300x150 mm
Two hands and sight	Between 400 mm and 500 mm	450x250 mm
Head and Shoulders	Between 500 mm and 760 mm	530x356 mm
Body plus ladder	Between 760 mm and 1320 mm	635x430 mm

- .3 Provide equipment and plenum doors as follows:

- .1 In ductwork with duct dimension over 1320 mm
- .2 In plenums;
- .3 On air handling equipment not supplied with factory-mounted access doors;

- .4 Where shown.

3.5 **INSTRUMENT TEST PORTS**

- .1 Install for duct velocity traverse readings and for duct air temperature readings.
- .2 Locate test ports across ducts or plenums at right angles to flow, at sufficient distance from elbows or transition sections to ensure stable readings of non-turbulent air, 75 mm from corners, at not more than 250 mm intervals for traverses and at not more than 500 mm for temperature measurements.
- .3 Install for velocity traverses:
 - .1 At ducted inlets to roof and wall exhausters;
 - .2 At inlet to and outlet from other fan systems;
 - .3 At main and branch where branch serves more than one outlet;
 - .4 At any other location as required by the Air Balancing Contractor, to permit testing, balancing and measurement of air quantities and static pressure in air handling systems.
- .4 Install for temperature measurement:
 - .1 At outside air intakes;
 - .2 At inlet and outlet of coils;
 - .3 Downstream of intersection of converging air streams of different temperatures.

3.6 **BALANCING DAMPERS**

- .1 Locate dampers to allow adjustment of blade position and locking of quadrant.
- .2 Provide balancing dampers in all locations necessary for the complete balancing of the air system, even if balancing dampers are not specifically shown on the Drawings.
- .3 Bolt all dampers in plenums to a counter frame using a neoprene gasket between damper and wall.
- .4 In stainless steel ducts, cover the neoprene gaskets with Teflon tape.
- .5 Use splitter dampers in supply ductwork where main ducts are split into two trunks and where specifically shown on the Drawings.
- .6 Use low pressure butterfly dampers at the following locations:
 - .1 At branch connections on the downstream side of terminal boxes;
 - .2 At individual branch outlets serving grilles or diffusers.
- .7 Use medium pressure butterfly dampers at the following locations:
 - .1 At floor connections to supply air riser ducts;
 - .2 In return ductwork where main ducts are split into two or more trunks;
 - .3 At branch duct connections to main or trunk ducts;
 - .4 Where shown.
- .8 Use rectangular opposed blade dampers at the following locations:
 - .1 At floor connections to riser shafts/ducts;

- .2 In supply and return ductwork where main ducts are split into two more trunks;
- .3 At rectangular branch duct connections to main or trunk ducts;
- .4 Where shown.
- .9 Dampers supplied with diffusers or grilles are to be used to balance $\pm 10\%$ of the indicated airflow and do not substitute branch dampers.
- .10 Install access panels in the ceiling where the dampers are located above gypsum board or other fixed type ceiling.
- .11 Install remote damper control or cable operated type dampers for locations not reachable using a stepladder and in finished areas where the installation of access panels is not desirable due to the type of finish installed (e.g. specialty ceilings). Refer to reflected ceiling plans for direction.
- .12 Support cables of cable operated dampers at each change of direction and at 0.9 m3 ft intervals using retaining clips provided by damper manufacturer. Install cables taut with minimum 102 mm radius turns.

3.7 **OPERATING DAMPERS**

- .1 General
 - .1 When used in fan discharge applications, locate dampers at least one-half the fan diameter away from the fan.
 - .2 For proper operation, dampers must be installed square and free from racking.
 - .3 Multiple section damper assemblies may require bracing to support the weight of the assembly and to hold against system pressure. Refer to the manufacturer's installation instructions.
 - .4 Seal between multiple damper modules and at damper frames using approved duct sealant.
 - .5 Install a duct access door adjacent to each damper installed in ductwork.
- .2 Automatic control dampers
 - .1 All damper actuators shall be rigidly mounted and supplied with heavy-duty linkage consisting of a crank arm, pushrod, and swivel ball joint to connect to the damper shaft. Secure linkages to prevent slipping under normal operating torque.
 - .2 Install damper motors on the outside of ducts in protected areas, not in locations exposed to outdoor temperatures where possible.
- .3 Relief dampers
 - .1 Position blade counter balance weights to set desired blade opening pressure per design.

3.8 **FIRE AND SMOKE DAMPERS**

- .1 Install fire and smoke dampers in accordance with manufacturer's instructions, with sleeve, break-away joints of approved design on each side of fire separation, duct connections and angle supports to comply with terms and conditions of listing or classification and maintain integrity of fire wall and/or fire/smoke separation.

- .2 Select damper types as follows:
 - .1 "Dynamic" - all locations.
 - .2 "Static" - restricted to unducted transfer air openings only.
- .3 Select damper style as follows:
 - .1 Type C – above 7.5 m/s air velocity or for any opening with a dimension smaller than 203 mm;
 - .2 Type B – all other locations.
- .4 Install individual dampers and/or assemblies of individual dampers within limitations of their listing or classification:
 - .1 Use curtain dampers in single damper installations.
 - .1 For greater clarity, do not use curtain dampers in multiple damper assemblies, with or without mullions.
 - .2 Where duct size exceeds above requirements for curtain dampers, use multiblade fire dampers.
 - .3 Where listing requires multiple damper assemblies, use multiblade fire dampers.
 - .4 Where duct size exceeds allowable dimensions for listed or classified multiblade fire damper assemblies, use combination fire and smoke dampers.
- .5 Install stainless steel dampers in stainless steel duct systems and/or wherever ductwork is specified to be watertight construction.
- .6 Fire damper sleeves
 - .1 Fabricate fire damper sleeves in accordance with damper listing requirements.
 - .2 For type B dampers, fabricate the sleeve to keep the folded-blade stack out of the air stream, by forming that portion of the sleeve to wrap-around the blade stack to eliminate air pockets on the entering and leaving side of the damper.
- .7 Smoke dampers and combination smoke/fire dampers
 - .1 Install smoke dampers and combination smoke and fire dampers, with leakage class as indicated, throughout supply, return and exhaust air systems as required. Provide low pressure loss dampers where required.
 - .2 Where combination smoke and fire dampers are required in stainless steel or watertight duct systems, install stainless steel interlocking blade fire damper and separate smoke damper constructed to listed or classified leakage rating, but with stainless steel blades.
 - .3 Install and connect damper operators to achieve smoke control and smoke venting sequences as required.
- .8 Power for fire and smoke damper actuators
 - .1 Provide power and conduit from nearest emergency 120 VAC power distribution panel, if emergency power is available.
 - .1 Provide 15 A breaker, with tamper lock, for each circuit.
 - .2 Maximum number of actuators on each electrical circuit: 5 A.
 - .3 Each circuit only to serve floor that power distribution panel is located on.

- .9 Damper access
 - .1 Position a duct access door at each fire damper, to permit visual inspection and replacement of fusible link.
 - .2 Position a duct access door at each combination fire and smoke damper, to permit visual inspection and service of detection/actuation mechanism.
 - .3 Provide a duct access door upstream or downstream of each smoke damper for visual inspection.

3.9 **ACOUSTIC TREATMENT**

- .1 Acoustic duct lining
 - .1 Install internal acoustic insulation in specific sections of ductwork and/or plenums as follows:
 - .1 Downstream of air terminal control units (CAV, VAV and fan powered), except units supplied with integral attenuator, for min. 1,524 mm length.
 - .2 Downstream of heat pump units, for min. 2,438 mm overall length, or min. 914 mm length beyond the first 90 degree elbow.
 - .3 In air transfer ducts for full length.
 - .4 In return air stub ducts at shaft intake openings for full length.
 - .5 In all ductwork serving spaces with noise criteria of NC-30 or lower.
 - .6 Where indicated on the Drawings.
 - .2 Do not apply acoustic duct lining in ducts conveying air containing high amount of moisture such as pool supply and exhaust, untreated outside air, or in ducts conveying air contaminants such as fume or dust exhaust.
 - .3 Duct dimensions, as indicated, are measured inside the duct lining.
 - .4 Fasten liner to interior sheet metal surface with 100 % coverage of adhesive to ASTM C916.
 - .5 Exposed leading edges and transverse joints to be factory coated or coated with adhesive during fabrication.
 - .6 In addition to adhesive, for fibreglass liner install weld pins not less than 2 rows per surface and not more than 432 mm on centres impact driven mechanical fasteners to compress duct liner sufficiently to hold it firmly in place. Spacing of mechanical fasteners shall be in accordance with SMACNA Standard and TIAC.
 - .7 In systems, where air velocities exceed 20.3 m/s, install galvanized sheet metal nosing to leading edges of duct liner.
 - .8 Seal butt joints, exposed edges, weld pin and clip penetrations and damaged areas of liner with joint tape and sealer. Install joint tape in accordance with manufacturer's written recommendations, and as follows:
 - .1 Bed tape in sealer.
 - .2 Apply two coats of sealer over tape.
 - .9 Protect leading and trailing edges of duct sections with sheet metal nosing having 15 mm overlap and fastened to duct.

- .10 When acoustically lined duct is cut for installation of access doors, cut edges of fibreglass acoustic lining shall be repaired using self-adhesive fibre glass tape and water based duct sealer.
- .11 Adhere new acoustic lining to match existing to inside of access panel or door to ensure continuity of acoustic properties of system.
- .2 Cross talk silencers:
 - .1 Install air transfer silencers according to manufacturer's written installation instructions.
 - .2 Support air transfer silencers independently from other ductwork.
 - .3 Ensure air transfer silencers are installed with airflow arrows in direction of airflow.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 23 05 00 - Common Works for HVAC shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 Supply and install stand-alone fans.

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for fans and related equipment. Shop drawings shall include, but not be limited to:
 - .1 Complete information on fan construction and performance
 - .2 Performance curves over full range from shut-off to free delivery
 - .3 Drive details
 - .4 Make, type and catalogue number of bearings
 - .5 State hour rating of bearings when specified.

1.3 REFERENCE STANDARDS

- .1 Fans: designed and constructed in strict conformity with the AMCA Standards and bearing the "Certified Rating Seal".
- .2 Applicable sections of CSA C22.2 No. 113 for fan construction and installation.
- .3 Occupational Health and Safety Act, O.Reg 851.

PART - 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- .1 Performance Ratings
 - .1 Type, size and capacity shown on Drawings for each specific application and conforming to requirements of manufacture, operation and performance as specified.
 - .2 Select fan size, operating rpm and rating point on stable head flow curve with smooth characteristics.
 - .3 Operating at least 20% below first critical speed when operating at maximum speed for class of construction.

- .4 Dynamically and statically balance wheels of free standing or unitary fans to acceptable tolerances relative to size and speed.
- .2 Cleaning and Metal Protection
 - .1 Thoroughly clean interior and exterior surfaces of fans including screens, at factory with approved de-greasing agent.
 - .2 Apply a coating of red oxide or zinc chromate primer unless special protective coating is specified.
 - .1 Exception: fans constructed of galvanized steel or aluminum
- .3 Materials
 - .1 Fan casings: heavy gauge steel or spun aluminum construction, as specified by model number.
 - .1 Explosion proof construction (non-sparking) where listed in schedules
 - .2 Fume hood fans
 - .1 Steel or cast iron casing
 - .2 Heresite coating
- .4 Bearings
 - .1 Service Life
 - .1 To L10 Life Standard in accordance with latest AFBMA Code.
 - .2 Unitary, axial and free standing fans: 200,000 (60,000) (80,000) (100,000) hour service
 - .3 Other fan bearings: 8,000 hour service
 - .2 Type:
 - .1 Grease lubricated ball or roller type fan bearings with ample thrust provision to prevent end play during normal life of bearings.
 - .2 Smaller than 36 mm diameter: cartridge type.
 - .3 36 mm dia. and larger: shaft adapter sleeve type bearings utilizing horizontally split pillow blocks and mechanical flinger type grease valves.
 - .4 Shafts smaller than 56 mm dia., interference fit bearings may be used in lieu of adapter sleeve type.
 - .3 Bearings in air stream:
 - .1 Well secured extended grease lubricating lines unless bearing is easily accessible through man-size access door.
 - .2 Pack bearings with low temperature grease in factory.
 - .4 Axial flow fans
 - .1 Conform to these specifications except where inner cylinder mounting methods are used or dimensions do not permit it and special or flange mounted type bearings are required.
 - .5 Grease Fittings, for fans driven by motors 0.375 kW (1/2 HP) and larger
 - .1 Provide bearings with Zerk or Alemite grease fittings, with provision for automatic relief of lubricant pressure to outside of fan, away from wheel

and visible from maintenance location.

- .2 Use service fittings and relief fittings easily accessible from maintenance locations and at separate and opposite sides of bearing housing.
- .5 Motors and Drives
 - .1 Motor ratings:
 - .1 To Section 20 05 12.
 - .2 Type, kW (HP) rating, motor speed and electrical characteristics shown on Drawings.
 - .3 Capable of satisfactory operation over range of performance from shut-off to run-out at 110% of rated rpm at point of selection.
 - .2 Drive and belt guards: to Section 20 00 19.
- .6 Accessories
 - .1 Casing Drains
 - .1 Fans discharging vertically through roof or as shown on drawings: fitted with 38 mm casing drains.
 - .2 Roof Mounted Fans
 - .1 Factory mounted unfused disconnect switches wired to motor terminals.
 - .2 Conduit or wiring post running through fan housing so that wiring may be run to line side of disconnect switch from below roof without disturbing roof construction.
 - .3 Roof Curbs for Roof Mounted Fans and Ventilators
 - .1 Prefabricated insulated galvanized steel sheet curbs for mounting to roof deck.
 - .2 Prefabricated insulated galvanized steel sheet curbs for mounting to roof deck.
 - .3 Minimum curb height: 300 mm on every side, or as dimensioned on drawings.

2.2 FAN TYPES

- .1 Centrifugal Fans
 - .1 Arrangements

Fan Type	Arrangement
Belt driven single inlet single width (SWSI) fans up to and including 915 mm wheel diameter	#1 or #2
Belt driven single inlet single width (SWSI) fans with wheel diameter larger than 915 mm diameter	#3
Belt driven double width double inlet (DWDI) fans	#3
Belt Drive Plenum (Plug) fans, single width single inlet (SWSI) fans	#3
Direct connected double width double inlet (DWDI) fans	#7
Direct connected single inlet single width (SWSI) fans	#8

Utility sets	#10
Tubular single width single inlet (SWSI) fans	#1 or #9

- .2 Fan wheels
 - .1 Backward curved or backward inclined for fan wheels less than 686mm diameter.
 - .2 Single or double thickness backward curved air foil blades for fan wheels 686 mm diameter and larger.
- .3 Fan casing
 - .1 Continuous seam welded
 - .2 Inlet mounting collar
 - .3 Outlet flanged collar
- .4 Plenum (plug) fans
 - .1 Safety screen enclosure around fan and motor fabricated from steel angle and expanded metal mesh
 - .2 Access covers to fan and motor shaft ends for speed measurements
- .5 In-line Cabinet fans
 - .1 Single wheel SWSI centrifugal fans with motor and V-belt drive
 - .2 Removable panels for access to internal parts
 - .3 Internally lined cabinet with 50 mm thick rigid acoustic insulation
 - .4 Expanded metal mesh over insulation on floor
 - .5 Motor pre-wired to external junction box
 - .6 Mounting ring or brackets for vertical or horizontal suspension from overhead structure
 - .7 Belt guard, motor and drive
 - .8 Hanger brackets
 - .9 Inlet and outlet cones
 - .10 Quick-opening access door
 - .11 External grease and relief fittings to each bearing
 - .12 Variable inlet vanes and linkage where noted.
- .6 Belted Utility Sets
 - .1 SWSI centrifugal fans
 - .2 Light weight construction, with V-belt pulley outboard of fan bearings and motor shaft pointing in same direction
 - .3 Belt-guard and motor enclosure
 - .4 Weatherproof enclosure where fans are located outdoors
 - .5 Gravity backdraft damper
 - .6 Access door.

- .7 Tubular centrifugal fans:
 - .1 Characteristics and construction as for centrifugal fan wheels
 - .2 (Direct drive motor) (Belt drive assembly)
 - .3 Smooth rounded inlet, and stationary guide vanes.
- .2 Tube and Vane Axial Fans
 - .1 Fan
 - .1 Fabricated of welded steel with welded motor support
 - .2 Quick-opening access door
 - .3 External grease and relief fittings to each bearing
 - .4 Streamlined inlet cone and discharge bell sections.
 - .5 Integral silencer casing
 - .6 Reinforced legs for floor mounted units
 - .7 Hanger brackets
 - .8 Support bracket welded to side of casing for suspended units
 - .2 Drives
 - .1 Direct driven: (adjustable pitch) (fixed pitch) (fan blade with totally enclosed "air-over" motors and diameter of wheel hub at least equal to that of motor frame.
 - .2 Belt driven: (fixed) (adjustable) blade wheels with externally mounted open drip proof motors, internal belt fairing, external belt guards and adjustable motor mounts.
- .3 Roof Top Fans and Ventilators
 - .1 Upblast exhaust and downward supply air fans
 - .1 Suitable for mounting on curbed roof openings
 - .2 Heavy gauge galvanized steel housing and windband
 - .3 Finished inside and outside with sprayed asphalt
 - .4 Heavy gauge curb cap
 - .5 Gravity or spring assisted steel dampers as required, with magnetic catches to dampers to prevent rattling in closed position
 - .6 TEAO motor
 - .7 Weatherproof protective motor cover and belt-drive
 - .8 Supply fans complete with 25 mm throwaway filters.
 - .2 Spun Aluminum Dome Type Fans
 - .1 Belt or direct driven as indicated in Schedules
 - .2 Spun aluminum housing
 - .3 Hinged or completely removable hood for access to motor and fan
 - .4 Non-overloading centrifugal fan wheel

- .5 Multi-blade gravity backdraft damper and aluminum 13 mm mesh birdscreen.
- .3 Gravity Relief Vents
 - .1 Spun aluminum cover
 - .2 Welded aluminum curb cap
 - .3 Galvanized bird screen
 - .4 Exhaust air outlets complete with backdraft dampers.
- .4 Penthouse Type Intake and Exhaust Hoods
 - .1 Extruded aluminum fixed louvres with birdscreens on inside
 - .2 Insulated metal roof
 - .3 Welded base to suit curbed opening and prefinished to later colour selection.
- .4 Propeller Fans
 - .1 Wall type belt or direct driven propeller fans
 - .1 Multi-bladed propellers of sheet or airfoil shape steel within bell mouth entrance.
 - .2 Grease lubricated ball bearings suited for operation in any position.
 - .3 (Direct) (or) (belt) driven, with motor as indicated.
 - .4 Bird screen (and automatic backdraft dampers with gasketed edges).
 - .5 Wire guard on motor side.
 - .6 Support motor with substantial brackets or frame. Motors supported integrally with wire guard will not be accepted.
- .5 Acceptable Manufacturers
 - .1 Industrial Type Construction (In-line, Propeller Utility Sets, Upblast, Fume):
 - .1 Twin City Fan
 - .2 Chicago Blower
 - .3 Northern Industrial
 - .4 Northern Blower
 - .5 Barry Blower
 - .6 Aeroflow
 - .7 Aerovent
 - .8 Howden Fan Co.
 - .2 Small Propeller Fans:
 - .1 Howden Fan Co.
 - .2 Greenheck
 - .3 Penn

- .3 Spun Aluminum Fans:
 - .1 Greenheck
 - .2 Jenn Air
 - .3 Penn
- .4 Intake and Exhaust Hoods, Penthouses, Relief Vents:
 - .1 Greenheck
 - .2 Jenn Air
 - .3 Penn
 - .4 Loren-Cook

PART - 3 EXECUTION

3.1 GENERAL

- .1 Fan installation
 - .1 Install fans complete with resilient mountings and restraining snubbers in accordance with Section 20 05 48.
 - .2 Provide flexible connections on inlet and outlet ductwork: in accordance with Section 23 33 00.
 - .3 Align shafts, belt drive and motor, adjust belt tension and check motor rotation before start-up.
 - .4 Protect motors and fans during construction and rotate fans, by hand, every month between delivery and acceptance of building.
- .2 Air Balancing
 - .1 Adjust variable pitch fan/motor sheaves during balancing to achieve specified air quantities.
 - .2 Provide sheaves and belts for final air balance.

3.2 FABRICATED GOOSENECK TYPE FRESH AIR INTAKE AND EXHAUST AIR HOODS

- .1 Fabrication: black steel construction.
- .2 Size, shape and arrangement as shown on Drawings.
- .3 Finish interior and exterior surfaces finished with rust inhibitive primer.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 23 05 00 - Common Works for HVAC shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 Supply and install all air inlet and outlet products.

1.2 RELATED WORK

- .1 The following work is provided under other Sections or Divisions of the Work:
 - .1 Door grilles: provided under General Trades scope of work.

1.3 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for grilles, diffusers and related accessories. Shop drawings shall include, but not be limited to: noise and airflow data, physical dimensions, finishes, installation details.

PART - 2 PRODUCTS

2.1 DIFFUSERS, REGISTERS AND GRILLES

- .1 General
 - .1 Neck size, dimensions and capacity as shown on Drawings. Catalogue numbers of first named supplier are listed on Drawings to show required type and style.
 - .2 Acoustic and airflow performance is based on catalogued information of the indicated manufacturer and model as shown on drawings or schedules. Other named manufacturer products must match these implied performance criteria.
 - .3 Border and frame as required to suit wall and ceiling construction.
- .2 Linear Diffusers and Grilles
 - .1 Extruded aluminum construction, unless otherwise shown on drawings
 - .2 Linear supply and return diffusers to have either natural anodized aluminum finish or baked enamel finish as listed on Drawings.
 - .3 Complete with engineered distribution plenum and internal opposed blade damper. Black finish on inside of plenums.
 - .4 Curved and custom shapes and finishes as detailed on drawings.

- .3 Square and Circular Pattern Diffusers
 - .1 Steel construction with baked white enamel finish, unless otherwise shown.
 - .2 True imperial or metric sizes.
 - .3 Radial opposed blade damper
- .4 Grilles
 - .1 Steel construction with baked white enamel finish, unless otherwise shown.
 - .2 Blade orientation parallel to the long dimension.
 - .3 Opposed blade damper in black finish.
- .5 Door Grilles
 - .1 Door grilles will be supplied and installed by General Trades.
- .6 Acceptable Manufacturers:
 - .1 E.H. Price
 - .2 Nailor Industries Inc.
 - .3 Titus

PART - 3 EXECUTION

3.1 GENERAL

- .1 Supply diffusers and registers to deliver indicated air quantities shown with throw to reach intended space limits without increasing the sound level of room. Provide blank-off baffles where required and equalizing deflectors on diffusers and in other locations as shown or required.
- .2 Coordinate placing of diffusers, registers and grilles in ceilings with electrical and ceiling installation trades and exact location to final approval of Consultant.
- .3 For connection to specific light-air troffers in flat ceilings provide boots to connect flexible duct to lighting fixtures.
- .4 For connection of air supply to coffered ceilings provide boots suitable for attachment to air slot on coffered ceilings as required and where shown on Drawings. Connect flexible supply air duct to neck of boot.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section for the following:
 - .1 Furnish and install indoor and outdoor mounted custom air handling units designed and manufactured to the specific requirements of this project, with all required support and accessories.
 - .2 Related Requirements:
 - .1 Comply with Conditions of the Contract and Division 01 - General Requirements.
 - .2 Sections 20 00 13 – Mechanical General Provisions and 23 05 00 - Common Works for HVAC shall apply to and govern this Section.

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for custom air handling units. Shop drawing shall include but not be limited to:
 - .1 Unit dimensions, unit weight, required clearances, wall, door and base construction details, coil rack and drain pan details, isolation base detail, isolator selection, field connection details, damper details, lifting lug details, and trapping requirements for cooling coil condensate.
 - .2 Product data indicating dimensions, weights, capacities, ratings, fan performance, motor electrical characteristics, metal gauges and finishes of materials.
 - .3 Fan curves with specified operating point clearly plotted.
 - .4 Sound power levels for both fan inlet and outlet at rated capacity. Provide sound power levels at the inlet and outlet of the unit.
 - .5 Product data of filter media, filter performance data, filter assembly, and filter frames.
 - .6 Electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
 - .7 Manufacturer's recommended installation instructions.
 - .3 Submit a load point calculation along with detailed lifting lug information.
 - .4 Submit all certified factory test reports including air leakage testing, sound testing, flood testing, performance testing and vibration testing.

1.3 REFERENCE STANDARDS

- .1 ASHRAE Standard 90.1 – Energy Standard for Buildings

- .2 ASHRAE Standard 33 – Methods of Testing Forced-Circulation Air-Cooling and Air-Heating Coils.
- .3 ASHRAE Standard 15 and 34 - Safety Standard for Refrigeration Systems and Designation and Classification of Refrigerants
- .4 ASHRAE Standard 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
- .5 ASHRAE Standard 84 - Method of Testing Air-to-Air Heat/Energy Exchangers
- .6 ASHRAE Guideline 16 - Selecting Outdoor, Return, and Relief Dampers for Air-Side Economizer Systems
- .7 National Energy Code of Canada for Buildings
- .8 AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils
- .9 AHRI 430/431 - Performance Rating of Central Station Air-handling Unit Supply Fans
- .10 AHRI 1060/1061 - Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment
- .11 AMCA 300 – Reverberant Room Method for Sound Testing of Fans
- .12 AMCA 500-L - Laboratory Methods of Testing Louvers for Rating
- .13 AMCA 511 – Certified Ratings Program Product Rating Manual for Air Control Devices
- .14 ANSI/AMCA Standard 204 – Balance Quality and Vibration Levels for Fans
- .15 ANSI/AMCA Standard 210 – Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating
- .16 ANSI/AMCA Standard 500-D - Laboratory Methods of Testing Dampers for Rating
- .17 ANSI B9.1 – Safety Code for Mechanical Refrigeration
- .18 ASME B31.3 – Process Piping
- .19 ASTM A249/A249M - Standard Specification for Welded Austenitic Steel Boiler, Superheater, Heat-Exchanger, and Condenser Tubes
- .20 ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus
- .21 ASTM E84 / UL 723 - Standard Test Method for Surface Burning Characteristics of Building Materials
- .22 CAN/ULC-S102 - Standard Method of Test for Surface Burning Characteristics of building Materials and Assemblies
- .23 CSA 22.2 – Canadian Electrical Code
- .24 CSA B51 / ASME 31.1 – Boiler and Pressure Vessel Code
- .25 NEMA MG1 - Motors and Generators
- .26 NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems

.27 NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems

.28 OSHA 1910.23 - Ladders

1.4 **QUALITY ASSURANCE**

.1 The following shall be used as selection criteria and shall be as specified:

.1 Air flow rates, external static pressures, water flow rates.

.2 The following shall be equalled or bettered:

.1 Coil face velocities, filter face velocities, casing leakage rates.

.3 The following shall be met within 10% of specified values:

.1 Water pressure drops.

.4 Unit shall be produced by a recognized manufacturer who maintains a local service agency and parts stock. Air handling units and major components shall be products of the manufacturer regularly engaged in production of such equipment.

.5 Fans shall conform to ANSI/AMCA bulletins regarding testing and construction. Airfoil fans shall bear the AMCA certified rating seal for airflow and sound. Fans shall be certified to AHRI Standard 430/431.

.6 Coils shall be certified to AHRI Standard 410.

.7 Filter media shall be ULC listed.

.8 Unit shall be factory CSA approved

.9 Manufacturer shall have factory weld certification for all structural welds in accordance with CSA W47.1 and CSA W59 and AWS D1.1.

.10 Standard of Acceptance

.1 Daikin

.2 Engineered Air

.3 Racan

.4 TMI

.5 Ingenia

PART - 2 PRODUCTS

2.1 **GENERAL**

.1 Provide factory assembled air handling units in configuration as indicated on the Drawings. Units shall include all specified components installed at the factory. Field fabrication of units and their components will not be accepted.

.2 The units shall be designed to be supported by a perimeter concrete housekeeping pad.

.3 Units too large to fit on a standard tractor-trailer may be shipped to site in sections. Otherwise units shall be shipped in one piece.

- .4 Internal components shall comply with the following Specification Sections, except where modified in this Section:
 - .1 Motors: Section 20 05 12 - Common Motor Requirements
 - .2 Wiring: Section 20 05 13 - Common Wiring Requirements
 - .3 Vibration isolation: Section 20 05 48 - Vibration Control
 - .4 Fans: Section 23 34 00 - Fans
 - .5 Air filters: Section 23 41 00 - Particulate Air Filtration
 - .6 Condensing units: Section 23 63 00 - Refrigerant Condensers
 - .7 Coils: Section 23 82 16 - Air Coils

2.2 **CASING**

- .1 Walls and roofs shall be constructed of 1.6mm galvanized steel. The inner liner shall be 0.9mm perforated galvanized steel. Insulation shall be 25 mm thick 72 kg/cu.m density fibreglass. Provide neoprene liner to seal insulation in sections with perforated panels. All permanently joined flanged panel surfaces shall be sealed with an individual strip of 3mm x 9mm tape sealer. Wall and roof seams shall be turned inward to provide a clean flush exterior finish. All panel seams shall be sealed during assembly to produce an airtight unit.
- .2 Outdoor units shall have roof panels broken outward to provide a lapped joint watertight seal. Outdoor roofs shall be sloped a minimum of 15mm away from the access side.
- .3 On outdoor units, screws and other similar fastening devices shall not penetrate the roof deck or the top of standing seems.

2.3 **INSULATION**

- .1 All insulation used in air handling unit walls, roof and base shall have a flame spread rating of less than 25 and a smoke development rating of less than 50 per ASTM E84 / UL 723 and CAN/ULC S102.
- .2 Insulation shall meet the requirements of NFPA 90A and 90B.

2.4 **STRUCTURAL BASE CONSTRUCTION**

- .1 Units shall be constructed from a minimum **C6 x 8.2 lb./sq.ft.** channel structural steel perimeter base, with 50mm x 50mm x 6mm intermediate structural steel channel and angle iron supports. Perimeter structural steel base shall be designed to directly support the weight of the walls. Intermediate structural steel and angle iron shall support the weight of all internal components (i.e. fans, coils, enthalpy wheels). Maximum base deflection shall be 6mm on unsupported spans of 3.6m. Structural steel base shall be designed so that it can be point loaded or set on an uneven surface, and shimmed within 3.6m spans without deflecting more than 6mm. The structural steel base shall be either I-beam construction or C-channel (not box channel) so that the base will shed all water. Base shall be provided with lifting lugs, minimum four (4) per shipping split. Formed metal bases formed from sheet metal will not be acceptable. Base shall prevent wall panel joints from separating during lifting, transportation and rigging.
- .2 Lifting lugs shall be located and engineered to properly support the loads within.
- .3 A 1.9mm thick aluminum checker plate floor shall be installed on the base. Floor seams shall be continuously welded providing a completely flat unit floor. Standing seems will not be accepted in any section. Steel checker plate floor shall be coated with grey epoxy paint.

A 38mm perimeter collar shall be provided to ensure the unit is internally watertight. The collar shall be alternately screwed down and tack welded to the unit base on one (1) foot centres. Caulk joint watertight.

- .4 The base shall be insulated with 76mm thick, 24 kg/m³ density fibreglass insulation and sheeted with a 0.85mm galvanized steel liner. The base liner shall be thermally broken, tack welded and sealed for rigidity and vapour barrier integrity.

2.5 **ACCESS DOORS**

- .1 Access door construction and width shall match the rest of the unit casing. Corners shall be welded for rigidity. Spot welding of corner seems will not be accepted. 72 kg/m³ density insulation shall be sandwiched between the outer and inner skins. A 250mm x 250mm double pane tempered glass window shall be provided in each door.
- .2 Provide two (2) chrome plated, high pressure latches, operable from either side of the door. Hinges shall be continuous piano type made of stainless steel. Door openings shall be fully gasketed with continuous 12mm closed cell hollow round black gasket with a metal encapsulated reinforced backing that mechanically fastens to the door opening perimeter. Door frames shall be framed from 1.6mm galvanized steel with the outside of the door flush to the unit. Minimum door width shall be as shown on the plans but in no case shall an access door be less than 450mm wide. Door height shall be the maximum permitted by the height of the unit up to 1.83m.
- .3 Doors shall open against positive pressure.

2.6 **FANS**

- .1 All fans shall be tested to ANSI/AMCA Standard 210. Backward inclined fans shall bear the AMCA sticker for both air and sound performance.
- .2 Provide air foil blades on all fans wheels. Provide forward curved blades where scheduled. Provide solid shafts keyed to the fan wheel. Coat fan shaft with rust inhibitor. Hollow shafts will not be acceptable.
- .3 Fan bearings shall be self-aligning pillow block, grease lubricated, extra heavy duty anti-friction ball or spherical roller type selected for an L10 life of 200,000 hours at design operating conditions. Bearings are to be mounted on the integral fan scroll bracing. (Provide an easily removable 610mm x 610mm access panel in the unit casing adjacent to the motor side bearing for ease of fan shaft/bearing replacement).
- .4 Fan and motor shall be mounted on an all welded, structural steel, prime coated and internal isolation base. The outlet of the fan shall be separated from the unit casing by means of a factory installed flexible connection. The internally mounted motor shall be provided on a slide rail base to allow proper adjustment of belt tension.
- .5 Provide plenum fan inlets on the fan wall and air outlets from the casing with a smooth bellmouth fitting with radius to match casing thickness, and free of protruding structural members and flanges.
- .6 Plenum fan assembly shall have an enclosed safety screen as per OSHA Standards.
- .7 Provide fan evase on all blow thru scrolled fans.

2.7 **MOTORS**

- .1 Motors shall be designed for severe duty in accordance with Section 20 05 12 - Common Motor Requirements. Fan motor shall be ECM, direct drive.

- .2 Motor shall be totally enclosed fan cooled, rated to IP55. A non-metallic cooling fan shall be provided. Frame, end bells and fan cowl shall be manufactured of heavy duty cast iron. The end plates shall be sealed to the frame joints. Enclosure shall be epoxy coated.
- .3 Motor windings shall have class F insulation with class B temperature rise ratings. Windings shall be 200°C inverter spike resistant wire. Motor windings shall withstand 2000V transients.
- .4 Bearings shall be re-greasable without disassembly and provide for the elimination of purged grease. Bearing life shall be a minimum of L10 at 50000 hours.
- .5 Motors shall be balanced to less than 2mm per second (filter out) and the vibration test data shall be shipped with the motor.
- .6 Motor nameplates shall be stainless steel and contain both NEMA data and bearing data.
- .7 Motors used with variable frequency drives shall be provided with a brush system to electrically ground the shaft and discharge any induced voltage on the motor shaft, with a direct path to ground.
- .8 Motor shall be provided with a 3-year warranty.

2.8 **AIRFLOW MEASURING PROBES**

- .1 Provide on each fan, air flow measuring probes.
- .2 Each airflow probe shall contain multiple, averaged velocity pressure taps located symmetrically around the throat of the fan inlet and a single static pressure tap located on the fan housing. The entire airflow monitoring probe shall be located outside the inlet throat as to not obstruct airflow.
- .3 The probes shall be capable of producing steady, non-pulsating signal of the velocity pressure, independent of the upstream static pressure without adversely affecting the performance of the fan. The sensing probes shall have an accuracy of $\pm 3\%$ of the actual fan airflow.

2.9 **AIRFLOW DISPLAY**

- .1 Provide on indicated fans a method of displaying digitally, in real time, the fan's current air flow.
- .2 The display shall be capable of showing the airflow of four (4) independent fans simultaneously.
- .3 For interaction with a controller, the display shall output one (1) 0-10VDC signal for each fan being monitored.
- .4 The output signal shall have an accuracy of $\pm 0.5\%$ of natural span, including non-linearity, hysteresis and non-repeatability.
- .5 The display shall be water-tight allowing for use in outdoor locations. If the display is not water tight it shall be enclosed in a weatherproof housing.

2.10 **VIBRATION ISOLATION**

- .1 Provide an integral, all welded steel vibration isolation base for each fan and motor.
- .2 Provide spring mounts in accordance with Sections 20 05 48 - Vibration Control and 20 05 49 - Seismic Control.

- .3 Horizontal stiffness shall be equal to vertical stiffness.

2.11 **COILS**

- .1 Coils shall be fully enclosed within casing and mounted on angle frames manufactured to allow coils to be individually removed. Cooling coil racks shall be 2.8mm. 304 stainless steel. Heating coils shall be mounted on galvanized angle racks.
- .2 Removable coil access panels shall be provided to remove coils through casing wall. Coil covers shall be double wall construction, with all exposed edges of insulation covered with sheet metal including holes through the cover for coil header stub outs. Coils shall be individually removable towards the access side.
- .3 All drain pans shall be double wall continuously welded 304 stainless steel. Intermediate drain pans shall be interconnected with stainless steel 25mm down pipes. Condensate drain pipe shall be a minimum 32mm diameter stainless steel tube extending 25mm out from unit for solder connection to trap. Drain pans shall be sloped within unit and fully drainable.
- .4 Coils shall be certified in accordance with AHRI Standard 410.
- .5 Construction:
 - .1 Tubes Horizontal, copper.
 - .2 Fins Aluminum (copper where coils are sprayed) mechanically bonded to tubes.
 - .3 Headers Seamless copper with vent and drain connections.
 - .4 Casing 1.6mm, galvanized steel (stainless steel) (aluminum where coils are sprayed) channels with 1.6mm center and end supports.
 - .5 Connections Same end, counterflow, with vent, drain, supply and return stubs extended to outside of unit casing with grommets for airtight casing. Roof mounted units shall have the centre of the bottom coil connections located 250mm off the unit floor.
- .6 All refrigerant coils shall be designed to conform to ANSI B9.1. All DX coils shall contain a holding charge of dry nitrogen when shipped from the factory.
- .7 Steam coils shall be non-freeze type. Pitch steam coils in units for proper drainage of steam condensate.
- .8 **Optional: Cooling** coils shall have a flexible epoxy polymer e-coat uniformly applied to all casing and coil surface areas without material bridging between fins. Coating process shall ensure complete coil encapsulation and a uniform dry film thickness from 0.8 – 1.2 mil on all surface areas including fin edges. Corrosion durability shall be confirmed through testing to no less than 5,000 hours salt spray per ASTM B117 using scribed aluminum test coupons. Coils subjected to ultraviolet (UV) exposure shall receive a spray-applied, UV-resistant polyurethane topcoat to prevent UV degradation of electrofin coat.

2.12 **ULTRAVIOLET LIGHTS**

- .1 The UVGI surface irradiation system shall consist of heavy duty, factory assembled and tested light fixtures that emit short wave UVC light. Units shall be constructed and tested for HVAC environments, be suitable for operating temperatures between 0°C and 65°C, and suitable for airflow velocities up to 5.1m/s.

- .2 Unit housings shall be made of 304 stainless steel, with electrical connectors on both ends. Reflectors or approved equivalent shall be constructed of high spectral finished aluminum alloy with a minimum 85% reflectance of 254-nm UVC energy.
- .3 Emitter tube shall be of the high output, hot cathode, T5 15mm diameter, and medium bi-pin type or single ended four pin connectors. The tube shall produce 95% of their energy at 254 nm and be capable of producing the specified output at airflow velocities to 5.1m/s at temperatures of 2°C – 65°C. UVC emitters shall produce no ozone or other secondary contamination.
- .4 Power source shall be 120 VAC, 60 Hz.
- .5 Emitters and fixtures shall be installed downstream of the cooling coil at right angles to the coil fins, such that UVC energy bathes all surfaces of the coil and drain pan.
- .6 Access door to UVC emitters shall be provided with an interlock switch which will cut power to the emitters when the door is opened. The window in this door shall be tested for use with UV lights.

2.13 **FINAL FILTERS**

- .1 Final filters shall be high performance, deep pleated disposable type. Each filter shall consist of glass fibre media, media support grid, contour stabilizer and enclosing frame.
- .2 Final filter media shall be of high density microfine glass fibers laminated to a non-woven synthetic backing to form a lofted filter blanket. The filter media shall have an average efficiency of MERV 13 to ASHRAE Standard 52. The filter shall be listed by Underwriters Laboratories as Class 2.
- .3 Holding frames shall be factory fabricated of 1.6mm galvanized steel and shall be equipped with gaskets and two (2) heavy duty positive sealing fasteners. Each fastener shall be capable of withstanding 111 N pressure without deflection. They will be capable of being attached or removed without the use of tools.
- .4 Final filters shall be slide out.

2.14 **DRAINS**

- .1 Provide 32mm capped floor drain connections on the side of the unit for complete drainability of the base pan for the following sections:
 - .1 Fresh air plenums;
 - .2 Humidifier sections;
 - .3 Service corridors;
 - .4 Fan sections;
 - .5 Sections upstream and downstream of coils;
 - .6 All sections if unit has wash-down liner.

2.15 **HOOD**

- .1 Fresh air hoods shall be provided complete with 12mm x 12mm birdscreen and finished to match the unit. A rain gutter shall be provided on all edges of the hood. Outside air hoods shall be sized for maximum inlet velocity of 3 m/s.

2.16 **ALUMINUM AIRFOIL DAMPERS**

- .1 Aluminum airfoil frames and blades shall be a minimum of 2.3mm extruded aluminum. Blades to be 152mm wide single air foil design.
- .2 Frames shall be extruded aluminum channel with grooved inserts for vinyl seals. Standard frames shall be 51mm x 102mm x 15mm on the linkage side, 25mm x 102mm x 25mm on the other sides.
- .3 Pivot rods shall be 11mm hexagon extruded aluminum interlocking into blade section. Bearings to be double sealed type with a Celcon inner bearing on a rod within a Polycarbonate outer bearing inserted into frame so that the outer bearing cannot rotate.
- .4 Bearing shall be designed so that there are no metal-to-metal or metal-to-bearing riding surfaces. Interconnecting linkage shall have a separate Celcon bearing to eliminate friction in linkage.
- .5 Blade linkage hardware is to be installed in frame out of airstream. All hardware to be on non-corrosive reinforced material or cadmium plated steel.
- .6 Damper seals shall be designed for minimum air leakage by means of overlapping seals.
- .7 Damper blades shall be maximum 1016mm long per section.
- .8 Dampers greater than 2 sections wide shall be provided with a jackshaft.

2.17 **FORMED STEEL DAMPERS**

- .1 Formed steel dampers and frames shall be made from 1.6mm galvanized steel.
- .2 Drive shaft clamp plates shall be made with 2.7mm galvanized steel and set screws.
- .3 Blade seals shall be PVC suitable for -40°C air temperature.
- .4 Jamb seals shall be stainless steel.
- .5 Provide jack shaft assemblies for multiple damper installations.

2.18 **BUBBLE TIGHT DAMPERS**

- .1 Dampers shall consist of a round channel frame with a single removable circular blade fabricated from steel.
- .2 Damper axle shall pivot on re-lubricable ball bearings bolted outboard of damper frame. Provide a double gland axle seal.
- .3 Dampers shall be equipped with silicone rubber blade seals for bubble tight leakage performance up to 121°C maximum.
- .4 Damper shall be suitable for pressures up to 7.5 kPa, and velocities up to 33 m/s.

2.19 **TEST PORTS**

- .1 Provide a 25mm diameter test port for unit air stream testing in each plenum section between each component within the AHU. Test ports shall have a tube that extends between the inside and outside of the unit, and a screwed cap on the exterior to allow access. The test ports shall have been flanged on the exterior to allow air seal and shall be flanged on the interior to cover the penetration of the casing.

2.20 **CONDENSING SECTION**

- .1 Provide a condensing section constructed and rated in accordance with the latest AHRI standard and ASME code.
- .2 The unit shall be assembled on a rugged steel base and shall be shipped with a holding charge of R32. Unit casing and all structural members and rails shall be fabricated of continuous G90 galvanized steel and galvanized steel channel. Exterior casing shall be cleaned and phosphatized, then partially painted with a urethane finish. Unit shall have easily removable, separate access panels to the control centre and the compressor compartment. Top panel and condenser fan deck assemblies shall also be removable.
- .3 Compressor shall be modulating digital scroll type, refrigerant gas cooled with forced feed lubrication system, solid state motor protection system, suction and discharge valves, and crank case heater. (Digital scroll compressors shall provide a modulating output from 10% to 100% of rated capacity, without the requirement for hot gas bypass.) Compressors shall be mounted on rubber in shear isolators.
- .4 Condenser coils shall be constructed from seamless copper tubes mechanically expanded into aluminum fins and have integral subcooling circuits. Condenser fans shall be direct drive, propeller type with inherently protected, permanently lubricated motors. Unit shall be provided with automatic head pressure control to permit operation at ambient air temperatures down to -18°C by cycling the condenser fans and controlling a variable speed fan in response to head pressure and ambient temperature.
- .5 Field power connection, control interlock terminals and unit control system shall be centrally located in a weatherproof enclosure. Panel access door shall key lock to prevent unauthorized access. Dead front panel shall protect service personnel against accidental contact with line voltage components.
- .6 Power and starting components shall include circuit breaker for each compressor, fusing for the control circuit, compressor starting contactors, solid state compressor sequence start timer, unit power terminal block for field connection to a single power supply and control power transformer. Wire the condensing section so the main disconnect in the air handler cuts the power to the entire unit.
- .7 Safety controls shall include unit control stop switch, recycling pump-down switch, oil safety switches, high and low pressure switches and solid state compressor anti-cycle timers.
- .8 Provide the unit with a terminal strip for connection to field installed controls.
- .9 Each refrigeration circuit shall include sight glass, filter drier, manual shutoff valve, and spring type high pressure relief valve. Provide each circuit with a subcooler circuit to provide 15 degrees of liquid subcooling.
- .10 Optional: Provide factory installed gauges for displaying high and low side refrigerant pressures and oil pressure. Gauges shall be mounted on manual shut off isolation valves.
- .11 Optional: Provide factory installed non-fused disconnect.
- .12 Optional: Provide factory installed phase failure protection.
- .13 Optional: Condensing units shall have compressor cycle counters and elapsed running hour meters.
- .14 Optional: Provide a 24 Volt alarm signal of the high pressure cutout or freeze protection pressure stat.

- .15 Optional: Spring vibration isolators shall be factory supplied for field installation.
- .16 Optional: Provide hot gas bypass for unit operation to 10% of load on one refrigerant circuits.
- .17 Optional: Provide part wind starters for the compressor(s).

2.21 **GAS HEATING SECTION (TUBULAR HEAT EXCHANGER)**

- .1 Provide a gas-fired heating section with a minimum thermal efficiency of 80%. The module shall employ tubular heat exchangers with a draft inducer assembly to provide for positive venting of flue gases.
- .2 Tubular heat exchanger shall be constructed of 1.6mm, minimum, type 304 stainless tubes, 58mm diameter having a minimum tube wall thickness of 1.2mm and shall be manufactured to ASTM A249 construction standards for heat exchanger application. Tubes shall employ integral formed-dimple restrictors to eliminate noise associated with expansion and contraction of internal baffles during heating cycles, and to provide for unobstructed drainage of condensate that occurs in the tubes during cooling operation. Drainage shall be configured so that burners and burner surfaces are not exposed to condensate during cooling system operation.
- .3 The furnace shall have a modulating 5:1 control system. On a call for heat, the modulating control shall control the firing rate between 25% and 100% of rated capacity. Stepped modulation is not acceptable.
- .4 All burners shall include an ignition control, roll out switch and air proving switch. Additionally, on full modulation models a fan relay, delay timer and high fire gas valve control relay shall be included. Burners shall accept either 0 to 10 VDC or 4 to 20mA input signals (signal provided by others). Two independent and adjustable (when compared to the analog input signal) SPDT relays shall be provided for fan and valve control.

2.22 **ELECTRICAL**

- .1 Factory wire and test all air handling units. Have units approved by CSA or ETLc.
- .2 Supply individual 575 V / 60 Hz / 3 Ph power connections for motors and other large electrical devices, and one 120 V / 60 Hz / 1 Ph power connection for lights, controls, heaters. (Provide a minimum 2kVA transformer fed from the main power source to power the lighting circuit.)
- .3 Optional: Provide a separate 120 V / 1 phase feed for a 20-Amp convenience outlet.
- .4 Provide necessary circuit breakers and/or fuses for each type of electric device.
- .5 A bonding wire shall be provided between the motor loads and the electrical panel. The use of the air handling unit casing for a bond will not be accepted.
- .6 Label and number code all wiring and electrical devices in accordance with the unit's electrical diagram. Mount the devices in a control panel inside the unit's service enclosure or on the outside. Control panel shall meet the requirements of CSA 22.2 or the Canadian Electrical Code (CEC) for the specific installation.
- .7 Provide a system of motor control including all necessary terminal blocks, motor contactors, motor overload protection, grounding lugs, auxiliary contactors and terminals for the connection of external control devices or relays. Individually fuse all fan and branch circuits.

- .8 Wire from the motors to the motor control in accordance with the local electrical code and contained by EMT conduit with liquid tight connections. Seal the casing penetrations in a manner that eliminates air leaks. At all split sections, provide a 300mm long piece of flexible conduit, with the extra wire spooled, for reconnection on site by the installing contractor.
- .9 External disconnects shall be provided in a NEMA 4 enclosure for superior water protection. Disconnects shall be interlocked with the electrical panels for added personnel safety.

2.23 **FINISH**

- .1 Unit shall be finished painted with two components, etch bond primer and finish painted with alkyd enamel, colour as selected by Owner. All uncoated steel shall be painted with grey enamel. All metal surfaces shall be pre-painted with vinyl wash primer to ensure paint bonds to metal. Outdoor units shall be finish coated with polyurethane paint. Paint for outdoor units shall be tested to ATSM B117 for 5000hr salt spray endurance.

2.24 **PIPE WORK**

- .1 The manufacturer shall have a quality assurance program in place, and have the quality assurance manual available for the customer upon request.
- .2 Documented test procedures shall be available to the customer upon request.
- .3 All piping systems shall be hydrostatically pressure tested at 1.5 times design pressure and hold pressure for one hour in the factory before shipping. A chart recorder shall be used to record the pressure for the test period and will be submitted to the Consultant for review prior to shipping the units.
- .4 Optional: Manufacturer shall X-ray 10% of the welds to verify compliance with CSA B51 / ASME 31.1. The X-ray examination shall be carried out by an independent certified party.
- .5 Factory testing equipment shall be calibrated as outlined in the quality assurance manual, and be made available for Owner's inspection upon request.
- .6 Register and obtain a CRN for pressure piping systems exceeding 103 kPa.
- .7 All pipe shall be welded construction in accordance with CSA B51 / ASME B31.1 and B31.3, ANSI/ASME Boiler and Pressure Vessel Code, Sections I and IX and ANSI/AWWA C206, using procedures conforming to AWS B3.0, AWS C1. The use of mechanical fasteners is not acceptable. Threaded connections shall only be permitted when connecting to equipment and valves with threaded connections.
- .8 Defects causing rejection shall be as described in CSA B51 / ASME 31.1 and the ANSI/ASME Boiler and Pressure Vessels Code. Re-inspect and re-test repaired or re-worked welds.
- .9 All valves and strainers shall be either full lug style or employ socket weld connections. The use of threaded valves on pipe over 20mm diameter is not acceptable.
- .10 Provide piping specialties not described in this Section as outlined in other Sections of the Specification.

2.25 PIPE SUPPORTS

- .1 Steam piping shall be supported with rollers and insulation saddles, supported by structural steel from the corridor base. Secure pipe to the rollers with temporary bracing for shipping purposes.
- .2 Condensate and hydronic pipe supports shall be heavy duty pipe clamps to support systems and pipework under all conditions of operation and prevent excessive stresses and vibration from being introduced into pipework or connected equipment.
- .3 The use of U-clamp pipe supports and clevis hangers are not acceptable.
- .4 Shop fabricate equipment supports not provided by equipment manufacturer from structural grade steel.
- .5 Provide removable angle iron blocking and bracing to prevent movement of pipe-work and equipment during shipping.

2.26 FACTORY MOUNTED CONTROLS

- .1 Furnish all labour and material of direct digital control required to meet the sequence of operation. Controller shall be native BACnet to allow connection to the BAS (or future BAS) via BACnet MS/TP or BACnet IP. Wire all components specified in EMT conduit with rain tight fittings. Electrical interlock wiring of field devices (i.e. flow switches, thermostats) is the responsibility of the Contractor performing the Work of Division 23 – HVAC unless indicated otherwise.
- .2 Supply and install sensors indicated in the points list.
 - .1 Provide high temperature limit thermostats with a single rod and tube type manual reset limit set at 57°C.
 - .2 Provide air proving switches that utilize a differential pressure activated, diaphragm actuated, snap acting SPDT switch rated at 9.8 Amp 120/1/60 AC full load.
 - .3 Supply factory calibrated temperature sensors compatible with DDC controller and an accuracy of +/- 1.0% at 20°C. Wall mounted temperature sensors shall have a momentary contact switch for override initiation, concealed temperature setpoint adjustment and telephone style jack for connection of portable service terminal.
 - .4 Supply load relays capable of switching 10 Amps at 120 V/60 Hz/1 Ph.
 - .5 Supply carbon dioxide sensors for air quality control purposes with the following characteristics:
 - .1 Measurement Range - 0-2000 PPM CO₂
 - .2 Accuracy +/- 100 PPM
 - .3 Repeatability +/- 20 PPM
 - .4 Drift +/- 100 PPM per year
 - .5 Output Signal 0-10 VDC proportional over the 0-2000 PPM range
 - .6 Response time 20 seconds maximum
 - .7 Operating conditions 0-50°C, 10-100% rH non-condensing
 - .6 Pressure sensors shall have a span of not greater than twice the static pressure at maximum flow or twice the differential pressure at shut off. Pressure switches shall have bourdon tube, bellows or diaphragm type sensing element, adjustable setpoint, and differential and snap acting contacts rated at 15 Amps for 120 Volts.

- .7 Temperature switch sensing elements shall be liquid filled for averaging and vapour filled for freeze protection. Supply temperature switches with adjustable setpoint and differential, snap acting contacts rated at 15 Amps for 120 Volts and automatic reset.
- .8 Supply current sensing relays in fan motor starters to detect flow. Current sensing relays shall match the load being metered, have a minimum differential of 10% of latch setting between latch level and release level and have an LED for local status indication.
- .3 Supply a native BACnet direct digital controller for each air handling unit. Controller shall be a microprocessor based, multi-tasking, real time, standalone controller capable of performing its specified control sequences.
 - .1 Controllers shall accept the following input types:
 - .1 AI - Temperature RTDs (10k RTD)
 - .2 AI - Universal transmitters (0-10VDC)
 - .3 DI - Momentary Inputs
 - .4 DI - Maintained Inputs
 - .5 DI - Pulsed Type
 - .2 Controllers shall support the following output signals:
 - .1 AO - 0-10VDC / 4-20 mA
 - .2 DO - single contact binary (maintained)
 - .3 DO - paired contact binary (momentary)
 - .4 DO - incremental type
 - .3 Controllers shall have a library of control processes to perform the sequence of operation specified in the "Execution" portion of this specification. Control processes shall include:
 - .1 Two Position Control and
 - .2 Proportional, Integral, plus Derivative Control.
 - .4 Each controller shall have sufficient memory to support its own operating system and databases, including control processes, energy management applications, operator I/O and local alarm management.
 - .5 Each controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

2.27 **PORTABLE SERVICE TERMINAL**

- .1 Controllers shall support the use of a portable service terminal than can be connected at the controller or at a jack located remotely. The capabilities of the portable service terminal shall include, but not be limited to, the following:
 - .1 Display temperature
 - .2 Display status
 - .3 Display set points
 - .4 Display control parameters
 - .5 Override analog set points

- .6 Modification of gain and offset constants
- .7 System graphics (laptop only)
- .8 Audible and visual alarm indication
- .9 Password protection
- .10 View trend data (laptop only).

2.28 **POWERFAIL PROTECTION**

- .1 All controller set points, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the DSC.
- .2 All controller memory containing program configuration and control parameters shall be either non-volatile EEPROM/EPROM memory or shall be provided with battery back-up sufficient to sustain the contents of RAM memory for a minimum of one (1) year.
 - .1 Optional: Controller shall have a 7 day programmable time clock.
- .3 Mount the controller, relays, 120 V/24 V transformer and terminal blocks in a control panel that meets the CSA or CEC standard for the specific installation. Wire all sensors and controlled devices to terminal strips mounted in the control panel. Run all wire in Panduit wire raceway. Number code all wiring in accordance with the unit electrical diagram.
- .4 Equipment manufacturer is responsible for verifying the proper operation of all sensors and control devices and programming the controller in accordance with the sequence of operations. Owner's operating and maintenance personnel shall receive instructions on the operation and maintenance of the system.
- .5 Controller shall communicate with the BAS through either BACnet MS/TP or BACnet IP allowing access to all inputs and outputs. The controllers shall have the capability of receiving configuration and program loading by both of the following:
 - .1 Locally, via a direct portable laptop service tool,
 - .2 Over the network, from the portable laptop service tool, and
 - .3 From the Operator Workstation, via the communication networks.

PART - 3 EXECUTION

3.1 **GENERAL**

- .1 Install outdoor units on roof curb. Provide vibration isolation and seismic reinforcement in accordance with Sections 20 05 48 - Vibration Control and 20 05 49 - Seismic Control.
- .2 Provide components furnished as per manufacturer's literature.
- .3 Locate air handling units to allow for proper service access to all components.
- .4 Provide certified wiring schematics to the electrical division for the equipment and controls.
- .5 Provide all necessary control wiring as recommended by the manufacturer.
- .6 Provide condensate traps in accordance with manufacturer's recommendations. Size depth of trap based on peak operating static pressure.
- .7 Provide flexible duct connections at each duct connection to the units.

- .8 Remove or loosen shipping bolts prior to start-up.
- .9 Protect motors and fans during construction and rotate fans, by hand, every month between delivery and acceptance of building.
- .10 Before starting up any fans, inspect and clean the inside of all air handling systems including fans, ducts, coils, and terminal units to ensure that they are completely free from dust and debris.

3.2 **GAS HEATERS**

- .1 Connect gas service to the units. Provide isolation valves, pressure regulators, and piping specialties as required by the local gas code and to suit gas pressure.
- .2 Install main gas shut-off valve, where supplied loose by the manufacturer.
- .3 Provide the services of the burner manufacturer's service representative for set-up and commissioning of the burner system.
- .4 Provide measurements of CO₂ and excess O₂ at four points of the firing range.

3.3 **CONDENSING UNITS**

- .1 Provide the services of the condensing unit manufacturer's service representative for set-up and commissioning of the condensing unit.
- .2 Provide liquid and suction refrigerant lines for remotely mounted condensing unit, in accordance with manufacturer's recommendations.

3.4 **FIELD WIRING**

- .1 At the completion of the installation, provide field inspection services from the local electrical utility company where equipment is not CSA labelled.
- .2 Provide field wiring between remote condensing unit and the air handling unit.

3.5 **AIR LEAKAGE TESTING**

- .1 Unit manufacturer shall factory pressure test each air handling unit to ensure the leakage rate of the casing does not exceed (0.5% of the unit airflow at 1.5 times the rated static pressure for 100mm thick casing units) (1.0% of the unit air flow at 1.5 times the rated static pressure for 50mm thick casing units).
- .2 Test shall be conducted in accordance with SMACNA duct construction manual. A calibrated orifice shall be used to measure leakage airflow.
- .3 An officer of the air handling unit manufacturer shall certify the test results. Forward copies of certified test results to the Consultant.

3.6 **SOUND TESTING**

- .1 Air handling unit sound power levels are not to exceed the levels shown on Drawings.
- .2 Measure sound power levels at supply connection, return connection, outside air opening relief air openings and casing radiation for each air handling unit. Test data shall show sound power levels re 10-12 watts for each of the eight octave band center frequencies.
- .3 The air handling unit manufacturer shall be responsible for providing an independent agency to factory test units.

3.7 **FLOOD TESTING**

- .1 All unit bases shall be flooded to a level of 32mm after manufacturing to assure no leakage through the floor and the perimeter water barrier. The results of the flood test shall be certified by the manufacturer.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 23 05 00 - Common Works for HVAC shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 Supply and install split-system air conditioning systems. Provide all necessary refrigerant system components, relays, contactors, starters, disconnects.

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for split-system air conditioning systems and related equipment. Shop drawings shall include, but not be limited to:
 - .1 Complete specifications.
 - .2 Product data sheets indicating rated capacities, weight, and sound power levels.
 - .3 Refrigerant piping diagram showing all required components (valving, filter-drier, sight glass, traps).
 - .4 Power and control wiring diagrams.
 - .5 Physical outline dimension drawing showing required clearances, weights, and location and size of connection entries.

PART - 2 PRODUCTS

2.1 SPLIT-SYSTEM AIR CONDITIONERS

- .1 General
 - .1 The split air conditioning system shall consist of a ceiling mounted packaged evaporator section and matching outdoor unit.
 - .2 The units shall be made within North America. The units shall be listed by Intertek Testing Service (ITS) and bear the ETL label. All wiring shall be in accordance with the National Electrical Code (N.E.C.). The units shall be rated in accordance with ARI Standard 210/240 and bear the ARI label. The units shall be manufactured in a facility certified to ISO 9001.
 - .3 The condensing unit shall contain an R32 or equal to refrigerant charge for the evaporator section and condenser section. System SEER shall meet or exceed requirements of the ASHRAE 90.1 latest edition. R-410 refrigerant maybe applied upon approval per production date of the unit.

.2 Warranty

- .1 The units shall have a manufacturer's warranty for a period of one (1) year from date of installation. The compressor shall have a warranty of five (5) years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer.
- .2 This warranty does not include labor.

.3 Indoor Unit

- .1 The indoor unit shall be factory assembled and wired. The cabinet shall be fabricated of galvanized steel, finished in "offwhite" with corrosion inhibiting polyester powder-coated paint.
- .2 The evaporator fans shall be a forward curve centrifugal type, dynamically balanced and directly mounted to the motor shafts. The motors shall be PSC type with internal thermal overload protection. The supply louvers shall be dual adjustable for airflow direction. Return air shall be filtered by means of an easily removable electrostatic washable filter. The indoor unit shall have fresh air capability thru the top and back of the unit.
- .3 The evaporator coil shall be on nonferrous construction with louvered fins bonded to rifled copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phosphor copper or silver alloy. The coil shall be pressure tested at the factory. A condensate pan and drain shall be provided under the coil.
- .4 System refrigerant flow shall be controlled by means of an orifice piston in the indoor unit.
- .5 The unit electrical power shall be 208/230 volts, 1 phase, 60 hertz. The system shall be capable of satisfactory operation within voltage limits of 208/230 +/- 10% volts.

.4 Control System

- .1 The control system shall consist of 24V wall thermostat control with anti-short cycle compressor protection; fan purge. Fan shall remain on for 60 seconds after heat/cool call is dropped for improved efficiency. An integral heating relay ensures that the fan operates whenever electric heat is energized.
- .2 Wiring shall run from indoor unit to the 24V wall thermostat and to outdoor unit. When running low voltage wiring a double insulated wire should be used. The control voltage between the indoor unit and the outdoor unit shall be 24 Volts A.C. The 24 Volts shall be generated from the outdoor unit 24-Volt 40VA transformer.

.5 Outdoor Unit

- .1 The outdoor unit shall be completely factory assembled, piped, wired and contain a low voltage transformer. The cabinet shall be fabricated of G60 galvanized steel, finished in "off-white" with corrosion inhibiting polyester powder-coated paint.
- .2 The unit shall be furnished with one (1) direct drive, propeller type fan arranged for horizontal discharge. The motor shall have inherent protection, be of the permanently lubricated type, and resiliently mounted for quiet operation. The fan shall be provided with a guard to prevent contact with moving parts. The compressor shall be of the high-performance reciprocating type with a thermal overload. The compressor shall be mounted so as to avoid the transmission of vibration.

- .3 The refrigeration system shall be equipped with a high pressure switch and have the capability to operate with a maximum height difference of 10.7m (35 feet) and overall refrigerant tubing length of 30.5m (100 feet) between indoor and outdoor sections without the need for line size changes or additional oil. The condenser coil shall be of nonferrous construction with louvered fins bonded to rifled copper tubing.
- .4 The unit shall be controlled by an electronic circuit board located in the indoor matching unit.

2.2 **REFRIGERANT PIPING**

- .1 In accordance with Section 23 23 00 - Refrigerant Piping.

PART - 3 EXECUTION

3.1 **INSTALLATION**

- .1 Install units and accessories neat and level, following manufacturer's instructions.
- .2 Install evaporator and condenser units using hanger kit and rubber isolators provided by unit supplier.
- .3 Install refrigerant piping between evaporator and condenser sections. Size piping as directed by unit's design manual. Refer to Section 23 23 00 - Refrigerant Piping for additional requirements.
- .4 Provide all piping so units and circuits are serviceable without having to dismantle excessive lengths of pipe.
- .5 Install and wire all accessories shipped loose with units for a fully operating system. Refer to Section 23 09 00 - Instrumentation and Control for HVAC for additional requirements.
- .6 Furnish the services of factory-trained representatives to supervise the installation, starting, testing and commissioning of the split-system air conditioners in accordance with the manufacturer's instructions. Upon completion of the installation, the manufacturer shall provide to the Owner a written report on the start-up of these units.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 23 05 00 - Common Works for HVAC shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 Supply and install duct mount hydronic, electric, refrigerant and steam coils.

1.2 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for all air coils and eliminators. Shop drawings shall include, but not be limited to:
 - .1 Data sheets showing air and fluid side rated capacities, temperatures, flow rates, working pressure, tube velocity, pressure rating, and condensate back-pressure for steam coils;
 - .2 Dimensions including tube length and tube face area, weights, and required clearances;
 - .3 Construction details, tube material, fin material and spacing, header material, casing and tube support material;
 - .4 Location and size of pipe connections for hydronic, refrigerant and steam coils;
 - .5 Wiring diagram, electrical performance and control details for electric coils;
 - .6 Drip pans and coil support details;
 - .7 CRN number for coils rated as pressure vessel.

1.3 REFERENCE STANDARDS

- .1 ASME Section VIII Division 1 - Pressure Vessel Code
- .2 CSA B-51 Part 1 - Boiler, Pressure Vessel and Pressure Piping Code

1.4 QUALITY ASSURANCE

- .1 Material and fabrication shall be stamped to ASME Section VIII Division 1, Pressure Vessel Code for the required working pressure and temperature.
- .2 Coils rated as pressure vessel shall be registered with TSSA, in accordance with Technical Standards and Safety Act, 2000, and O. Reg. 220/01 – Boilers and Pressure Vessels.
- .3 Coils rated as pressure vessel shall be have CRN registration.

- .4 Standard of Acceptance
 - .1 Aerofin
 - .2 Trane
 - .3 Daikin
 - .4 York
 - .5 Carrier
 - .6 Heatcraft
 - .7 Engineered Air
 - .8 USA Coil & Air
 - .9 Coil Company
 - .10 RAE Corporation
 - .11 Ventrol
 - .12 Marlo

PART - 2 PRODUCTS

2.1 COILS (WATER, STEAM, AND REFRIGERANT)

- .1 General Requirements
 - .1 Provide all coils specified as shown on equipment schedules.
 - .2 Working Pressure:
 - .1 Suitable for 1400 kPa working pressure or as scheduled
 - .2 Factory tested for 1750 kPa or 1½ times design pressure, whichever is greater.
 - .3 Coils Designated as Pressure Vessels:
 - .1 Water and glycol coils with design temperatures in excess of 121°C (250°F) or operating pressures in excess of 1100 kPa
 - .2 Glycol coils with design temperatures below -28°C (-20°F)
 - .3 Steam coils with design pressure in excess of 100 kPa.
- .2 Standard of Acceptance
 - .1 Reference to coil models are based on Aerofin coils, to designate requirements not otherwise specified.
 - .2 Acceptable Manufacturer's:
 - .1 Aerofin
 - .2 McQuay
 - .3 Trane
 - .4 Carrier
 - .5 Coil Company
 - .6 USA Coil (Airex)

.3 Refrigerant Cooling Coils

.1 Construction:

- .1 Direct expansion, 16 mm copper tubes, copper fins
- .2 Fin protective coating: full solder, or backed phenolic.
- .3 Fin spacing: not to exceed 8 per 25 mm.
- .4 Headers shall be fabricated from seamless copper pipe with bronze sweat connections.
- .5 Same end connections.
- .6 Galvanized steel casing with drilled flanges for connection to equipment.
- .7 Provide galvanized steel tube supports on coils 1067 mm or larger.

.2 Model Type: Aerofin type "DP"

2.2 **COILS (ELECTRIC)**

.1 General Requirements

- .1 Provide all coils specified as shown on equipment schedules.
- .2 Size, capacity and electrical characteristics as shown on drawings.

.2 Duct Mounted Booster Coils

.1 Construction:

- .1 Pre-wired, CSA approved, heavy duty flanged construction and complete with the following accessories:
 - .2 Terminal box with inlet and discharge screens.
 - .3 Fintube type elements.
 - .4 Magnetic contactors, one for each stage of control.
 - .5 Disconnect switch and 24 volt control transformer.
 - .6 Manual and automatic safety reset stats.
 - .7 Air flow proving switch.
 - .8 Fused control circuit and SCR controller
 - .9 Each coil completely wired and ready to receive a single source of power.

.2 Acceptable Manufacturers:

- .1 Thermolec
- .2 P. M. Wright
- .3 Indeeco

PART - 3 EXECUTION

3.1 **INSTALLATION**

- .1 Provide gasketed or caulked duct or casing connecting flanges on all coils to ensure an air tight seal between coil and duct or casing.

- .2 Install coils in equipment such as air handling units, ducts, condensers, etc. in accordance with manufacturer's instructions. Enclose all other coils within a coil cabinet.
- .3 Install each row of stacked coils on supporting frame to allow removal of each coil section.
- .4 Run drain pipe from cooling coil drain pans to nearest drain. Provide a deep seal trap with seal depth not less than 150% of the specified static pressure.
- .5 Install duct booster coils to allow removal. Provide duct access doors on upstream and downstream sides of coils.
- .6 Install duct mounted coils in heavy duty galvanized steel frames, flanged and drilled for duct installation.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Sections 20 00 13 – Mechanical General Provisions and 23 05 00 - Common Works for HVAC shall apply to and govern this Section.
- .2 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .3 Scope of Work:
 - .1 Furnish and install humidification systems including all associated controls and accessories.

1.2 RELATED WORK

- .1 The following work is provided under other Sections or Divisions of the Work:
 - .1 Steam and condensate piping: Section 23 22 13 – Steam and Condensate Heating Piping.
 - .2 Steam and condensate piping specialties: Section 23 22 16 - Steam and Condensate Heating Piping Specialties.
 - .3 Steam control valve: Division 25 – Integrated Automation.

1.3 SUBMITTALS

- .1 Shop Drawings
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit product data for humidification systems. As a minimum provide the following details:
 - .1 Performance and design data including a computer verification of the absorption distance.
 - .2 Piping diagrams.
 - .3 Data sheets showing capacities and rating method.
 - .4 Arrangement drawing showing overall dimensions, clearance requirements, size and location of connections.
 - .5 Control schematics with sequence of operation.

1.4 QUALITY ASSURANCE

- .1 The humidifier grid shall provide absorption characteristics that preclude water accumulation on any in-duct surfaces within the scheduled downstream distance from the humidifier. The absorption distance shall be at duct temperatures and relative humidity as scheduled.
- .2 Humidifiers shall have a two (2) year replacement parts warranty from the date of Substantial Completion.
- .3 Standard of Acceptance

- .1 Dristeem
- .2 Armstrong
- .3 Nortech

PART - 2 PRODUCTS

2.1 STEAM INJECTION HUMIDIFIERS

- .1 Provide steam injection humidifiers which directly injects steam into ducted air for humidification. Single tube grids shall be factory assembled. Multiple tube grids shall be field assembled.
- .2 Dispersion tubes shall be constructed of 304 stainless steel with heli-arc welded seams. Dispersion tubes shall be fitted with a series of steam discharge tubelets. Each high temperature tubelet insert shall extend through and into the approximate center of the dispersion tube and incorporate a properly sized calibrated orifice.
- .3 Dispersion tubes provided without tubelet inserts shall be supplied with full width, 50mm deep, stainless steel drain pans extending 600mm upstream and 1.2m downstream of the grid for grids mounted within air handling units, and 600mm upstream and 3.0m downstream of the grid for grids mounted in ducts.
- .4 Multiple tube grids
 - .1 The factory-assembled steam dispersion panel shall include the following components:
 - .1 Steam supply header/separator
 - .2 Condensate collection header
 - .3 Closely-spaced steam dispersion tubes spanning the distance between the two headers
 - .2 Tubes shall be joined to headers with slip-fit couplings to facilitate easy removal.
 - .3 Each packaged humidifier panel assembly of tubes and headers shall be contained within a stainless steel casing to allow convenient duct mounting, or to facilitate the stacking of and/or the end-to-end mounting of multiple humidifier panels in ducts or air handler casings.

2.2 CONDENSATE TEMPERING

- .1 Provide a condensate-tempering device to cool a maximum of 0.38 L/s of condensate from 100°C to 60°C.
- .2 Mixing chamber and fittings shall be constructed of 304 stainless steel with welded seams. Include a self-contained brass-body tempering valve with temperature adjustment and charged bulb.
- .3 Provide a 20mm brass-bodied, ball-type drain valve and a vacuum breaker.

PART - 3 EXECUTION

3.1 GENERAL

- .1 Install humidifiers in accordance with the manufacturers' instructions.

- .2 Install all accessories provided with humidifiers in accordance with the manufacturer's instructions.
- .3 Provide instrumentation and interconnecting electrical wiring.
- .4 Install condensate piping from condensate separator or condensate cooler to the nearest floor drain with air gap or as shown on the Drawings.
- .5 Install condensate traps and drains on steam distribution grids.

3.2 **INJECTION TYPE HUMIDIFIERS**

- .1 Supply unit-mount distribution manifolds to manufacturer of air handling unit for mounting by manufacturer.
- .2 Install isolation valve, steam trap, strainer, control valve, piping and internal steam distributor support for each humidifier.
- .3 Secure steam jacket header to main steam header to limit movement to 12mm due to expansion and contraction on multiple tube distribution grids.

3.3 **START-UP**

- .1 Furnish the services of a factory trained representative of the equipment manufacturer to supervise the installation, wiring, set up and testing of the humidifier system. Upon completion of the installation, the manufacturer shall instruct the Owner on the proper operation of the system.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.

1.2 CODES, PERMITS AND INSPECTIONS

- .1 Applicable Codes
 - .1 Ontario Electrical Safety Code
 - .2 Ontario Building Code
- .2 Comply with Ontario Electrical Safety Code, all local, provincial and federal laws, where applicable and with authorities having jurisdiction. Make any changes or alterations required by authorized inspector of authority having jurisdiction.
- .3 Equipment and material must be acceptable to Electrical Safety Authority.
- .4 Where materials are specified which require special inspection and approval, obtain such approval for the particular installation with the co-operation of the material supplier.
- .5 Obtain and pay for permits and inspections required for work performed.
- .6 Supply and install warning signs, nameplates and glass covered Single Line Diagrams as required by Electrical Safety Authority.
- .7 Submit required Documents and shop drawings to authorities having jurisdiction in order to obtain approval for the Work. Copies of Contract Drawings and Specifications may be used for this purpose.

1.3 REFERENCE STANDARDS

- .1 These Specifications supplement the referenced standards.
- .2 Where standards differ between authorities, the most rigid apply.
- .3 Where requirements of the specifications exceed referenced standards, the specifications apply.

1.4 SUSTAINABLE DESIGN

- .1 Provide installation and documentation to ensure targets are achieved.

1.5 COORDINATION

- .1 Carefully examine Work and Drawings of all related trades and thoroughly plan the Work so as to avoid interferences. Report defects which would adversely affect the Work. Do not commence installation until such defects have been corrected.
- .2 Coordinate Work of this Division such that items will properly interface with Work of other Divisions.
- .3 Architectural Drawings, or in the absence of Architectural Drawings, Mechanical Drawings govern all locations.

- .4 Coordinate work of this Division to ensure that damage does not occur to the fireproofing work of any other Division.
- 1.6 **SUBSTITUTIONS**
 - .1 When only one manufacturer's catalogued trade name is specified, provide only that catalogued trade name, material or product.
 - .2 When more than one manufacturer's trade name is specified for a material or product, the choice is the bidders.
 - .3 No substitution is allowed upon award of contract.
- 1.7 **DIMENSIONS AND QUANTITIES**
 - .1 Dimensions shown on Drawings are approximate. Verify dimensions by reference to shop drawings and field measurement.
 - .2 Quantities or lengths indicated in Contract Documents are approximate only and shall not be held to gauge or limit the Work.
 - .3 Make necessary changes or additions to routing of conduit, cables, cable trays, and the like to accommodate structural, mechanical and architectural conditions. Where raceways are shown diagrammatically run them parallel to building column lines.
- 1.8 **EQUIPMENT LOCATIONS**
 - .1 Devices, fixtures and outlets may be relocated, prior to installation, from the location shown on the Contract Drawings, to a maximum distance of 3 m, without adjustment to Contract price.
 - .2 Switch, control device and outlet locations are shown diagrammatically.
- 1.9 **INSTALLATION DRAWINGS**
 - .1 Prepare installation drawings for equipment, based upon approved Vendor drawings, to check required Code clearances, raceway, busway and cable entries, sizing of housekeeping pads and structure openings. Submit installation drawings to Consultant for review.
 - .2 For existing buildings, verify locations of existing junction boxes, pull boxes etc., to ensure existing access requirements are maintained. Identify these locations to other disciplines.
- 1.10 **"AS BUILT" RECORD DRAWINGS**
 - .1 Maintain a set of Contract Drawings on site and record all deviations from the Contract Documents. **As a mandatory requirement, recording must be done on the same day deviation is made. Be responsible for full compliance with this requirement.**
 - .2 Mark locations of feeder conduits, junction and terminal boxes and ducts or conduits run underground either below the building or outside the building.
 - .3 Where conduit and wiring are underground or underfloor, furnish field dimension with respect to building column lines and inverts with respect to finished floor levels or grades.
 - .4 Record deviations from branch circuit numbers shown on Drawings.
 - .5 Prepare diagrams of interconnecting wiring between items of equipment including equipment supplied by Owner and under other Specification Sections.

- .6 Provide drawings in Autocad format as as-built record drawings at time of building turnover.
- 1.11 **SINGLE LINE DIAGRAM**
 - .1 Reproduce this diagram in drawing form under glazed frame and mount in main Switchgear Room. Provide a copy of this diagram to the Consultant and include in the Maintenance Manuals.
- 1.12 **TEST REPORTS**
 - .1 For each check and test performed prepare and submit a Test Report, signed by the Test engineer, and where witnessed, by the Consultant.
 - .2 Include record of all tests performed, methods of calculation, date and time of test, ambient conditions, names of testing company, test engineer, witnesses, also calibration record of all test instruments used together with manufacturers name, serial number and model number.
 - .3 Include calibration record, percentage error and applicable correction factors.
 - .4 Submit a Certified Test Report from each manufacturer, signed by the certifying inspector, confirming correct installation and operation of each product and part of Work. Include name of certifying inspector, date and times of inspection, ambient conditions.
- 1.13 **SHOP (VENDOR) DRAWINGS AND PARTS LISTS**
 - .1 Submit for review, manufacturer's or vendor's drawings for all products being furnished except cable (up to 1000V), wire and conduit. Include rating, performance, specification sheets, descriptive literature, schematic and wiring diagrams, dimensional layouts and weights of components as well as complete assembly.
- 1.14 **FACTORY WITNESS TESTS**
 - .1 Prior to Consultant attendance at factory for witness testing, perform the following:
 - .1 Successfully conduct test to be witnessed.
 - .2 Following successful testing, inform the Consultant, in writing, that tests to be witnessed have been successfully performed.
- 1.15 **OPERATING AND MAINTENANCE MANUALS**
 - .1 Refer to related Sections.
- 1.16 **SERIES RATED COMBINATIONS**
 - .1 Series rated combination of over-current protective devices are not permitted.
- 1.17 **WARRANTY**
 - .1 Warranties for work of Division 26, to begin after equipment is commissioned, training is complete and building handover is substantially complete.
- PART - 2 PRODUCTS**
- 2.1 **APPROVALS AND QUALITY**
 - .1 Provide new materials bearing certification marks or labels acceptable under Ontario Electrical Safety Code.

- .2 Equipment must bear, on manufacturer's label, certification mark or label acceptable under Electrical Safety Authority.
- .3 Provide units of same manufacture where two or more units of same class or type of equipment are required.
- .4 Manufacturer's names are stated in this Specification to establish a definite basis for tender submission and to clearly describe the quality of product that is desired for the work.

2.2 **STANDARD SPECIFICATIONS**

- .1 Ensure that the chemical and physical properties, design, performance characteristics and methods of construction of all products provided comply with latest issue of applicable Standard Specifications issued by authorities having jurisdiction, but such Standard Specifications shall not be applied to decrease the quality of workmanship, products and services required by the Contract Documents.

2.3 **SPRINKLER PROOF EQUIPMENT**

- .1 Ensure that electrical equipment installed in electrical rooms and other areas containing sprinklers is constructed such that exposure to water from the sprinkler heads does not impair the effectiveness of the enclosed equipment.
- .2 Provide a separate cover or roof on all 2285 mm high equipment. Provide an overhang at the front, rear and sides to effectively prevent the entrance of water either at the top or through projecting faceplates, meters, etc.
- .3 Where penetrations are made in drip shields, flash and seal using manufacturer's approved caulking to maintain drip shield integrity.
- .4 Ensure that enclosure louvres are of outdoor design such that falling water or water running down the sides will not enter the enclosure.
- .5 Where enclosure openings in the top or sides are required for outgoing conduits, provide waterproof conduit fittings.
- .6 Provide panels and transformers with hoods.
- .7 Provide sprinkler proof busways.
- .8 In electrical rooms containing sprinklers provide wall mounted equipment such as pull boxes, junction boxes, splitter troughs, wireways, auxiliary gutters, cable troughs and disconnect switches located below the level of the sprinkler heads with the following accessories:
 - .1 Gaskets on doors and drip shields on equipment, panelboards, panels and enclosures.
 - .2 Louvres facing outward and downward where openings are required for heat dissipation. Expanded metal screening is not acceptable.

2.4 **HOUSEKEEPING PADS**

- .1 Provide 100 mm high concrete pads under floor mounted electrical equipment. Extend pads 50 mm outside the equipment perimeter.

2.5 **FIRE BARRIERS**

- .1 Where electrical material or devices pass through fire rated separations, make penetrations and provide fire barrier seals with a fire resistance rating equivalent to the rating of the separation.
- .2 Prior to installation, submit for review, proposed fire barrier seal materials, method of installation and ULC system number.
- .3 Acceptable Manufacturers:
 - .1 A/D Fire Protection Systems
 - .2 Dow Corning
 - .3 Fire Stop Systems
 - .4 IPC Flamesafe Firestop
 - .5 Nelson Electric
 - .6 3M
 - .7 Tremco
- .4 Firestop Putty Pad
 - .1 Hilti CP-617 series to suit outlet box.

2.6 **MISCELLANEOUS METAL FABRICATIONS**

- .1 Provide miscellaneous structural supports, platforms, braces, brackets and preformed channel struts necessary for suspension, attachment or support of electrical equipment.

2.7 **ACCESS DOORS**

- .1 Minimum size: 200 mm x 200 mm size, unless otherwise specified on the Drawings or in other divisions of the Specifications, or as required to replace or repair said equipment.
- .2 Material:
 - .1 Fabricated of 2.5 mm bonderized steel.
 - .2 Fabricated of 2.5 mm stainless steel in areas finished with tile or marble surfaces.
 - .3 Flush mounted, concealed hinges and screwdriver lock.
 - .4 Plast lock and anchor straps.
- .3 Doors to be of a type and fire rating to suit the particular type of wall or ceiling construction in which they are to be installed.
- .4 Doors in painted partitions to be painted to match adjacent partition. Doors shall be installed prior to final painting. Bear all costs for repainting of partition/ceiling and doors resulting from failure to do so.

2.8 **EQUIPMENT COLOUR CODING**

- .1 Exterior finish paint colour for switchgear, control panels, panelboards and devices on emergency and UPS systems:
 - .1 Emergency systems: red
 - .2 UPS systems: blue

- .1 Carefully examine the Vendor or Manufacturers' drawings and provide any incidental and miscellaneous materials, mounting hardware and supports required for complete systems.

PART - 3 EXECUTION

3.1 MANUFACTURER'S ATTENDANCE

- .1 Provide manufacturer's representatives to initially start-up each part of the Work, as specified, to check, adjust, calibrate and balance as applicable all components including controls and field wiring. Provide these services for such period and for as many visits as necessary to achieve complete working order in the subject Work.

3.2 FIELD INSPECTION

- .1 Provide field engineer for inspection and certification of equipment during installation, testing and commissioning as required.

3.3 HOUSEKEEPING PADS

- .1 Provide concrete pads to the requirements of Division 03.

3.4 FIRE BARRIERS

- .1 Provide fire stopping to the requirements of Division 07.

3.5 MOUNTING HEIGHTS

- | | | |
|----|--|----------|
| .1 | Mounting heights of equipment is from finished floor to centre line of equipment unless noted otherwise. | |
| .2 | If mounting height of equipment is not specified or indicated, verify before proceeding. | |
| .3 | Install electrical equipment at following heights unless indicated otherwise. | |
| .1 | Local switches: | 1150 mm. |
| .2 | Wall receptacles: | 450 mm. |
| .3 | Receptacles above continuous baseboard heater: | 200 mm. |
| .4 | Receptacles above top of counters or backsplash: | 175 mm. |
| .5 | Fire alarm stations: | 1150 mm. |
| .6 | Wall mounted Fire alarm speaker and strobes: | 2100 mm. |

3.6 ACCESS DOORS

- .1 Supply access doors for installation by other trades in walls or ceilings where accessibility is required for the accessibility to electrical components.

3.7 PAINTING

- .1 Touch up finishes on electrical equipment found to be marred on completion of the Work using same colour and type of finish as originally used.
- .2 Prime paint field fabricated metalwork.
- .3 Other painting will be provided under Section 09 91 00.

3.8 **TRAINING**

- .1 Arrange for training of systems as detailed in technical sections.
- .2 Provide for a minimum of two training sessions for each item.
- .3 Training to be videotaped. Contractor to record and edit to suit.
- .4 Training to take place after system has been commissioned
- .5 Schedule training 3 weeks in advance of training date.
- .6 Attendance of participants to be recorded.

3.9 **PRICING**

- .1 Provide for the purposes of monthly draw recognition only the electrical price broken down into the following components.
 - .1 Mobilization
 - .2 Selective Demolition
 - .3 Power and Systems Equipment and Installation
 - .4 Lighting Equipment and Installation
 - .5 Fire Alarm Equipment and Installation
 - .6 Telecommunications Equipment and Raceway and Installation
 - .7 Wire and Conduit
 - .8 Project Closeout

3.10 **CORE DRILLING**

- .1 Core Drilling Procedure
 - .1 Examine locations to be core drilled where:
 - .1 Diameter is greater than 25 mm
 - .2 Multiple drillings required and where the distance between centres is less than 10 times the diameter of the hole
 - .2 Examine by most suitable method including:
 - .1 X-ray
 - .2 Ferro scan
 - .3 Cable detection
 - .3 Examine from both sides of the structure to be drilled.
 - .4 Examine proposed core drilling locations to determine:
 - .1 Possible interference with
 - .1 Services
 - .2 Structural components
 - .2 Possible presence of asbestos tile or other asbestos based material. Report any occurrence or suspected occurrence to the Consultant immediately.

- .5 Select locations as suitable for core drilling and label them:
 - .1 Uniquely number each drilling location and core so that markings will be legible after drilling
 - .2 Mark each core with a north pointing arrow where drilling a slab or upward pointing arrow where drilling a wall
- .6 Without interfering with or damaging any services or structural elements, drill pilot holes sufficient to verify location of potential obstructions or for alignment purposes.
- .7 Use impact drill when drilling holes of 25 mm diameter or less. For holes of greater diameter use core drill.
- .8 Prepare report showing intended core drill locations including printouts, X-ray images. Submit the report for approval prior to drilling to Consultant.
- .9 Proceed with core drilling only after approval has been received from Consultant.
- .10 Confine drilling operation to time-of-day as stipulated by Consultant.
- .11 Position suitable warning notices of a type acceptable to Consultant and exercise caution to ensure safety and protection of personnel and property during drilling especially from effects of water, dust damage, or falling objects below the slab or behind the wall being drilled.
- .12 Stop drilling immediately, and report to Consultant, if contact is made with foreign objects such as reinforcing steel (rebar), electrical conduit, water pipes, drainage pipes.
- .13 Cover open holes with secured covers to guard against fall through of objects.
- .14 Provide necessary firestopping, temporary or otherwise, sufficient to firestop holes that would be otherwise open during hours that the location is unattended. Coordinate placement of firestopping with Consultant.
- .15 Store all cores or core fragments on site and make them available for inspection by Consultant. Dispose of the cores or core fragments after permission is received from Consultant.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
- .2 Related Requirements:
 - .1 Comply with Conditions of the Contract.

1.2 RELATED SECTIONS

- .1 Section 26 05 01: Common Work Results for Electrical.

1.3 REFERENCES

- .1 Conform to latest issues, amendments and supplements of following standards:
 - .1 CISC/CPMA 2.75 - Canadian Institute of Steel Construction/ Canadian Paint Manufacturers Association, A Quick Drying Primer for Use on Structural Steel
 - .2 CAN/CGSB-1.40-M - Primer, Structural Steel, Oil Alkyd Type
 - .3 CAN3-C21.1-M - Control Cable - 600V
 - .4 CAN3-C21.2-M - Control Cable for Low Energy Circuits 150V and 300V
 - .5 CAN/CSA C22.2 No. 18 - Outlet Boxes, Conduit Boxes, and Fittings
 - .6 CAN/C22.2 No. 26 - Wireways, Auxiliary Gutters and Associated Fittings
 - .7 CSA C22.2 No. 30-M - Explosion-Proof Enclosures for Use in Class I Hazardous Locations
 - .8 CSA C22.2 No. 38-M - Thermoset Insulated Wires and Cables
 - .9 CSA C22.2 No. 40-M - Cutout, Junction and Pull Boxes
 - .10 CSA C22.2 No. 42-M - General Use Receptacles, Attachment Plugs and Similar Wiring Devices
 - .11 CSA C22.2 No. 45-M - Rigid Metal Conduit
 - .12 CSA C22.2 No. 49 - Flexible Cords and Cables
 - .13 CAN/CSA C22.2 No. 51-M - Armoured Cables
 - .14 CSA C22.2 No. 52-M - Service-Entrance Cables
 - .15 CSA C22.2 No. 56 - Flexible Metal Conduit and Liquid-Tight Flexible Metal Conduit
 - .16 CSA C22.2 No. 65 - Wire Connectors
 - .17 CSA C22.2 No. 75-M - Thermoplastic Insulated Wires and Cables
 - .18 CSA C22.2 No. 76-M - Splitters
 - .19 CSA C22.2 No. 83-M - Electrical Metallic Tubing
 - .20 CAN/CSA-C22.2 No. 85-M - Rigid PVC Boxes and Fittings
 - .21 CAN/CSA C22.2 No. 94-M - Special Purpose Enclosures
 - .22 CSA C22.2 No. 123-M - Aluminum Sheathed Cables

- .23 CSA C22.2 No. 124-M - Mineral-Insulated Cables
- .24 CSA C22.2 No. 127 - Equipment Wires
- .25 CAN/CSA-C22.2 No. 131-M - Type Teck 90 Cable
- .26 CSA C22.2 No. 159-M - Attachment Plugs, Receptacles and Similar Wiring Devices for Use in Hazardous Locations: Class I, Groups A, B, C, and D; Class II, Group G, in Coal or Coke Dust, and in Gaseous Mines
- .27 CSA C22.2 No. 174-M - Cable and Cable Glands for Use in Hazardous Locations
- .28 CSA C22.2 No. 182.1 - Industrial Type, Special Use Attachment Plugs, Receptacles, and Connectors
- .29 CSA C22.2 No. 182.2-M - Industrial Locking Type, Special Use Attachment Plugs, Receptacles, and Connectors
- .30 CSA C22.2 No. 182.3-M - Special Use Attachment Plugs, Receptacles, and Connectors
- .31 CSA C22.2 No. 208-M - Fire Alarm and Signal Cable
- .32 CSA C22.2 No. 211.2-M - Rigid PVC (Unplasticized) Conduit
- .33 CSA C22.2 No. 211.3 - Rigid Fiberglass Reinforced Epoxy (RE) Conduit and Associated Fittings
- .34 CSA C22.2 No. 214-M - Communications Cables
- .35 CSA C22.2 No. 227.1 - Electrical Nonmetallic Tubing
- .36 CSA C22.2 No. 227.2 - Flexible Liquid-Tight Nonmetallic Conduit
- .37 CSA C22.2 No. 227.3-M - Flexible Nonmetallic Tubing
- .38 CSA C22.2 No. 230-M - Tray Cables
- .39 CSA C22.2 No. 232-M - Optical Fiber Cables
- .40 SSPC - Steel Structures Painting Council "Steel Structures Painting Manual, Vol. 2"

1.4 **SUBMITTALS**

- .1 Consultant reserves the right to require Contractor to submit samples of any materials to be used in this project.
- .2 Cable pull and tension calculations for all cables under vertical tension.

PART - 2 PRODUCTS

2.1 **WIRE - LOW VOLTAGE UP TO 1000V SERVICE**

- .1 Conductors
 - .1 ASTM Class B, soft drawn, electrolytic copper
 - .2 Stranded
- .2 Insulation
 - .1 CSA type RW90 XLPE (-40°C)
 - .1 Heat and moisture resistant

- .2 Low temperature, chemically cross-linked thermosetting polyethylene material
 - .3 600V rated
 - .4 For maximum 90°C conductor temperature
 - .5 For installation at minimum -40°C temperature
 - .6 To CSA C22.2 No. 38
- .2 CSA type RWU90 XLPE (-40°C):
 - .1 Heat and moisture resistant
 - .2 Low temperature, chemically cross-linked thermosetting polyethylene material
 - .3 1000V rated
 - .4 For maximum 90°C conductor temperature
 - .5 For installation at minimum -40°C
 - .6 To CSA C22.2 No. 38
- .3 CSA type T90 NYLON (-10°C):
 - .1 Heat resistant
 - .2 Flame retardant
 - .3 Thermoplastic PVC material with extruded nylon cover
 - .4 600V rated
 - .5 For maximum 90°C conductor temperature dry and 75°C in wet locations
 - .6 For installation at minimum -10°C
 - .7 To CSA C22.2 No. 75-M
- .4 CSA type TEW:
 - .1 Heat resistant
 - .2 600V rated
 - .3 For maximum 105°C conductor temperature
 - .4 To CSA C22.2 No. 127
- .5 CSA type SEW-2
 - .1 Heat resistant
 - .2 600V rated
 - .3 For maximum 200°C conductor temperature
 - .4 To CSA C22.2 No. 127
- .3 Acceptable Manufacturers
 - .1 Alcan Cable
 - .2 Alcatel Canada Wire
 - .3 Pirelli Cables

2.2 CABLE - LOW VOLTAGE UP TO 1000V SERVICE

.1 CSA Type AC90 XLPE (-40°C)

.1 Conductors

- .1 ASTM Class B, soft drawn, electrolytic copper
- .2 Solid for sizes #10 AWG and smaller
- .3 Stranded for sizes #8 AWG and larger

.2 Insulation

- .1 Heat and moisture resistant
- .2 Low temperature, chemically cross-linked thermosetting polyethylene material
- .3 600V rated for sizes #10 AWG and smaller
- .4 600V rated for sizes #8 AWG and larger
- .5 For maximum 90°C conductor temperature
- .6 For installation at minimum -40°C temperature
- .7 To CSA C22.2 No. 38

.3 Construction

- .1 2, 3 or 4 insulated conductors
- .2 Bare ground conductor
- .3 Overall interlocking aluminum armour
- .4 To CSA C22.2 No. 51

.4 Acceptable Manufacturers

- .1 Alcan Cable
- .2 Alcatel Canada Wire
- .3 Pirelli Cables

.2 CSA Type TECK90 (-40°C)

.1 Conductors

- .1 ASTM Class B, soft drawn, electrolytic copper
- .2 Stranded

.2 Insulation

- .1 Heat and moisture resistant
- .2 Low temperature, chemically cross-linked thermosetting polyethylene material
- .3 600V or 1000V rated
- .4 For maximum 90°C conductor temperature
- .5 For installation at minimum -40°C temperature
- .6 CSA type RW90 XLPE

- .7 To CSA C22.2 No. 38
- .3 Construction
 - .1 1 or more insulated conductors
 - .2 Bare, stranded, copper ground conductor for multi-conductor cables
 - .3 Bare, solid, served copper ground conductors for single conductor cables
 - .4 Fillers with binder tape to produce a circular cross-section for multi-conductor cables
 - .5 Power cables
 - .1 1, 2, 3 or 4 conductors
 - .2 Conductors 1000V rated
 - .6 Control cables
 - .1 2 or more conductors
 - .2 Conductors 600V rated
 - .7 Composite cables
 - .1 3 power conductors
 - .2 3 #14 AWG control conductors
 - .3 Conductors 600V rated
 - .8 Extruded PVC inner jacket over conductor assembly
 - .9 Interlocking aluminum armour over inner jacket
 - .10 Extruded PVC overall jacket over armour
 - .1 FT4 flame test rated
 - .2 Colour black unless otherwise indicated
 - .11 Cable assembly for installation at minimum -40°C temperature
 - .12 To CSA C22.2 No. 131 and CSA C22.2 No. 174
- .4 Acceptable Manufacturers
 - .1 South Wire
 - .2 Texcan
 - .3 Nexans
 - .4 General Cable
 - .5 Northern Cable
- .3 CSA Type RA90 XLPE (-40°C)
 - .1 Conductors
 - .1 ASTM Class B, soft drawn, electrolytic copper
 - OR
 - .2 CSA type ACM aluminum alloy
 - .3 Stranded

- .2 Insulation
 - .1 Heat and moisture resistant
 - .2 Low temperature, chemically cross-linked thermosetting polyethylene material
 - .3 600V rated
 - .4 For maximum 90°C conductor temperature
 - .5 For installation at minimum -40°C temperature
 - .6 CSA type RW90 XLPE
 - .7 To CSA C22.2 No. 38
- .3 Construction
 - .1 Single conductor
 - .2 Continuous, corrugated aluminum sheath of minimum cross-sectional area to comply with Electrical Code Table 16
 - .3 Extruded PVC overall jacket over armour
 - .1 FT4 flame test rated
 - .2 Colour black unless otherwise indicated
 - .4 Cable assembly for installation at minimum -40°C temperature
 - .5 To CSA C22.2 No. 123 and CSA C22.2 No. 174
- .4 Acceptable Manufacturers
 - .1 Alcan Cable
 - .2 Alcatel Canada Wire
 - .3 BICC Phillips
- .4 CSA Type TC, Tray Cable (-40°C)
 - .1 Conductors
 - .1 ASTM Class B, soft drawn, electrolytic copper
 - .2 Stranded
 - .2 Insulation
 - .1 Heat and moisture resistant
 - .2 Low temperature, chemically cross-linked thermosetting polyethylene material
 - .3 600V rated
 - .4 For maximum 90°C conductor temperature
 - .5 For installation at minimum -40°C temperature
 - .6 CSA type RW90 XLPE to CSA C22.2 No. 38
 - .3 Construction
 - .1 2 or more insulated conductors
 - .2 Bare, stranded, copper ground conductor

- .3 Fillers with binder tape to produce a circular cross-section
- .4 Jacket
 - .1 PVC
 - .2 FT4 flame test rated
 - .3 Low acid gas rated to CSA C22.2 No. 0.3
 - .4 Black colour
 - .5 To CSA C22.2 No. 230
- .4 Acceptable Manufacturers
 - .1 Alcatel Canada Wire
 - .2 BICC Phillips
 - .3 Pirelli Cables
- .5 CSA Type MI
 - .1 General
 - .1 Mineral insulated wiring cable shall have:
 - .1 Description C22.1-02 Canadian Electrical Code, Part 1 Type M1
 - .2 Conductor: solid high conductivity copper
 - .3 Insulation Voltage Rating: 600 volts
 - .4 Cable Temperature Rating: 90 degrees C
 - .5 Termination Temperature Rating: 90 degrees C
 - .6 Insulation Material: Magnesium oxide.
 - .7 Sheath Material: seamless soft-drawn copper
 - .8 Fire Rating: complete cable system shall have a 2-hour fire rating as listed and classified by Underwriters Laboratories of Canada.
 - .2 Conductors
 - .1 ASTM Class B, soft drawn, electrolytic copper
 - .2 Solid
 - .3 Insulation
 - .1 Powdered magnesium oxide
 - .2 600V rated
 - .4 Construction
 - .1 Solid conductor
 - .2 Insulation around the conductor compressed to form a solid, homogeneous mass between the conductor and the metal sheath throughout the entire length of cable
 - .3 Soft annealed seamless copper sheath over insulation
 - .4 Extruded PVC overall jacket over sheath
 - .1 FT4 flame test rated

- .2 Colour black unless otherwise indicated
 - .5 To CSA C22.1 No. 124-M
 - .5 Acceptable Manufacturer
 - .1 Pyrotenax
 - .6 EMF-Free Power Cable
 - .1 Conductors
 - .1 ASTM Class B, soft drawn, electrolytic copper
 - .2 Stranded central conductor
 - .3 Solid, served concentric return conductors, equivalent to central conductor
 - .4 Conductor size and number of runs to suit feeder ratings as shown on drawings
 - .2 Insulation
 - .1 Heat and moisture resistant
 - .2 Ethylene propylene rubber (EPR)
 - .3 Minimum 600 V rated
 - .4 For maximum 90°C conductor temperature
 - .5 For installation at minimum -40°C temperature
 - .6 To CSA C22.2 No. 38
 - .3 Construction
 - .1 Single conductor with served wire return conductor (coaxial)
 - .2 PVC inner-jacket over return conductor
 - .3 Interlocking aluminum over inner jacket
 - .4 Overall PVC jacket (for not plenum installation)
 - .4 Power Filters
 - .1 Filter parameters to suit the feeder characteristics (rating, length, etc.)
 - .2 EEMAC type 1 enclosure
 - .5 Engineered System
 - .1 Provide EMF-free power cables and power filters as a complete engineered system from the manufacturer
 - .6 Acceptable Manufacturer
 - .1 United Wire & Cable (ZeroFlux[®] Power Cable)
- 2.3 **CABLE CONNECTORS**
 - .1 Connectors for Type AC90 Cable
 - .1 Steel or malleable iron
 - .2 Insulated throat

- .3 Acceptable manufacturers
 - .1 Efcor 1000B series
 - .2 Elliott 65200 series
 - .3 Thomas & Betts 3110 series
- .2 Connectors for Type TECK90 Cable
 - .1 Copper free aluminum body
 - .2 Steel or copper free aluminum fittings and locknut
 - .3 Certified for use in hazardous locations Classes I, II, and III
 - .4 Class I hazardous location sealing fitting
 - .5 Acceptable manufacturers
 - .1 Thomas & Betts "STE" series
 - .2 Crouse-Hinds type TMC
 - .3 Commander/Iberville type TEK
- .3 Connectors for Type RA90 Cable
 - .1 Copper free aluminum body
 - .2 Steel or copper free aluminum fittings
 - .3 Acceptable manufacturers
 - .1 Alcatel Canada Wire
 - .2 Crouse-Hinds, type TMC
- .4 Connectors for Type TC, Tray Cable
 - .1 Copper free aluminum body
 - .2 Steel or copper free aluminum fittings and locknut
 - .3 Acceptable manufacturers
 - .1 Thomas & Betts, Tray-Star, HLT series
 - .2 Crouse-Hinds, type TMC
- 2.4 **WIRE AND CABLE CONNECTORS**
 - .1 Copper compression type wire and cable terminations for #8 AWG and larger conductors, colour keyed, sized to suit. Long barrel NEMA 2 hole lugs for sizes #1/0 AWG and larger.
 - .1 Acceptable Manufacturers
 - .1 Thomas & Betts series 54000
 - .2 Ideal Powr-Connect
 - .3 Burndy Hylug
 - .2 Twist type splicing connectors, copper, sized to suit, with nylon or plastic shroud for tee connections in #10 AWG and smaller conductors.
 - .1 Acceptable Manufacturers
 - .1 Thomas & Betts spring type

- .2 Ideal Twister
 - .3 Marr Marrette
 - .3 Conductor compression splice for #10 AWG or smaller.
 - .1 Acceptable Manufacturers
 - .1 Thomas & Betts STA-Kon series
 - .2 Ideal Splices
 - .3 Burndy
- 2.5 **HEAT SHRINKABLE TUBING INSULATION, HEAVY WALL**
 - .1 Acceptable Manufacturers
 - .1 Thomas & Betts, Shrink-Kon series
 - .2 Ideal Thermo-Shrink, TS-46
 - .3 Raychem tubing WCSM
 - .4 3M cable sleeve ITCSN
- 2.6 **MOTOR LEAD CONNECTION KITS, 600 VOLT**
 - .1 Connection kits for low voltage motors.
 - .2 Acceptable Manufacturers
 - .1 3M, motor lead splice kit, pigtail, 5300 series
 - .2 Raychem, motor connection kit, MCK, type V
- 2.7 **CONDUIT AND FITTINGS**
 - .1 Rigid Steel Conduit
 - .1 To CSA C22.2 No. 45-M
 - .2 Rigid thickwall galvanized steel threaded conduit
 - .2 Coated Steel Conduit
 - .1 Corrosive resistant coated rigid thickwall steel threaded conduit, CSA approved.
 - .2 Acceptable Manufacturers
 - .1 Rob Roy Plastibond PVC coated
 - .2 Columbex Green Guard II epoxy polyester coated
 - .3 Rigid PVC Conduit
 - .1 To CSA C22.2 No. 211.2-M
 - .2 Rigid PVC conduit
 - .4 Flexible Steel Conduit
 - .1 To CSA 22.2 No. 56
 - .2 Liquid-tight flexible steel conduit with PVC cover

- .5 Non-Metallic Flexible Conduit
 - .1 Non-metallic extra flexible PVC conduit
 - .2 Acceptable Manufacturers
 - .1 Carlon, Carflex X-Flex
 - .2 Hubbell, Polytuff Black
- .6 Rigid Steel Conduit Fittings
 - .1 To CAN/CSA C22.2 No. 18
 - .2 Galvanized or polymer coated cast steel fittings
 - .3 Expansion fittings, watertight with integral bonding jumper suitable for linear expansion and 19 mm deflection in all directions
 - .4 Sealing condulets for hazardous areas
 - .5 Corrosive resistant coated cast steel fittings for corrosive resistant conduit
- .7 Rigid PVC Conduit Fittings
 - .1 To CSA C22.2 No. 85-M
 - .2 Rigid PVC fittings of same manufacture as rigid PVC conduit
- .8 Liquid Tight Flexible Steel Conduit Fittings
 - .1 Watertight connectors with nylon insulated throat
 - .1 Acceptable Manufacturers:
 - .1 T & B Series 5331 with Sealing O-ring Series 5262
 - .2 Commander/Iberville Series 6300-IT with nitrile O-ring

2.8 **EMT AND FITTINGS**

- .1 EMT
 - .1 To CSA C22.2 No. 83-M
 - .2 EMT galvanized cold rolled steel tubing
- .2 EMT Fittings
 - .1 Compression type, steel
 - .1 Gland compression connectors with insulated throats
 - .2 Compression couplings
 - .3 Acceptable manufacturers:
 - .1 T & B Series 5123 & 5120
 - .2 O-Z/Gedney type ZTC series
 - .3 Commander/Iberville Series 5600-IT and 5700

2.9 **WIREWAY**

- .1 To CSA C22.1 No. 94-M.
- .2 Steel with hinged cover to give uninterrupted access.

- .3 Elbows, tees, couplings and hanger fittings manufactured as accessories for wireway supplied.
- .4 Acceptable Manufacturers:
 - .1 Amalgamated Electric
 - .2 Canadian Electrical Raceways
 - .3 Schneider Square D
 - .4 Pilgrim
 - .5 Pursley

2.10 **FASTENINGS, SUPPORTS AND SLEEVES**

- .1 Fastenings
 - .1 Galvanized steel straps, beam clamps and threaded rods
- .2 Sleeves
 - .1 Schedule 40 steel pipe, minimum I.D. 13 mm larger than O.D. of conduit or cable passing through.
- .3 Strut
 - .1 Continuous slotted channel
 - .2 12 gauge pre-galvanized steel
 - .3 41.2 mm x 41.2 mm minimum
 - .4 Acceptable manufacturers:
 - .1 B-Line
 - .2 Pilgrim
 - .3 Pursley
 - .4 Unistrut

2.11 **SPLITTER BOXES**

- .1 Code gauge (galvanized) sheet steel enclosure EEMAC Type (1) (4) (12) welded corners and formed hinged cover suitable for locking in closed position.
- .2 Cast steel enclosure EEMAC 7 (9) with gasketed bolt on cover for hazardous locations.
- .3 Copper main and branch lugs to match required size and number of incoming and outgoing conductors.
- .4 At least 3 spare terminals on each set of lugs in splitters less than 400 A.

2.12 **JUNCTION BOXES**

- .1 Galvanized steel EEMAC Type 1 (4) (12) size as required by code for number and size of conduits, conductors and devices, complete with covers, corrosion resistant screws, terminal blocks and mounting rails.
- .2 Screw-on sheet steel covers to match enclosure for surface mounting boxes.
- .3 Covers with 25 mm minimum extension around for flush-mounted junction boxes.

- .4 Galvanized steel barriers as required.
- 2.13 **TERMINAL BLOCKS - SURGE PROTECTION**
 - .1 Terminal blocks, rail mounted, with surge voltage protection, rated for circuit voltage.
 - .2 Acceptable Manufacturers
 - .1 Phoenix Contact Termitrab SLKK5 for medium protection up to 110 VAC, Termitrab SLKK5-F for coarse protection up to 110 VAC, TT-SLKK5-S for fine protection up to 60 VAC.
- 2.14 **PULL BOXES**
 - .1 Galvanized sheet steel welded construction, EEMAC Type 1, (4) (12).
 - .2 Screw-on galvanized sheet steel covers for surface mounting boxes.
 - .3 Covers with 25 mm minimum extension around, for flush mounted pull boxes.
 - .4 Galvanized steel barriers as required.
- 2.15 **CONDUIT BOXES - GENERAL**
 - .1 Boxes for EMT
 - .1 Galvanized pressed steel
 - .2 Boxes for Rigid Steel Conduit
 - .1 Galvanized cast iron alloy FS boxes with mounting feet for surface mounted switches and receptacles
 - .2 Gasketed cover plate for exterior location
 - .3 For corrosive resistant coated conduit: cast boxes with same finish as conduit
 - .3 Boxes for Rigid PVC Conduit
 - .1 PVC boxes
- 2.16 **OUTLET BOXES - SHEET STEEL**
 - .1 Pressed steel single and multi-gang flush device boxes, minimum size 100 mm x 50 mm x 38 mm. 100 mm square outlet boxes where more than 1 conduit enters 1 side, with extension rings as required.
 - .2 100 mm square or octagonal outlet boxes.
 - .3 119 mm square outlet boxes with extension and plaster rings as necessary for flush mounting devices in gypsum board, plaster or panelled walls.
- 2.17 **MASONRY BOXES**
 - .1 Pressed steel masonry single and multi-gang boxes for devices flush mounted in exposed masonry walls with extension and plaster rings as required.
- 2.18 **CONCRETE BOXES**
 - .1 Pressed steel concrete type boxes for flush mount in concrete with extension and plaster rings as required.

2.19 **OUTLET BOXES - FITTINGS**

- .1 Bushings and connectors with nylon insulated throats.
- .2 Knock-out fillers to prevent entry of foreign materials.
- .3 Double locknuts and insulated bushings for sheet steel metal boxes.

2.20 **WIRING DEVICES - SWITCHES**

- .1 Specification grade, general purpose AC switches, manual toggle operated, ivory and brown colour, 15A, 20A, 120-277V, 347V, single pole, double pole, three-way, four-way switches as required.
- .2 Acceptable manufacturers:
 - .1 Hubbell - HBL1201 Series: HBL1221 Series: HBL18201 Series: HBL 18221 Series
 - .2 P & S - 15AC Series: 20AC Series: 370000 Series
 - .3 Arrow Hart - 1891 Series: 1991 Series: 18201 Series: 18221 Series
- .3 Specification grade, general purpose AC switches, manual rocker operated, ivory colour, 15A, 20A, 120-277V, 347V, single pole, double pole, 3 way, 4 way switches as required.
- .4 Acceptable Manufacturers
 - .1 Bryant, 120-277V, Fashion Series 9000
 - .2 Hubbell, 120-277V, Style Line 2100 Series
 - .3 Leviton, 120-277V and 347V, Decora Plus 5600 Series
 - .4 Pass & Seymour, 120-277V and 347V, Sierraplex Decorator, 2600 and 2600000 Series

2.21 **WIRING DEVICES - DIMMER SWITCHES**

- .1 Dimmer switches: solid state, full range with slider type handle on-off switch, rated to suit circuit load, 1000 watts minimum, 120 volts.
- .2 Acceptable Manufacturers:
 - .1 P & S
 - .2 Lutron

2.22 **WIRING DEVICES - RECEPTACLES FOR GENERAL SERVICE**

- .1 Receptacles: specification grade suitable for back and side wiring, complete with grounding terminal, colour as required for type of area for straight blade devices and black colour for twistlock devices.
- .2 Receptacles of one manufacturer.
- .3 Acceptable Manufacturers:
 - .1 15A, 125V, (5-15R) Single Straight Blade
 - .1 Arrow Hart 5261
 - .2 Leviton 5261
 - .3 Hubbell 5261

- .4 Pass & Seymour 5261
- .2 15A, 125V, (5-15R) Duplex Straight Blade
 - .1 Arrow Hart 5262
 - .2 Leviton 5262
 - .3 Hubbell 5262
 - .4 Pass & Seymour 5262
- .3 20A, 125V, (5-20R) Single Straight Blade
 - .1 Arrow Hart 5361
 - .2 Leviton 5361
 - .3 Hubbell 6331
 - .4 Pass & Seymour 5361
- .4 20A, 125V, (5-20R) Duplex Straight Blade
 - .1 Arrow Hart 5392
 - .2 Leviton 5362
 - .3 Hubbell 5392
 - .4 Pass & Seymour 5362
- .5 15A, 125V, (5-15R) Duplex GFCI, Straight Blade
 - .1 Arrow Hart GF5242AH
 - .2 Leviton 6599-W
 - .3 Hubbell GF-5252
 - .4 Pass & Seymour 1591
- .6 15A, 125V, (5-15R) Duplex Isolated Ground Straight Blade
 - .1 Arrow Hart IG5262AH
 - .2 Leviton 5262-IG
 - .3 Hubbell IG-5262
 - .4 Pass & Seymour IG6200
- .7 20A, 125V, (L5-20R) Single locking, 2 pole, 3 wire grounding
 - .1 Arrow Hart 6200
 - .2 Leviton 2310
 - .3 Hubbell 2310ACN
 - .4 Pass & Seymour L520-RCN
- .8 20A, 250V, (L6-20R) Single locking, 2 pole, 3 wire, grounding
 - .1 Arrow Hart 6210
 - .2 Leviton 2320
 - .3 Hubbell 2320ACN
 - .4 Pass & Seymour L620-RCN

- .9 30A, 250V, (L6-30R) Single locking, 2 pole, 3 wire, grounding
 - .1 Arrow Hart 6340
 - .2 Leviton 70630-FR
 - .3 Hubbell 2620CAN
 - .4 Pass & Seymour L630RCN
- .10 30A, 250V, (L15-30R) Single locking, 3 pole, 4 wire, phase, grounding
 - .1 Arrow Hart 6520
 - .2 Leviton 2720
 - .3 Hubbell 2720ACN
 - .4 Pass & Seymour L1530-RCN
- .11 20A, 277V, (L7-20R) Single locking, 2 pole, 3 wire, grounding
 - .1 Arrow Hart 6220
 - .2 Leviton 2331
 - .3 Hubbell 2330ACN
 - .4 Pass & Seymour L720R
- .12 20A, 347V (L24-20R) Single locking, 2 pole, 3 wire grounding
 - .1 Leviton 3721
 - .2 Pass & Seymour L3720-RCN
- .13 15A, 125V (5-15R) Quad straight blade, 2 pole, 3 wire grounding
 - .1 Bryant 1254
 - .2 Hubbell 415 series
 - .3 Pass & Seymour 1254
- .14 15A, 347V, (24-15R) Quad straight blade, 2 pole, 3 wire grounding
 - .1 Bryant 3474W
 - .2 Hubbell 415347WC
 - .3 Pass & Seymour 3474W
- .15 15A, 125V, (5-15R) Duplex straight blade decorator type
 - .1 Arrow Hart 26262
 - .2 Leviton Decora Plus
 - .3 Hubbell 2152 series
 - .4 Pass & Seymour 885
- .16 15A, 125V (5-15R) Duplex straight blade, 2 pole, 3 wire grounding, surge suppression indicator light, blue (ivory) colour
 - .1 Arrow Hart 5250
 - .2 Hubbell 5260

- .17 15A, 125V (5-15R) Duplex straight blade, 2 pole, 3 wire grounding, isolated ground surge suppression indicator light, blue (ivory) colour
 - .1 Arrow Hart IG5250
 - .2 Hubbell IG5262,
- .18 15A, 125V (5-15R) Duplex straight blade, 2 pole, 3 wire grounding, surge suppression indicator light, blue colour
 - .1 Arrow Hart 5250
 - .2 Hubbell 5260
- .19 15A, 125V (5-15R) Duplex straight blade, 2 pole, 3 wire grounding, isolated ground surge suppression indicator light, blue colour
 - .1 Arrow Hart IG5250
 - .2 Hubbell IG5262
- .20 15A 125 V (5-15R) Duplex straight blade, 2pole 3 wire grounding arc fault interrupting receptacle to CSA Standard C22.2 No. 42
 - .1 Hubbell AFR15TRW
 - .2 Leviton AFTR1-W
 - .3 Legrand AF15TRW

2.23 **WIRING DEVICES - COVER PLATES**

- .1 Stainless steel Type 302 alloy, vertically brushed, 0.8 mm thick cover plates.
- .2 Pressed steel, galvanized.
- .3 Cast covers for cast boxes with gaskets.
- .4 Cover plates of same manufacture as devices.

2.24 **WELDING RECEPTACLES**

- .1 Circuit Breaking Receptacle
 - .1 Receptacle and back box assembly, 600 volt, 60 amp, 3 wire, 4 pole, weatherproof, aluminum housing.
 - .2 Acceptable Manufacturers
 - .1 Appleton Powertite, AJA mounting box and spring door
 - .2 Crouse-Hinds, Arktite AREA 6000 series, AJ back box, angle adaptor and spring door
 - .3 Russellstoll, type JRFA, 20 degree angle adaptor and spring door
- .2 Interlocked Receptacle and Switch
 - .1 Receptacle interlocked with unfused disconnect switch, 600 volt, 60 amp, 3 wire, 4 pole. Receptacle with aluminum housing and spring door. Disconnect switch with NEMA 12 sheet steel enclosure.
 - .2 Acceptable Manufacturers
 - .1 Appleton WSRD interlocked receptacle
 - .2 Crouse-Hinds Arktite receptacle with WSRD disconnect switch

- .3 Schneider Square D with Crouse-Hinds Arktite receptacle and class 3110 disconnect switch
- .3 Compact Interlocked Receptacle and Switch
 - .1 Compact unit, receptacle interlocked with unfused disconnect switch, 600 volt, 60 amp, 3 wire, 4 pole, watertight, NEMA 4X non-metallic enclosure.
 - .2 Acceptable Manufacturers
 - .1 Bryant, 460SM series
 - .2 Crouse-Hinds, Arktite CSR Series
 - .3 Hubbell, Circuit-Lock
- 2.25 **PLYWOOD BACKBOARDS**
 - .1 Plywood backboards, good one side, 4' x 8' x 3/4" unless indicated otherwise. Treat with primer and two coats of fire retardant paint.
 - .2 Mount plywood on vertical strapping, on 40 mm centres to provide 10 mm clearance between wall and rear of plywood. Treat strapping similar to plywood.
- 2.26 **FINISH**
 - .1 Equipment enclosure finish: baked grey enamel, ANSI 49 or ANSI 61.

PART - 3 EXECUTION

3.1 WIRE AND CABLE

- .1 Install wiring in raceways unless noted otherwise.
- .2 Minimum wire sizes:
 - .1 Power and lighting No. 12 AWG
 - .2 Control No. 14 AWG
 - .3 Fire alarm No. 18 AWG
- .3 Wire and cable application and type:

Application	Type
Lighting branch circuit where connection to luminaire is AC90 cable	T90 nylon
Receptacle branch circuit	T90 nylon
Ceiling boxes to luminaires in suspended ceiling	T90 nylon or AC90 cable
Wiring under raised floor used as plenum	AC90 cable or wire in flexible metal conduit
Wiring inside high temperature equipment	TEW or SEW-2
Branch circuits other than those covered above	RW90
Equipment feeders, circuits	RW90
Underground and under slab raceways, duct banks, direct burial	RWU90

- .4 Type AC90 cable length limitations:
 - .1 Ceiling box to luminaire:
 - .1 1.2 m maximum in non-accessible ceilings;
 - .2 1.8 m in accessible ceilings
 - .2 Junction box to outlet:
 - .1 3.6 m maximum
- .5 Load current limitations:
 - .1 Conductors rated for more than 90°C:
 - .1 90°C code ampacity rating
 - .2 Motor connection:
 - .1 75°C code ampacity rating

3.2 **TECK CABLES**

- .1 Store cables in a clean, dry environment
- .2 Install per manufacturer's written instructions, taking care to not exceed pulling tension nor bend radius.
- .3 Install cable in tray unless noted otherwise on the drawings.
- .4 Do not use cable splices.
- .5 Where TECK cable is not installed in tray, provide support at a minimum of 600 mm intervals.
- .6 Use cable reels and sheaves at bends.
- .7 Submit cable pulling tension calculations for all cables under vertical tension. For horizontal installations, submit calculations when requested by the Engineer.
- .8 Perform insulation resistance (megger test) on each TECK low voltage (<1001V) cable.

3.3 **MINERAL INSULATED CABLE**

- .1 Verify that the factory installed temporary end seals are intact.
- .2 Verify that no moisture has entered cable insulation.
- .3 Cables shall be shipped from the manufacturer with ends temporarily sealed against moisture.
- .4 Protect the exposed cable ends with shrinkable, molded polyolefin end caps or other suitable means such as standard conduit sealing compound and PVC tape.
- .5 Cable shall be stored in a clean dry location.
- .6 Cable shall be uncoiled by rolling or rotating supply reel.
- .7 Take precautions necessary to prevent damage to cable from contact with sharp objects, such as when it is pulled over foreign material on sheaves.

- .8 Installation
 - .1 The wiring cable shall be installed and supported according to the manufacturer's recommendations, the instructions in the Installation Specification or Manual and the requirements of the ULC Fire Resistance Directory listing.
 - .2 Ensure maximum pulling tension is not exceeded during installation.
 - .3 Install brass plate at entrance to all ferrous enclosures.
- .9 Field Quality Control
 - .1 Inspect cable for physical damage and proper connection.
 - .2 Measure tightness of bolted connections and compare torque measurements with manufacturer's recommended values.
 - .3 Verify continuity of each conductor.
 - .4 Prior to energizing cables, measure insulation resistance of each cable. Tabulate and submit for approval.
 - .5 Provide certification through an inspection from cable manufacturer "Field Services Support" group that installation is in accordance with their requirements.

3.4 **EMF-FREE POWER CABLES**

- .1 Install the EMF-free power cable system in complete accordance with the manufacturer's written instructions.
- .2 Provide a manufacturer's representative on site during installation of the system.
- .3 At completion of the work, provide a letter from the manufacturer indicating that the system was installed to the manufacturer's satisfaction and that it is ready for use.
- .4 Provide manufacturer's commissioning report to include the manufacturer's standard readings and specifically the following readings taken at 3 locations, determined by the Consultant; 1 m from the feeder and distance from the feeder where the EMF is 0.5 micro Teslas.
 - .1 Background ac and steady state (dc) EMF readings (feeder de-energized)
 - .2 EMF readings at full load, balanced $\pm 5\%$
 - .3 EMF readings near full load with 20% $\pm 5\%$ unbalance
- .5 Acceptance Criterion
 - .1 The installation will be deemed not acceptable if the ac EMF is in excess of 0.5 micro Teslas above the background EMF at any point along the feeder not within 2 m of either end for all load conditions

3.5 **CONNECTORS**

- .1 Install compression terminations and splices in accordance with manufacturer's written instructions.
- .2 Make splices in junction boxes.
- .3 Make connections in lighting circuits with twist type splicing connectors.
- .4 Terminate and splice conductors No. 8 and larger at terminal blocks in junction boxes.

- .5 Seal terminations and splices exposed to moisture, corrosive conditions or mechanical abrasions with heavy wall heat shrinkable insulation.

- .6 Install fixture type connectors and tighten. Replace insulating cap.

3.6 **MOTOR LEAD CONNECTION KITS, 600 VOLT**

- .1 Install motor lead connection kits for low voltage motors.

3.7 **CONDUIT AND EMT - GENERAL**

- .1 Run parallel or perpendicular to building lines.
- .2 Group raceways wherever possible. Support on channels.
- .3 Install expansion joints as required.
- .4 Run raceways in web portion of structural steel columns and beams.
- .5 Do not drill structural members to pass through.
- .6 Locate raceways behind infrared or unit heaters with 1500 mm clearance.
- .7 Locate raceways not less than 25 mm clear where parallel to steam or hot water lines with a minimum of 75 mm at crossovers.
- .8 Do not install horizontal runs in masonry walls.
- .9 Use metallic raceway where temperatures exceed 75°C or where enclosed in thermal insulation.
- .10 EMT and non-metallic conduits to contain insulated green ground wire.
- .11 Install 6 mm diameter nylon pull cord in empty raceways.

3.8 **CONDUIT AND FITTINGS**

- .1 Minimum conduit sizes:
 - .1 Surface installation: 21 mm trade size conduit
 - .2 Embedded in concrete: 27 mm trade size conduit
 - .3 Directly buried: 53 mm trade size conduit
- .2 Conduit application and type:

Application	Type
Corrosive areas	rigid steel corrosion resistant coated
Hazardous areas	rigid steel
Outdoor areas	rigid steel
Embedded in concrete, other than grade slab	rigid steel (PVC)
In or below grade slab	PVC
Exposed in unfinished areas up to 3 m above finished floor. Use EMT above 3m	rigid steel
Connection to motors and equipment subject	liquid tight flexible steel conduit

to vibration	
Final connection to dry type transformer	flexible steel conduit
Whip connection to modular furniture	non-metallic extra flexible PVC

- .3 Use field threads on rigid conduit of sufficient length to draw conduits up tight.
- .4 Do not bend coated steel conduit. Use elbows for deflections.
- .5 Do not install conduit in or under slab.
- .6 Use factory "ells" where 90° bends are required for 1 (27 mm) trade size and larger conduits.
- .7 Bend conduit offsets cold. Do not install crushed or deformed conduits and avoid trapped runs in damp or wet locations. Prevent the entrance of water and lodging of concrete, plaster, dirt, or trash in conduit, boxes, fittings, and equipment during course of construction.
- .8 Where conduit joints occur in damp or wet locations, make joints watertight by applying an approved compound on the entire thread area before assembling. Draw up all conduit joints as tightly as possible.
- .9 Cap exposed empty conduits which do not terminate in outlets, panels, cabinets, etc., with standard galvanized plumber's pipe caps.
- .10 Plug empty conduits which terminate flush with floors or walls with flush coupling and brass plug.
- .11 Install conduit sleeves for all exposed conduits and cables passing through walls, ceilings, or floors, and fill void between sleeve and conduit with caulking. If fire-rated caulking is required by code, use same class as walls, ceilings or floors.
- .12 Terminate conduit stubbed up through concrete floor for connection to free standing equipment with a coupling flush with finish floor, and extend rigid conduit to equipment, except where required, use flexible conduit from a point 150 mm above floor.
- .13 Install double locknuts and bushings on all rigid conduit terminations into threadless openings. Increase length of conduit threads at terminations sufficiently to permit bushing to be fully seated against end of conduit.
- .14 Mechanically bend steel conduit.
- .15 Install sealing condulets in conduits at hazardous area boundaries.
- .16 Conduits in Poured Concrete
 - .1 Locate to suit reinforcing steel. Secure firmly to prevent movement during pour.
 - .2 Clear each conduit with mandrel and brush before concrete sets.
 - .3 Protect conduits from damage where they stub out of concrete.
 - .4 Install sleeves where conduits pass through slab or wall.
 - .5 Provide oversized sleeve before membrane is installed where conduits pass through waterproof membrane. Use cold mastic between sleeve and conduit.
 - .6 Encase conduits completely in concrete; provide 50 mm minimum concrete cover.

- .7 Replace with exposed conduit, any conduit run found to be obstructed after concrete sets.

3.9 **EMT AND FITTINGS**

- .1 Minimum EMT size: 21 mm trade size conduit.
- .2 EMT Application
 - .1 Exposed in unfinished areas, above truss level and for drops in column web to 3 m above finished floor. Use rigid steel conduit below 3 m.
 - .2 In block walls and stud partitions.

3.10 **WIREWAYS**

- .1 Install per manufacturer's recommendations.
- .2 Keep number of elbows, offsets and connections to a minimum.
- .3 Install barriers where required by Code.
- .4 Install gutters to full length of equipment.

3.11 **FASTENINGS AND SUPPORTS**

- .1 Provide supports and fastenings for the Work of this Division. Do not use supports or equipment provided by other Trades.
- .2 Equipment fastenings and supports shall conform to manufacturers recommendations.
- .3 Do not attach to, or suspend any electrical product or service from the roof deck, mechanical ductwork or piping.
- .4 Do not use wire lashing or perforated strap to support or secure raceways or cable.
- .5 Support rods for any suspended item must not be attached to or extended through steel pan type roofs or through concrete slab roofs.
- .6 For surface mounting of two or more raceways or cables use channels.
- .7 Where there is no wall support for raceways and cables dropped vertically to equipment, provide channel properly secured to floor and structure.
- .8 Hang supports from structural members. Where location does not permit direct support from structure provide necessary brackets, frames, channels secured to structural members.
- .9 Fasten exposed conduit and cables to building construction or support systems using straps. Use beam clamps on exposed steelwork.
- .10 Masonry, tile and plaster surfaces: use lead anchors.
- .11 Poured concrete: use expandable inserts. Low velocity powder activated fastenings may be used only in poured concrete.
- .12 Steel structures: use clips, spring loaded bolts, cable clamps, designed as accessories to basic channel members.
- .13 Do not use powder activated fasteners in, tile, precast concrete or steel structure.

- .14 Do not install conduits or cables on the bottom chord of joists or trusses.
 - .15 Use beam clamps of the 2-bolt design and of such type that the rod load is transmitted only concentrically to the beam web centreline. The use of "C" and "I" beam side clamps will not be allowed.
 - .16 Where the roof or floor framing consists of open web or long span steel joists and/or trusses, ensure that hangers are located at or within 150 mm of the joist or truss top or bottom chord panel points, otherwise provide additional structural steel as required where hanger spacing does not coincide with joist or truss spacing. Design suspension assembly such that the hanger load is transmitted only concentrically to the supporting joist or truss. The use of "C" and "I" beam clamps, brackets, etc., will not be allowed.
 - .17 Locate secondary structural steel members between joists or trusses at or within 150 mm of top or bottom chord panel points. Where the secondary structural steel member cannot be located at or near a joist or truss panel point, provide additional diagonal structural steel web member/members designed for the applicable load to the nearest panel point in the opposite chord member. Diagonal hangers which will induce lateral stresses in the chord members of the joist will not be permitted. Submit shop drawings of the suspension assembly indicating the location of suspension or support points, the maximum load at each suspension point, location and size of hangers, brackets and intermediate framing members when required, and also details of connection to building structure.
- 3.12 **SPLITTER BOXES**
- .1 Install splitters as indicated and mount plumb, true and square to the building lines.
 - .2 Extend splitters full length of equipment arrangement.
- 3.13 **JUNCTION BOXES**
- .1 Install junction boxes in inconspicuous but accessible locations. Secure to structure.
 - .2 Install terminal blocks on mounting rails, for termination of each wire and cable regardless of size.
 - .3 Only one voltage source is permitted in a junction box.
 - .4 Install barriers to separate different auxiliary systems.
- 3.14 **TERMINAL BLOCKS - SURGE SUPPRESSION**
- .1 Install surge suppression terminal blocks.
- 3.15 **PULL BOXES**
- .1 Install pull boxes in inconspicuous but accessible locations. Secure to structure.
 - .2 Install pull boxes so as not to exceed 30 m of conduit run between pull boxes.
 - .3 Only one voltage source is permitted in a pull box.
 - .4 Install barriers to separate different auxiliary systems.
- 3.16 **OUTLET AND CONDUIT BOXES**
- .1 Install conduit outlet boxes for conduit up to 32 mm and pull boxes for larger conduits.
 - .2 Support boxes independently of connecting conduits.

- .3 Seal boxes during construction to prevent entry of debris, dust and dirt.
- .4 For flush installations mount plaster rings to box, flush with wall surface to permit wall finish to come within 6 mm of opening.
- .5 Provide correct size of openings in boxes for conduit, armoured cable connections. Reducing washers will not be acceptable.
- .6 Install switches and other controls close to door lock or latch jambs and other openings, maintaining a minimum of 100 mm from trims of doors (except where installed in door frames of metal partitions) check door swings.
- .7 Install 100 mm square or octagonal outlet boxes for lighting fixture outlets.

3.17 **MASONRY BOXES**

- .1 In block walls use deep boxes to provide clear space around knockout for AC90 cable entry.

3.18 **WIRING DEVICES - SWITCHES**

- .1 Install single throw switches with handle in UP position when switch is closed.
- .2 Install switches in gang type outlet box when more than one switch is required in a location.
- .3 Mount toggle switches at height indicated.
- .4 Install switch colours as follows:

Area	Colour
Gypsum board, plaster or panelled	White
Office	White
Factory, service	White

3.19 **WIRING DEVICES - DIMMER SWITCHES**

- .1 Install each dimmer switch in outlet box at locations indicated.
- .2 Mount dimmer switches at height indicated.

3.20 **WIRING DEVICES - RECEPTACLES**

- .1 Install receptacles vertically, use gang type outlet box where more than one receptacle is required in a location.
- .2 Where split receptacle has a portion switched, mount vertically and switch upper portion.
- .3 Coordinate with architectural and interior design drawings for final positioning and mounting heights of power and voice/data receptacles. Where there is disagreement between electrical and architectural drawings, take the architectural drawings as correct.
- .4 Maintain clearances between receptacle outlet boxes and millwork as stipulated on the drawings.
- .5 Align and evenly space outlet boxes that are mounted as a group.
- .6 Install receptacle colours as follows:

Area	Colour
Gypsum board, plaster or panelled	White
Office	White
Factory, service, exterior	White

3.21 **WIRING DEVICES - COVER PLATES**

- .1 Protect stainless steel cover plate finish with paper or plastic film until painting and other work is finished.
- .2 Install suitable common cover plates where wiring devices are grouped.
- .3 Do not use cover plates designed for flush outlet boxes on surface-mounted boxes.
- .4 Provide plaster ring where necessary.
- .5 Install cover plates as follows:

Area	Cover Plate Type
Gypsum board, plaster or panelled	stainless steel
Factory, service	galvanized steel
Exterior	cast cover

3.22 **WELDING RECEPTACLES**

- .1 Install welding receptacles.
- .2 Ensure that phase rotation is similar for all receptacles.

3.23 **CONTROL DEVICES**

- .1 Install as indicated.

3.24 **PLYWOOD BACKBOARDS**

- .1 Install plywood backboards.

3.25 **FIELD FABRICATED METAL WORK**

- .1 Clean and prime paint field fabricated metal work.
- .2 After fabrication deburr, scrape, grind smooth, wire brush with power brush and degrease metal work.
- .3 Prime paint steel with 1 coat of CISC/CPMA 2.75 oil alkyd primer.
- .4 Prime paint aluminum as follows: wash with detergent solution and wipe down with SSPC-SP1 solvent. Apply Glidden #Y-5229 primer to 1.5 mils DFT.
- .5 For brass and bronze alloy materials, prepare as for aluminum but apply 1 coat of CAN/CGSB-1.40-M zinc chromate primer.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
 - .2 Modifications, demolition and installation of services within this building require utmost care due to vital operation of systems involved. Removal and installation of systems require constant communication with Consultant.

1.2 CO-ORDINATION BETWEEN NEW AND EXISTING INSTALLATIONS

- .1 Provide interfacing components between new and existing systems as necessary for proper performance and operation.

1.3 EXISTING SERVICES

- .1 Ensure existing services remain undisturbed and energized except where indicated to be disconnected.
- .2 Disconnect and remove abandoned wiring materials and devices.
- .3 Cut raceways flush where embedded in structure.
- .4 Retain abandoned embedded outlet boxes and close with pressed steel coverplates.
- .5 Make safe all circuit wiring left for future use.

1.4 INTERRUPTION OF SERVICES

- .1 Obtain Consultant's written approval before interrupting any service. Long outages are not acceptable.
- .2 Provide temporary services to maintain continuity in the event that services must be interrupted.

1.5 PREMIUM TIME

- .1 Include cost of premium time in tender price for work during nights, weekends or other time outside normal working hours necessary to do the work and maintain electrical services in operation.

PART - 2 PRODUCTS

2.1 USE OF EXISTING MATERIAL AND EQUIPMENT

- .1 Unless noted otherwise, existing panels, boxes and wiring materials may be reused if acceptable to Inspection Authority.
- .2 Unless noted otherwise, provide additional equipment of same type and manufacture to supplement existing equipment.
- .3 Reused Luminaires: Furnish new lamps.

PART - 3 EXECUTION

3.1 EXAMINATION

- .1 Visit the site, examine the existing conditions and become familiar with the extent of the necessary removal, relocation, reconnecting, and rerouting of electrical equipment and wiring as necessary for the completion of the project.
- .2 Review and confirm with the Architect/Designer's drawings for the complete extent of demolition and alteration.

3.2 EXISTING MATERIAL AND EQUIPMENT

- .1 Equipment to be reused or relocated: test for proper operation and repair as necessary.
- .2 Repair or replace existing equipment which is damaged in process of relocation.
- .3 Reused Luminaires: Install lamps, clean fixtures and touch up damaged finish.
- .4 Relocate existing junction, pull or terminal boxes which become inaccessible due to new mechanical ductwork or equipment.
- .5 Ensure all electrical, life safety services, and services for existing equipment, in areas outside the areas of this work, that are required to remain in service, shall be kept in service and without interruption.
- .6 Relocate any electrical feeders or equipment that are required to remain in service that are secured to existing walls, floors or ceilings to be demolished or that are buried and required to be excavated for new work.
- .7 When deleting and/or making safe existing electrical work, ensure that it includes all wiring back to the associated panel boards or control panel.
- .8 Disconnect and remove existing light fixtures, devices, outlets, etc., which are not to be reused. Such items shall be cartoned and turn over to the Owner at a place designated by the Owner. Cut back and cap unused raceway and outlets and removed unused wiring back to panel board in approved manner.

3.3 DEMOLITION

- .1 Make safe and disconnect all power and systems, as and when, and to the extent required to facilitate with the demolition.
- .2 Demolish existing work, where indicated, and remove from site.
- .3 Execute all demolition work so as to create minimum vibration or dust within and outside the building. Obtain Consultant's approval of methods before proceeding.
- .4 Include in demolition work for removal of all communication devices, outlets, and cables etc., which are not be reused. Remove all unnecessary cables and equipment in hub rooms and/or telephone rooms with extreme care to avoid any accidental shutdown to existing services serving other parts of the building.
- .5 All existing electrical equipment which is no longer required shall be removed and disposed of, off site.
- .6 Be responsible and pay for any damage to the Base Building incurred by work of this Division, or repair to the satisfaction of the Consultant.

- .7 Carry out the work with minimum of noise, dust and disturbance.

3.4 **WORK IN EXISTING TENANT FACILITIES**

- .1 Coordinate work in tenant facilities with tenant. Ensure that no interruptions and/or interferences occur with tenant's normal operation.
- .2 Be responsible for any damage created in existing tenant facilities when installing equipment and materials.

3.5 **PENETRATIONS IN EXISTING STRUCTURE**

- .1 Perform cutting, patching and repairing. Before proceeding obtain Consultant's approval.
- .2 Where necessary to penetrate existing floors, walls, ceiling, roof or structural members provide sleeve and follow Consultant's instructions.
- .3 Restore surfaces to same finish and condition as existed prior to penetration.
- .4 Core Drilling Procedure – as per Section 26 05 01 Common Work Results for Electrical.

3.6 **SALVAGE MATERIALS**

- .1 Remove from site materials in renovated areas that are not to remain or be reused, unless noted as remaining property of Owner.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.

1.2 APPROVALS

- .1 Identification subject to prior approval of Consultant.

PART - 2 PRODUCTS

2.1 WIRE AND CABLE MARKERS

- .1 Wire and Cable Diameter Less Than 13 mm
 - .1 Acceptable manufacturer
 - .1 Wieland Z type
- .2 Cable Diameter 13 mm and Larger
 - .1 Acceptable manufacturer
 - .1 Wieland K type
- .3 Non-Circular Wire
 - .1 Acceptable manufacturer
 - .1 Raychem Shrinkmark sleeves

2.2 CONDUIT AND ELECTRICAL METALLIC TUBING MARKERS

- .1 Stick-On Marker
 - .1 Raceway Size Minimum Character Height
 - .1 ¾" - 1¼" 15 mm
 - .2 1½" - 2" 19 mm
 - .3 over 2" 32 mm
- .2 Acceptable Manufacturers
 - .1 Brady, vinyl cloth, black on orange, type B-500
 - .2 Panduit, vinyl cloth, black on yellow, type PCL
 - .3 Wieland, mylar, black on yellow, type NL

2.3 PANELBOARD IDENTIFICATION

- .1 Engraved laminated plastic, black lettering on white background, 6 mm character height.
- .2 Typical 2-line identification for lighting panel:

"Lighting Panel C, 120/208V, 3 ph, 4W"

"Supplied from panel BB"

- .3 Directories: Typewritten identification of breaker number, ampere rating and connected equipment.

2.4 **MOTOR STARTER, CONTACTOR AND DISCONNECT SWITCH IDENTIFICATION**

- .1 Engraved laminated plastic, black lettering on white background, 6 mm character height.
- .2 Typical Identification: "Pump S4, 208V, 3 ph".

2.5 **MARKER TAPE, SERVICE AND PHASE IDENTIFICATION**

- .1 Acceptable Manufacturer
 - .1 3M, Scotch Code Tape, type STD with SDR colour refills or 3M Scotch 35 colour tape.

PART - 3 EXECUTION

3.1 **SYSTEMS IDENTIFICATION**

- .1 Identify outlet boxes for various systems with distinctive paint colour. Apply a small area of paint to inside of outlet, junction and pull boxes and panels. In suspended ceiling areas, apply paint to inside and outside of junction boxes. System colours:

System	Normal	Emergency	UPS
120/208 volt	black	black/red	black/blue
347/600 volt	orange	orange/red	orange/blue
Fire alarm	red		
Intercom	brown		
Low voltage control	black		
PA and sound	light green		

3.2 **POWER COMPANY SERVICE IDENTIFICATION**

- .1 Identify service conductors with coloured marker tape as follows:
 - .1 Phase A red
 - .2 Phase B black
 - .3 Phase C blue
 - .4 Neutral white
 - .5 Ground green

3.3 **WIRE AND CABLE IDENTIFICATION**

- .1 Identify power, control, lighting and receptacle wires with continuous colouring as follows:
 - .1 Phase A red
 - .2 Phase B black
 - .3 Phase C blue
 - .4 Neutral white

- .5 Ground green
- .6 Isolating ground green and yellow
- .7 Control red
- .8 Interlock yellow
- .9 D.C. blue
- .2 For larger wire sizes available only in black, install coloured wire marker tape in accordance with above coding.
- .3 Cables Bearing Identification Numbers on the Drawings
 - .1 Install identification markers at each end of cable run.
- .4 Control/Indication Conductors
 - .1 Install conductor identification markers at switchgear, motor control centres and motor starter terminal blocks and at remote devices.
 - .2 Identification in accordance with the Drawings and reviewed shop drawings.
- .5 Lighting and Receptacle Branch Circuits
 - .1 Install conductor identification markers at panel, outlet box connections to lighting fixtures and device outlet boxes.
 - .2 Typical identification if fixture or device is connected to panel A, circuit 5: A-5.
- .6 Low Voltage Lighting Control
 - .1 Install conductor identification marker at relay phase conductors. Typical identification if connected to panel A, circuit 5: A-5.
 - .2 Install conductor identification marker on conductors between control locations and relay panels. Identify in accordance with reviewed shop drawings.
- .7 Data, Voice and Fibre Optic Cables
 - .1 Label horizontally distributed cabling at the following locations:
 - .1 Both ends of cable run
 - .2 Entrance and exit of cable pathway (i.e. cable trays, zone conduits, etc.)
 - .2 Label riser/backbone distribution cables at the following locations:
 - .1 Both ends of cable run
 - .2 Entrance and exit of cable pathway (ie. cable trays, zone conduits, etc.)
 - .3 1.5 m above finished floor in communication closets and equipment rooms
 - .4 At entrance and exit of a sleeve or slot in communication closets and equipment rooms
 - .3 Use the following colour codes for labels:

Function	Colour
Auxiliary and miscellaneous circuits	Yellow
Common equipment	Purple
Customer side of network interface	Green

First level backbone	White
Horizontal cabling to workstations	Blue
Interbuilding backbone	Brown
Key telephone systems	Red
Network side of network interface	Orange
Second level backbone	Gray

Note: Common equipment refers to PBX equipment, host computer, LANs and multiplexer. Miscellaneous refers to maintenance alarms, security, paging systems, and other system and circuits not an integral part of common equipment. Colour codes to ANSI/TIA/EIA-606.

.8 Fire Alarm and Miscellaneous Systems

- .1 Install identification on conductors at panels, remote devices and system connections. Identify in accordance with reviewed shop drawings.
- .2 Install maglock/fire alarm pull station identification adjacent to each door equipped with a maglock.

3.4 **CONDUIT AND ELECTRICAL METALLIC TUBING (EMT) IDENTIFICATION**

- .1 Where Drawings indicate conduit and EMT identification numbers/letters, install identification markers at each end of run and at pull box locations.

3.5 **CABLE TRAY IDENTIFICATION**

- .1 Install markers indicating system, voltage, or voltages for trays with barriers, and identification number at intervals of 20 m maximum, at branches and termination locations.

3.6 **PANELBOARD IDENTIFICATION**

- .1 Install identification plates, using adhesive, on outside of panel.
- .2 Install directory.
- .3 Identify main bus as follows:
 - .1 Phase A red
 - .2 Phase B black
 - .3 Phase C blue
 - .4 Neutral white
 - .5 Ground green

3.7 **MOTOR STARTER, CONTACTOR AND DISCONNECT SWITCH IDENTIFICATION**

- .1 Install identification plates using self-tapping screws.

3.8 **IDENTIFICATION AFTER FINISH PAINTING**

- .1 Behind access doors at shaft plenums: identify busways, feeder cables and feeder conduits.

3.9 **RECEPTACLES IDENTIFICATION**

- .1 Identify each receptacle with panel and circuit number on type written label.

3.10 **EQUIPMENT WARNING SIGNS**

- .1 Install "Danger - High Voltage" signs.
- .2 When equipment is supplied from more than one source install red warning signs to this effect.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.
 - .2 Integrated System Testing.

1.2 TESTING AND INSPECTION

- .1 Arrange for site attendance by representatives of product manufacturer companies as requested by Testing and Inspection Company.

1.3 REFERENCES

- .1 Conform to latest issues, amendments and supplements of following standards:
 - .1 ASTM American Society for Testing and Materials
 - .2 CSA C22.2 No. 41-81 Grounding and Bonding Equipment
 - .3 CAN/CSA-C22.3 No. 1-M Overhead Systems
 - .4 CSA C22.3 No. 2 General Grounding Requirements and Grounding Requirements for Electrical Supply Stations
 - .5 NETA International Electrical Testing Association Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems, 1987
 - .6 ICEA Insulated Power Cable Engineer's Association
 - .7 IEEE Institute of Electrical and Electronic Engineers Guide for Making High Voltage Tests on Power Cable Systems the Field Std. 400
 - .8 CAN/ULC - S1001-11 Standard for Integrated Systems Testing of Fire Protection and Life Safety Systems.

1.4 PROJECT SITE CONDITIONS

- .1 Prior to testing, concrete and masonry work in vicinity of equipment and enclosures, walls, doors, gates and fences shall be completely installed, loose dirt and debris removed, and area cleaned. Interior areas shall be broom cleaned and washed down to remove dust.

1.5 SAFETY

- .1 Conform to Federal, Provincial and Municipal safety requirements.
- .2 Provide adequate protection for persons performing, assisting, or witnessing tests.
- .3 Guard test areas from persons not involved in test procedures.

1.6 QUALITY ASSURANCE

- .1 Perform testing of the following:
 - .1 Ground system
 - .2 Motors

- .3 Low voltage cables
- .4 Panelboards
- .5 Distribution transformers
- .6 Thermographic scanning

1.7 **SUBMITTALS**

- .1 Submit an integrated testing plan to the requirements on CAN/ULC S1001. Integrated tests with the fire alarm system to include but not be limited to:
 - .1 Fan shutdowns
 - .2 Pressurization Fans
- .2 Submit testing plan c/w schedule a minimum of 4 weeks prior to commencing testing.
- .3 Submit completed testing forms and documentation with Operations and Maintenance manuals.

PART - 2 PRODUCTS

2.1 **MATERIALS**

- .1 Furnish materials, instruments, and equipment required to execute specified pre-test inspection, testing and cleaning.
- .2 Furnish megger test instruments as follows:

	System Voltage	Megger Voltage
.1	less than 208V	500V
.2	277V to 1000V	1000V

PART - 3 EXECUTION

3.1 **GENERAL**

- .1 Remove dust, debris, surplus material and tools from equipment.
- .2 Check and tighten bus connections and terminations with a calibrated torque wrench. Refer to manufacturer's instruction for proper foot pound levels. Mark with adhesive tape or label when satisfactory.
- .3 Insulation resistance values:

System Voltage	Megger Voltage	Minimum Acceptable Resistance in Megohms
less than 208V	500V	25
277 to 1000V	1000V	100

3.2 **LOW VOLTAGE CABLES (LESS THAN 1000V)**

- .1 Install low voltage feeder cables to switchgear, panelboards, MCC's and distribution transformers but do not terminate to equipment.

- .2 Take precautions necessary to ensure that installed cable runs which have not been terminated to their respective equipment and exposed terminals of equipment are protected from any damage.
- .3 Visually inspect and megger cables to ensure they are ready for testing by Testing and Inspection Company.
- .4 Terminate cable runs to equipment when instructed to do so by Consultant.

3.3 **PANELBOARDS**

- .1 Inspect for physical, electrical, and mechanical condition.
- .2 Compare equipment nameplate information with latest single line diagram and report discrepancies.
- .3 Inspect for paint, dents, scratches, fit, and missing hardware.
- .4 Verify that fuse and/or circuit breaker sizes and types correspond to drawings.
- .5 Check tightness of bolted bus joints by calibrated torque wrench method. Refer to manufacturer's instructions for proper torque levels.
- .6 Clean panelboard.
- .7 Megger test.

3.4 **DRY TYPE TRANSFORMERS - UP TO 600V**

- .1 Inspect for physical damage, broken insulation, tightness of connections, defective wiring and general condition.
- .2 Thoroughly clean unit prior to making any tests.
- .3 Verify taps if applicable and connect transformer to desired tap.
- .4 Check that connections are not mechanically stressed.

3.5 **LOW VOLTAGE MOTOR CONTROL CENTRES, STARTERS, CONTACTORS UP TO 1000 VOLT SERVICE**

- .1 Visually inspect components and the complete assembly, check drawout and plug connections.
- .2 Clean equipment.
- .3 Check each contactor and starter for rating, contactor size and operation, auxiliary contact operation.
- .4 Check starter overloads and fuses with motor full load nameplate ratings.
- .5 Check controls, starters and contactors operation on load.
- .6 Check phasing.
- .7 Check tightness of bolted bus joints by calibrated torque wrench method. Refer to manufacturer's instructions for proper torque levels.

3.6 **FUSIBLE AND NON FUSIBLE DISCONNECT SWITCHES**

- .1 Clean equipment.
- .2 Inspect for physical and mechanical condition.
- .3 Verify that fuse sizes and types correspond to drawings.

3.7 **MOTORS**

- .1 Inspect for physical damage.
- .2 Inspect for proper anchorage, mounting, grounding, connection, and lubrication.
- .3 Inspect for unusual mechanical or electrical noise or signs of overheating during initial test run.

3.8 **FIRE DETECTION AND ALARM SYSTEM**

- .1 Engage manufacturer's qualified representative to make an inspection of fire alarm system. Inspection shall verify the following:
 - .1 The installation is that designated by the Consultant's specifications.
 - .2 The installation complies with standard CAN/ULC-S537-M.
 - .3 The equipment has been installed in accordance with manufacturer's recommendations, and that all signalling devices of whatever manufacture have been operated or tested to verify their operation.
 - .4 That supervisory wiring of those items of equipment connected to a supervised circuit is operating and that governmental regulations, if any, concerning such supervisory wiring, have been met.
- .2 On completion of inspection and when all of above conditions have been complied with, manufacturer shall issue to Consultant:
 - .1 A copy of inspection report showing location of each device and certifying test results of each device.
 - .2 A certificate of verification confirming that inspection has been completed and showing conditions upon which such inspection and certification have been rendered.

3.9 **INTEGRATED TESTING**

- .1 Perform and document integrated tests between the fire alarm system and all associated systems to the requirements of CAN/ULC S1001 and the Testing plan.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.

1.2 RELATED SECTIONS

- .1 Section 26 05 01: Common Work Results for Electrical.

1.3 REFERENCES

- .1 Conform to latest issues, amendments and supplements of following standards:
 - .1 CSA C9-M Dry-Type Transformers
 - .2 CSA C22.2 No. 47 Air-Cooled Transformers (Dry Type)
 - .3 CAN/CSA C802.2-M Minimum efficiency valves for Dry Type Transformers

1.4 WASTE MANAGEMENT AND DISPOSAL

- .1 Remove from site and dispose of all packaging materials at appropriate recycling facilities.
- .2 Collect and separate for disposal packaging material for recycling in accordance with Waste Management Plans.

PART - 2 PRODUCTS

2.1 DRY TYPE TRANSFORMERS - UP TO 600V

- .1 Dry-type Transformers: Type ANN, copper windings, insulation Class H, 150°C rise.
- .2 Three independent windings with delta primary and wye secondary.
- .3 Enclosure: Steel, ventilated, EEMAC.
- .4 Taps: 4 full capacity primary taps, +/- 2 x 2.5%
- .5 Impedance: Minimum 1.5% and maximum 6% with efficiency to CSA C802.2.
- .6 Vibration Isolators: Internal noise and vibration isolating pads.
- .7 Primary and Secondary terminations to be accessible from the front.
- .8 Mounting Brackets: Floor and wall standard.
- .9 Sound Level: Standard
- .10 Acceptable Manufacturers:
 - .1 Marcus Transformer
 - .2 Hammond Power Solutions
 - .3 Schneider Rex Power Magnetics

2.2 **DRY TYPE TRANSFORMER - ELECTROSTATIC SHIELD**

- .1 Full width electrostatic shield between primary and secondary windings, where indicated.

2.3 **DRY TYPE TRANSFORMER - K-FACTOR**

- .1 Transformer rated for non-linear loading with K-factor of 13, where indicated.

PART - 3 EXECUTION

3.1 **GENERAL**

- .1 Protect equipment from dust, debris, moisture, and physical damage, with sealed envelope of plastic or other impervious material until building is enclosed and cleaned and equipment is energized.
- .2 Protect from condensation by maintaining at suitable temperature above 0°C.
- .3 Finish equipment enclosures to ANSI 49 or ANSI 61, baked grey enamel.

3.2 **DISTRIBUTION TRANSFORMERS**

- .1 Support from building structure on trapezes or L brackets. Locate to provide free flow of cooling air.
- .2 Loosen isolation pads until no compression is visible.
- .3 Make final connection with flexible metal conduit.
- .4 Leave slack in cables and flexible conduit, to avoid stress on connections.

3.3 **INSTALLATION**

- .1 Mount dry-type transformers on floor or wall mount where shown on the drawings. Transformers up to maximum 75 kVA may be mounted on wall or suspended on thread on rods from slab. Provide seismic restraint and obtain structural engineer approval prior to installation for all transformer.
- .2 Ensure adequate clearance around transformer for ventilation.
- .3 Install transformers in level upright position.
- .4 Remove shipping supports only after transformer is installed and just before putting into service.

3.4 **CONNECTIONS**

- .1 Make primary and secondary connections shown on the drawings with liquid-tight flexible metal conduits.
- .2 Make bonding and grounding connections.
- .3 Energize transformers immediately after installation is completed, where practicable.

3.5 **EQUIPMENT IDENTIFICATION**

- .1 Size 7 label in accordance with Section 26 05 00 - Common Work Results for Electrical.

- .2 Typical label shall read: "Transformer T-II1- 75 kVA fed from DPA - 600 volt to 600/347 volt, 3-phase, 4-wire".

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.

1.2 RELATED SECTIONS

- .1 Section 26 05 01: Common Work Results for Electrical.

1.3 REFERENCES

- .1 Conform to latest issues, amendments and supplements of following standards:
 - .1 CSA C22.2 No. 5.1M - Moulded Case Circuit Breakers

PART - 2 PRODUCTS

2.1 PANELBOARDS - CIRCUIT BREAKER TYPE

- .1 Panelboards to be product of 1 manufacturer.
- .2 Enclosures: Steel, EEMAC 1, sprinklerproof.
- .3 Bus: Copper, half capacity ground bar and full (200%) capacity neutral bar, braced for interrupting capacity as indicated.
- .4 Circuit Breakers: Bolt-on, quick-make, quick-break, thermal and magnetic trips, trip indicating, trip free handle. Common operating handle on multipole breaker.
- .5 Integral transient voltage surge suppressor, where indicated, with features as follows:
 - .1 Connection to panelboard bus via circuit breaker.
 - .2 Hybrid filter consisting of metal oxide varistors and a parallel filter circuit.
 - .3 High energy transient voltage suppression, surge current diversion and high frequency attenuation of wave shapes in Category B environment as defined in ANSI/IEEE C62.41.
 - .4 Surge current rating, based on 8 x 20µs wave shape, as follows:
 - .1 Per mode: 60 kA minimum
 - .2 Per phase: 120 kA minimum
 - .5 Filter noise attenuation: 50 dB minimum, normal mode, at 100 kHz.
 - .6 Normal protection modes: line to line (and line to neutral for 4 wire system). Common protection modes: line to ground (and neutral to ground for 4 wire system)
 - .7 Fusing for each protection mode.
 - .8 Status LED indication of each phase.
 - .9 UL1449 and UL1283 listed, CSA or CUL approved.
- .6 Door: Hinged lockable door.

- .7 Keys: 2 keys per panelboard; key panelboards alike.
- .8 In addition to CSA requirements, manufacturer's nameplate to indicate panel withstand fault current.
- .9 Lock-on Devices: For circuits supplying continuously operating equipment. Minimum quantity 10% of 15A, 20A and 30A rated breakers.
- .10 Spaces: Fully bussed for future breakers with removable filler plates.
- .11 Breaker Arrangement: Locate breakers at specific circuit number locations shown on panelboard schedule sheet.
- .12 Acceptable Manufacturers
 - .1 Schneider, FPL or Square D
 - .2 Cutler-Hammer
 - .3 GE Canada
 - .4 Siemens, I-T-E

PART - 3 EXECUTION

3.1 GENERAL

- .1 Protect equipment from dust, debris, moisture, and physical damage, with sealed envelope of plastic or other impervious material until building is enclosed and cleaned and equipment is energized.
- .2 Protect from condensation by maintaining at suitable temperature above 0°C.
- .3 Finish equipment enclosures to ANSI 49 or ANSI 61, baked grey enamel.

3.2 PANELBOARDS

- .1 Locate panelboards, secure, plumb true and square to structure.
- .2 Mounting Methods
 - .1 Exterior walls and interior combustible walls: mount on continuous slotted channel strut with 75 mm clear between back of panel and wall. Where practical, group panelboards on common frame.
 - .2 Interior non-combustible walls: mount against wall.
- .3 Where panelboards are flush mounted, provide 3 – 25 mm empty conduits from each panelboard into ceiling space above.
- .4 Identify load circuits on panel directory complete with name and location.
- .5 Where panelboards are equipped with fused switches, install fuses immediately prior to energization. Record fuse rating on breaker or switch cover.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section.

1.2 RELATED SECTIONS

- .1 Section 26 05 01: Common Work Results for Electrical.
- .2 Section 26 05 54: Electrical Identification for Electrical Systems.

1.3 REFERENCES

- .1 Conform to latest issues, amendments and supplements of following standards:
 - .1 CSA C22.2 No. 4-M Enclosed Switches
 - .2 CSA C22.2 No. 39 Fuseholder Assemblies
 - .3 CSA C22.2 No. 106-M HRC Fuses

PART - 2 PRODUCTS

2.1 FUSIBLE AND NON FUSIBLE DISCONNECT SWITCHES

- .1 Enclosure: Steel, EEMAC 1 (4) (12).
- .2 Switches: Quick-make, quick-break, heavy duty, short circuit rating 100,000A rms sym. Provision for locking in off position with up to 3 padlocks.
- .3 Viewing Window: For viewing blades.
- .4 Electrical Interlock: Mechanically operated from switch mechanism, rated 120 VAC, 15A, 1 NO and 1 NC contact.
- .5 Acceptable Manufacturers:
 - .1 Schneider, Square D
 - .2 Cutler-Hammer
 - .3 GE Canada
 - .4 Siemens, I-T-E

2.2 FUSES

- .1 HRC fuses to CSA C22.2 No. 106-M.
- .2 Time delay fuses as follows:
 - .1 Fuses up to 600V, up to 600A HRCI-J, Form I: Class J Bussman JHC, Gould Shawmut AJT.
 - .2 Fuses above 600A HRC-L, Form I: Class L Bussman KLU, Gould Shawmut A4BT.

- .3 Time delay fuses as follows:
 - .1 Fuses 250V, up to 600A HRCI-R, Form I: Class R Bussman FRN-R250 volt, Gould Shawmut TRNR.
 - .2 Fuses 600V, up to 600A HRCI-R, Form I: Class R Bussman FRS-R600 volt, Gould Shawmut TRSR.
 - .3 Fuses above 600A HRCI-R, Form I: Class L Bussman KRP-C Hicap 600 volt.
- .4 Provide spare fuses of each type and size in use as follows:
 - .1 600A and below: 6
 - .2 Above 600A: 3
- .5 Submit a list of spare fuses to Consultant for approval.

PART - 3 EXECUTION

3.1 GENERAL

- .1 Protect equipment from dust, debris, moisture, and physical damage, with sealed envelope of plastic or other impervious material until building is enclosed and cleaned and equipment is energized.
- .2 Protect from condensation by maintaining at suitable temperature above 0°C.
- .3 Finish equipment enclosures to ANSI 49 or ANSI 61, baked grey enamel.

3.2 DISCONNECT SWITCHES

- .1 Install local to equipment on adjacent wall, column, or other suitable mounting surface. Where necessary provide free standing rigid continuous slotted channel strut frame.
- .2 Where mounted on masonry walls, allow minimum of 6 mm clear space between enclosure and masonry wall.

3.3 FUSES

- .1 Store fuses in a moisture free location until ready to energize.
- .2 Install fuses immediately prior to energization.
- .3 Prior to acceptance of the Work, clearly mark manufacturer's labels on inside cover of each fusible unit, with ampere rating and catalogue symbol of replacement fuses to be used.

END OF SECTION

PART - 1 GENERAL

1.1 SUMMARY

- .1 Section includes:
 - .1 Labour, products, equipment and services necessary to complete the work of this Section including, but not limited to, the following:
 - .1 Lighting equipment as per the luminaire schedule and as specified herein.
- .2 Refer to Architectural reflected ceiling plans for exact location of luminaires.
- .3 Check latest ceiling finish schedule in areas where recessed luminaires are specified to ensure that luminaires have suitable ceiling trim for particular ceiling finish.

1.2 SUBMITTALS

- .1 Submit the following Product Data:
 - .1 Provide manufacturer's printed product literature, specifications and datasheet and include all product characteristics, performance criteria, BUG ratings, physical size, finish and limitations.
 - .2 Provide complete photometric test data prepared by independent testing laboratory in accordance with IESNA test procedures for all luminaires for approval by Consultant.
 - .3 Provide complete "useful lifetime" TM-21 report data, including L70/L80/L90 (as applicable) ratings for all luminaires for approval by Consultant.
 - .4 Provide photometric calculations for all interior lighting as required per plans.
- .2 Each luminaire catalogue cut sheet to be provided with individually tagged luminaire number and all selected options to be highlighted.
- .3 Submit samples as directed by Consultant for luminaires as indicated on plans.
- .4 Submit battery sizing calculations for unit equipment.

1.3 REFERENCES

- .1 Canadian Standards Association (CSA):
 - .1 C22.2 NO. 9.0-96 (R2016), General Requirements for Luminaires.
 - .2 CSA C22.2 No. 34-M1987 (R2013), Electrode Receptacles, Fittings, and Connectors for Gas Tubes.
 - .3 C22.2 NO. 43-08 (R2013), Lampholders (Bi-national standard, with UL 496).
 - .4 CSA C22.2 No. 66-1988 (R2001), Specialty Transformers.
 - .5 CSA C22.2 NO. 74-16, Equipment for use with electric discharge lamps.
 - .6 C22.2 NO. 141-15, Emergency lighting equipment
 - .7 CAN/CSA-C866-17, Performance of LED Luminaires.
- .2 IEEE (Institute of Electrical and Electronics Engineers)
 - .1 ANSI/IEEE C62.41, IEEE Recommended Practice on Surge Voltages in Low Voltage AC Power Circuits.

1.4 **CODES AND STANDARDS**

- .1 All wiring to be in accordance with the Ontario Electrical Safety Code.
- .2 Luminaires and all associated components, including but not limited to remote drivers, quick connects, control devices, etc. must be CSA certified or field evaluated and approved by ESAFE (ESA Field Evaluation) at the expense of this contractor. NOTE: where luminaires utilize remote components, each individual component must be CSA certified complete with CSA mark or label, in addition to the complete luminaire assembly/system's CSA certification.

PART - 2 PRODUCTS

2.1 **LUMINAIRES**

- .1 General
 - .1 Furnish luminaires in accordance with CSA C22.2 No. 9.
 - .2 Furnish medium screw base lampholders of nickel or brass in accordance with CSA C22.2 No. 43.
 - .3 Furnish mogul screw base lampholders of porcelain and nickel in accordance with CSA C22.2 No. 43.
 - .4 Furnish lamp bases for gas tube lamps in accordance with CSA C22.2 No. 34.
 - .5 Luminaire finishes shall resist chipping, crazing, discolouration.
 - .6 Luminaires to contain no asbestos.
 - .7 Furnish luminaires with flanges and gaskets to eliminate light leaks.
- .2 Exit Light Luminaires
 - .1 Cast aluminum housing, stencil face, knock-out directional arrows.
 - .2 Green Running Man pictogram.
 - .3 Universal ceiling, end-to-wall, surface back-to-wall mounting or recessed mounting if indicated.
 - .4 Connection for emergency source as indicated.
 - .5 LED type with diffusing lens.

2.2 **LED LUMINAIRES**

- .1 LED drivers shall be electronic-type, labelled as compliant with radio frequency interference (RFI) requirements of FCC Title 47 Part 15.
 - .1 NEMA SSL 1 "Electronic Drivers for LED Devices, Arrays, or Systems".
 - .2 LED drivers shall have a sound rating of "A", have a minimum efficiency of 85%, and be rated for a THD of less than 20 percent at all input voltages.
- .2 Dimmable LED drivers shall be 0-10V type. Dimmable LED drivers shall be capable of dimming without LED strobing or flicker from 100%-1% of rated light output, unless noted otherwise.
- .3 Luminaires must be tested in accordance with IESNA LM-63 by an independent LM-63 accredited laboratory. LM-63 test data in the form of IES-format electronic files must be available for all luminaires. Software generated/calculated IES files will **not** be accepted.

- .4 LED fixtures are to be provided by manufacturers with a minimum (8) years' experience and provide minimum (5) years warranty on all electrical parts.
- .5 All LED sources to be tested in accordance with IESNA LM-80. Test data must be available for all luminaires.
- .6 LED lighting systems with unmatched drivers and power supplies will not be considered.
- .7 Driver mA rating should be indicated when reporting initial delivered lumens of a specified fixture. Unless otherwise stated, no driver current shall exceed 750 mA.
- .8 Maximum Efficacy (lm/W) of luminaires must be greater than 60 lm/W for downlights (pot lights) and greater than 90 lm/W for linear/volumetric luminaires, unless noted otherwise.
- .9 'Useful Lifetime' projections for luminaire's to be calculated in accordance with IESNA TM-21-11. Unless otherwise noted, all luminaires to have minimum useful lifetimes to 70% of their original output (L70 ratings) of 50,000 hours.
- .10 Luminaires shall have a CRI ≥ 80 , source LEDs shall be binned per ANSI within a 3-step MacAdam Ellipse.
- .11 Correlated Colour Temperature of 3,500. Colour changing LED luminaires shall provide full spectrum colour changing capability through the use of red, blue, green and white LED's.
- .12 Lumen values stated for luminaires in contract documentation or plans are stated as delivered lumens.

2.3 **EMERGENCY BATTERY UNITS**

- .1 Supply voltage 347 V dc.
- .2 Output voltage 24 V dc.
- .3 Batteries: sealed lead acid calcium alloy grid type sized to operate the lamp load to 91% of initial voltage for 30 minutes.
- .4 Battery charger: solid state, multi-rate, voltage/current regulated, sized to restore battery to full charge in 12 hours.
- .5 Low voltage disconnect: solid state, modular, operates at 80% battery voltage.
- .6 EEMAC 1 code gauge steel housing.
- .7 Auxiliary equipment:
 - .1 "AC Power ON"
 - .2 "Fast charge" pilot light
 - .3 Voltmeter
 - .4 Test switch
 - .5 5 minute time delay relay
 - .6 Cord and plug
- .8 Lamp heads: mounted as indicated, 360° horizontal and 180° vertical adjustment, LED lamps.

PART - 3 EXECUTION

3.1 INSTALLATION - GENERAL

- .1 Provide supports for luminaires. Support single units from luminaire studs in outlet boxes. For continuous row fluorescent type, provide support for each end plus at least one for each channel section, or additional as required. Swivel mount stems. Provide concrete inserts at points of luminaire support in unfinished areas where a concrete slab serves as ceiling. Provide support from concrete floor and roof steel above ceiling as applicable.
- .2 Align luminaires in rows, maintain required heights, and install luminaires clear of other work.
- .3 Clean and relamp existing luminaires being removed and installed in new locations.
- .4 Keep luminaires covered and protected from construction dust and debris until building is broom clean and free of suspended dust clouds.
- .5 Do not lamp luminaires until ready for testing and use. Obtain Owner's approval before lamping. Install lamps in lampholders.
- .6 When installation is complete, demonstrate operation to satisfaction of Owner.
- .7 Standard octagonal boxes may be supplied where conduits feeding luminaires in finished areas are exposed on ceiling if hanger canopies entirely cover outlet boxes and are neatly notched for conduit. Otherwise, provide cast conduit outlet boxes with a diameter larger than canopies.
- .8 Attach boxes or hickies directly to poured concrete with 6 mm minimum diameter bolts and lead expansion anchors where luminaires are suspended directly from concrete slabs. Use 8 mm minimum bolts through precast slabs, welded to 100 mm x 100 mm minimum, 3.5 mm plate above slabs.
- .9 Do not mount luminaires above pipes, ducts or equipment. In event of unavoidable tight locations, provide hangers to clear obstructions. Check layouts of other trades on job and plan cooperatively. Luminaires in any room shall hang at one height. Obtain approval before any changes are made to layouts shown.
- .10 Provide continuous 12 mm x 38 mm channel above ceiling, where luminaires are suspended or mounted on furred ceilings. Fasten luminaires to channel with two 6 mm minimum diameter studs with minimum 1220 mm on centre.
- .11 Where two 4'-0" surface or suspended fluorescent luminaires occur in tandem, an 8'-0" body may be used. Where two single lamp luminaires occur in tandem, a common lamp ballast may be used.
- .12 Verify catalogue number of luminaires with description prior to ordering, and check for final ceiling finish in areas where recessed luminaires are called for in order to provide ceiling trim, flanges and mounting brackets to suit particular construction used where luminaires are installed.
- .13 Support luminaires in an approved manner to comply with the Ontario Electrical Safety Code and the Ontario Building Code.
- .14 Provide steel luminaire studs, brackets and hangers. Where luminaires are hung on chain hangers, provide chain of closed link type capable of supporting ten times luminaire weight. Use U-bolts for chain ends; S-hooks are not acceptable.

3.2 **INSTALLATION – LED**

- .1 Verify LED drivers are compatible with selected dimming system where applicable.
- .2 Locate and install remote drivers in concealed location. Provide access hatch when installed above hard ceilings.

3.3 **INSTALLATION - EMERGENCY AND EXIT LIGHTS**

- .1 Exit sign installation shall meet all requirements of the authorities having jurisdiction.
- .2 Install exit signs flush on suspended acoustic tile and drywall ceilings.
- .3 Install exit sign with housing on wall mounted applications.
- .4 For applications where there is no suspend ceiling exit signs to be supported from slab. Provide stems of sufficient length such that top of exit sign is 25 mm lower than bottom of general luminaires in the space.
- .5 Where double arrows are shown, install 2 running man exit signs.
- .6 Install emergency battery units where shown. Support on brackets supplied by manufacturer.
- .7 Aim emergency heads to properly illuminate exit path.
- .8 Connect exit signs to emergency battery units.

3.4 **INSTALLATION - CEILINGS**

- .1 Suspend luminaires mounted from or in a suspended T-bar ceiling directly from building structure, independent of the T-bar system, to ULC, Local Fire Marshal's Office, Ontario Building Code, Electrical Safety Authority (ESA) and Consultant's approval.
- .2 Provide additional safety chain secured to luminaire in 2 locations such that luminaire cannot swing below ceiling in the event of support failure.
- .3 In non-accessible ceilings wire with not more than 1200 mm of AC90 or RW90 XLPE wire in flexible conduit to adjacent outlet boxes placed above finished ceiling within reach of the luminaire openings.
- .4 In accessible ceilings wire with not more than 1800 mm of AC90 or RW90 XLPE wire in flexible conduit to adjacent outlet boxes, locations as shown on the Drawings.
- .5 Provide suitable trim for all luminaires installed in drywall ceilings or within lay-in or snap-in tiles.

3.5 **FIELD QUALITY CONTROL**

- .1 Perform a visual inspection to verify cleanliness and alignment of the fixtures. Misalignment and light leaks shall be corrected, and rattles due to ventilation system vibration shall be eliminated.
- .2 Perform an operational test to verify that all fixtures illuminate properly, dimming systems dim properly (i.e. no flicker), and lighting zones are switched according to the drawings.
- .3 Record at night normal light levels achieved with all luminaires at full brightness. Readings to be taken at workplane height in the centre of each room and at 5 metre intervals in larger rooms and corridors.

- .4 Record at night emergency light levels achieved with luminaires connected to life safety systems at full brightness. Readings to be taken at tread level along all exit paths at 3 metre intervals.
- .5 Assist with commissioning activities once field quality control is complete and documented.

END OF SECTION