

PROJECT: OUR LADY OF VICTORY
CATHOLIC ELEMENTARY SCHOOL
ADDITION & RENOVATION

CLIENT: HALTON CATHOLIC DISTRICT SCHOOL BOARD

PROJECT No.: 25106

DATE: MAY 2026

BINDER: **B** MECHANICAL & ELECTRICAL



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- 21-05-19 Pressure Gauges
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Facility Sanitary Sewerage

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23 34 23	Packaged Exhausters
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23 36 16	Variable-Air Volume Units
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Building Automation System

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25 20 04 Controllers

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END OF SECTION

Part 1 General

1.1 GENERAL PROVISIONS

- .1 Conform to Division 1 General Conditions and to all sections of Mechanical Division.
- .2 Furnish labour, materials, and equipment necessary for completion of work as described in contract documents.
- .3 Unless specifically indicated, all materials and equipment provided under this contract shall be new and shall be manufactured in the project year.
- .4 The term "Mechanical Contractor" shall remain active and shall mean a "single contractor" performing plumbing, drainage, heating, cooling, ventilation, and control services.
- .5 When quoting as a subcontractor this contractor shall explicitly state the services, they are providing i.e. Mechanical (all services), Plumbing (water and drainage systems) or HVAC (including hydronic and air systems).
- .6 Contractors shall be explicit to identify whether Fire Protection is included or omitted from the mechanical scope.

1.2 INTENT

- .1 Mention herein or indication on Drawings of articles, materials, operations or methods requires: supply of each item mentioned or indicated, of quality, or subject to qualifications noted; installation according to conditions stated: and, performance of each operation prescribed with furnishing of necessary labour, equipment, and incidentals for fire protection work.
- .2 Where used, words "Section" and "Division" shall also include other Subcontractors engaged on site to perform work to make building and site complete in all respects.
- .3 Where used, word "supply" shall mean furnishing to site in location required or directed complete with accessory parts.
- .4 Where used, word "install" shall mean secured in place and connected up for operation as noted or directed.
- .5 Where used, word "provide" shall mean supply and install as each is described above.

1.3 REGULATIONS, PERMITS, AND FEES

- .1 All materials and quality of work shall meet all current and latest Provincial, Municipal and Fire Marshall requirements, regulations, codes, and by-laws in force in the area of the project.
- .2 Each contractor shall give all necessary notices, obtain all necessary permits, and pay all fees in order that the work shown or specified may be carried out. Each contractor shall furnish any certificates necessary as evidence that the work installed conforms with the laws and regulations of all authorities having jurisdiction.
- .3 In the event that changes, or alterations are required on completed work by authorized inspectors, these changes shall be made at the contractor's expense.

- .4 Special equipment which does not have a standard CSA label shall be inspected by the local electrical authority having jurisdiction and the Approval Certificate shall be submitted to the Consultant as soon as possible. All costs and fees for inspections shall be borne by this contractor.

1.4 DRAWINGS

- .1 The drawings and this specification have been assembled together as a responsibility of the consultant. The same is true for the other consultants, i.e. architect, structural engineer, civil engineer, fire protection engineer, electrical engineer, etc.
- .2 The drawings and specifications are not assembled together for responsibility/division between subcontractors. The division of work between subcontractors remains the responsibility of the buildings' contractor (also known as the prime contractor or general contractor).
- .3 All subcontractors are encouraged to perform work amicably utilizing all of the drawings and specifications published by all of the consultants.
- .4 Fire protection drawings do not show architectural, structural, plumbing, mechanical and related details. Take information involving accurate measurement of building from building drawings, or at building. Make, without additional charge, any necessary changes, or additions to runs of piping, conduits, and ducts to accommodate structural conditions. Location of pipes and other equipment may be altered by Consultant without extra charge provided change is made before installation and does not necessitate major additional material.
- .5 As work progresses and before installing piping and any other fittings and equipment which may interfere with interior treatment and use of building, provide detail drawings, or obtain directions for exact location of such equipment and fitment's.
- .6 Install piping clear structural members and any fireproofing. Locate work to permit installation of specified insulation. Do not remove or damage structural fireproofing. Leave space to permit fireproofing and insulation to be inspected and repaired.
- .7 Before commencing work, check and verify all sizes, locations, grade and invert elevations, levels, and dimensions to ensure proper and correct installation.
- .8 Locate all fire protection piping and equipment in such a manner as to facilitate easy and safe access to and maintenance and replacement of any part.
- .9 In every place where there is indicated space reserved for future or other equipment, leave such space clear, and install piping and other work so that necessary installation and connections can be made for any such apparatus. Obtain instructions whenever necessary for this purpose.
- .10 Relocate equipment and/or material installed but not coordinated with work of other Sections and/or installed incorrectly as directed, without extra charge.
- .11 Where drawings are done in metric and product not available in metric, the corresponding imperial trade size shall be utilized.

1.5 INTERFERENCE AND COORDINATION DRAWINGS

- .1 Prepare interference and equipment placing drawings to ensure that all components will be properly accommodated within the constructed spaces provided.
- .2 Prepare drawings to indicate co-ordination and methods of installation of a system with other systems where their relationship is critical. Ensure that all details of equipment apparatus, and connections are coordinated.
- .3 Ensure that clearances required by jurisdictional authorities and clearances for proper maintenance are indicated on drawings.
- .4 Upon consultant's request submit copies of interference drawings to consultant.
- .5 Due to the nature of the building and the complexity of the building systems provide the following:
 - .1 Interference drawings, showing coordination of architectural, structural, plumbing, mechanical, and electrical systems for the consultant's review prior to fabrication.
 - .2 Detailed layout drawings, clearly showing fasteners and hangers.
- .6 Provide CAD drawings (minimum file version AutoCAD 2013) in addition to hard copies.

1.6 QUALITY ASSURANCE

- .1 Perform work in accordance with applicable provisions of local Code and NFPA requirements. Ordinances, and adoptions thereof for all fire protection systems. Provide materials and labor necessary to comply with rules, regulations, and ordinances.
- .2 In case of differences between building codes, provincial laws, local ordinances, utility company regulations, and Contract Documents, the most stringent shall govern. Promptly notify Consultant in writing of such differences.

1.7 EXAMINATION

- .1 Site Reviews
 - .1 Examine premises to understand conditions which may affect performance of work of this Division before submitting proposals for this work.
 - .2 No subsequent allowance for time or money will be considered for any consequence related to failure to examine site conditions.
- .2 Ensure that items to be furnished fit space available. Make necessary field measurements to ascertain space requirements including those for connections and furnish and install equipment of size and shape so final installation shall suit true intent and meaning of Contract Documents. If approval is received by Addendum or Change Order to use other than originally specified items, be responsible for specified capacities and for ensuring that items to be furnished will fit space available.

1.8 SEQUENCING, SCHEDULING, AND COORDINATION

- .1 It is understood that while Drawings are to be followed as closely as circumstances permit, this Division will be held responsible for installation of systems according to the true intent and meaning of Contract Documents. Anything not clear or in conflict will be explained by making application to Consultant. Should conditions arise where certain changes would be advisable, secure Consultant's approval of these changes before proceeding with work.
- .2 Coordinate work of various trades in installing interrelated work. Before installation of fire protection items, make proper provision to avoid interferences in a manner approved by Consultant. Each Contractor shall refer to all sections of the specification for their responsibilities with other trades. Changes required in work specified in Fire Protection Division caused by neglect to do so shall be made at no cost to Owner.
- .3 Arrange pipes, ducts, and equipment to permit ready access to valves, unions, traps, starters, motors, control components, and to clear openings of doors and access panels.
- .4 Furnish sleeves, inserts, supports, and equipment that are an integral part of other Divisions of the Work to Sections involved in sufficient time to be built into construction as the Work proceeds. Locate these items and see that they are properly installed. Expense resulting from improper location or installation of items above shall be borne by Fire Protection Division.
- .5 Be responsible for required cutting, and patching incident to work of this Division and make required repairs afterwards to satisfaction of Consultant. Cut carefully to minimize necessity for repairs to existing work. Do not cut beams, columns, or trusses.
 - .1 Patch and repair walls, floors, ceilings, and roofs with materials of same quality and appearance as adjacent surfaces unless otherwise shown. Surface finishes shall exactly match existing finishes of same materials.
 - .2 Each Section of this Division shall bear expense of cutting, patching, repairing, and replacing of work of other Sections required because of its fault, error, tardiness, or because of damage done by it.
- .6 Adjust locations of pipes, equipment, fixtures, etc., to accommodate work from interferences anticipated and encountered. Determine exact route and location of each pipe prior to fabrication.
 - .1 Make offsets, transitions, and changes in direction of pipes as required to maintain proper head room and pitch of sloping lines whether or not indicated on Drawings.
- .7 Slots and openings through floors, walls, and ceilings shall be provided by this contractor but performed by a trade specializing in this type of work. This Division shall see that they are properly located and do any cutting and patching caused by its neglect to do so.

1.9 REQUEST FOR INFORMATION (RFI) PROCEDURES

- .1 RFIs shall be submitted to the consultant a minimum of two (2) weeks prior to answer being required. Failure to submit an RFI in a timely manner will forfeit delay claims and schedule extension requests by the contractor.

- .2 All RFIs will be submitted with the following information:
 - .1 RFI number
 - .2 Name of project
 - .3 Date of initiation
 - .4 Date response required by (minimum two (2) weeks)
 - .5 Subject
 - .6 Submitter's name
 - .7 Drawing/specification reference
 - .8 Photograph of the issue (if applicable)
 - .9 Description of the issue
 - .10 Contractor's proposed resolution

1.10 SHOP DRAWINGS AND PRODUCT DATA

- .1 Furnish complete catalog data for manufactured items of equipment to be used in the Work to Consultant for review within 14 days after award of Contract.
- .2 Upon receipt of reviewed shop drawing, product is to be ordered immediately.
- .3 Provide a complete list of shop drawings to be submitted prior to first submission.
- .4 Before submitting to the Consultant, review all shop drawings to verify that the products illustrated therein conform to the Contract Documents. By this review, the Contractor agrees that it has determined and verified all field dimensions, field construction criteria, materials, catalogue numbers, and similar data and that it has checked and coordinated each shop drawing with the requirements of the work and of the Contract Documents. The Contractor's review of each shop drawings shall be indicated by stamp, date and signature of a qualified and responsible person possessing by the appropriate authorization.
- .5 If material or equipment is not as specified or submittal is not complete, it will be rejected by Consultant.
- .6 Additional shop drawings required by the contractor for maintenance manuals, site copies etc., shall be photocopies of the "reviewed" shop drawings. All costs to provide additional copies of shop drawings shall be borne by the contractor.
- .7 Catalog data or shop drawings for equipment, which are noted as being reviewed by Consultant or their Engineer shall not supersede Contract Documents.
- .8 Review comments of Consultant shall not relieve this Division from responsibility for deviations from Contract Documents unless Consultant's attention has been called to such deviations in writing at time of submission, nor shall they relieve this Division from responsibility for errors in items submitted.
- .9 Check work described by catalog data with Contract Documents for deviations and errors.

- .10 Shop drawings and product data shall show:
 - .1 Mounting arrangements.
 - .2 Operating and maintenance clearances. e.g., access door swing spaces.
- .11 Shop drawings and product data shall be accompanied by:
 - .1 Detailed drawings of bases, supports, and anchor bolts.
 - .2 Manufacturer to certify as to current model production.
 - .3 Certification of compliance to applicable codes.
- .12 Shop drawings shall be submitted electronically as per the following directions:
 - .1 Electronic Submissions:
 - .1 Electronically submitted shop drawings shall be prepared as follows:
 - .1 Use latest software to generate PDF files of submission sheets.
 - .2 Scanned legible PDF sheets are acceptable. Image files are not acceptable.
 - .3 PDF format shall be of sufficient resolution to clearly show the finest detail.
 - .4 PDF page size shall be standardized for printing to letter size (8.5"x11"), portrait with no additional formatting required by the consultant. Submissions requiring larger detail sheets shall not exceed 11"x17".
 - .5 Submissions shall contain multiple files according to section names as they appear in Specification.
 - .6 File names shall include consultant project number and description of shop drawing section submitted.
 - .7 Each submission shall contain an index sheet listing the products submitted, indexed in the same order as they appear in the Specification. Include associated PDF file name for each section.
 - .8 On the shop drawing use an "electronic mark" to indicate what is being provided.
 - .9 Each file shall bear an electronic representation of the "company stamp" of the contractor. If not stamped the file submission will not be reviewed.
 - .2 Email submissions shall include subject line to clearly identify the consultants project number and the description of the shop drawings submitted.
 - .3 Electronic attachments via email shall not exceed 10MB. For submissions larger than 10MB, multiple email messages shall be used. Denote related email messages by indicating "1 of 2" and "2 of 2" in email subject line for the case of two messages.
 - .4 Electronic attachments via web links (URL) shall directly reference PDF files. Provide necessary access credentials within link or as username/password clearly identified within body of email message.

- .5 On site, provide one (1) copy of the "reviewed" shop drawings in a binder as noted above.
- .6 Contractor to print copies of "reviewed" shop drawings and compile into maintenance manuals in accordance with requirements detailed in this section.

1.11 EQUIPMENT NAMEPLATE DATA

- .1 Between the manufactures design published literature, the shop drawing submission literature, and the nameplate data on the equipment, they can all read differently.
- .2 Most of the confusion and differences are coming out of the electrical power installation.
- .3 The contractors installing and connecting the equipment are responsible for the coordination of this data through the construction period.
- .4 The contractors shall share and/or request this information through out the project and monitor/make adjustments, provide recommendations accordingly based on any discrepancies.
- .5 The contractors are responsible for any cost associated with the changing data.
- .6 The final installation must meet the "Nameplate Data" on the equipment on site.

1.12 OPERATION AND MAINTENANCE MANUAL

- .1 Provide operation and maintenance data for incorporation into manual as in submittals' requirements.
- .2 Operation and maintenance manual to be approved by, and final copies deposited with, Consultant before final inspection.
- .3 Submit one (1) copy of Operation and Maintenance Manual to Consultant for review and approval. Submission of individual data will not be accepted unless directed by Consultant. Submission can be done electronically in PDF format or as a hard copy.
 - .1 Electronic submission/pdf file is required to be bookmarked. Any submission received without bookmarking will be immediately returned as unacceptable.
 - .2 Hard copy submission shall be in a three-ring binder (minimum 50 mm (2") ring) and labelled as 'Operation and Maintenance Manual' with project name and location. Dividers are to be used for binder organization.
- .4 Make changes as required and re-submit as directed by Consultant.

1.13 AS-BUILT DRAWINGS

- .1 Site records:
 - .1 Contractor shall provide two (2) sets of reproducible fire protection drawings. Provide sets of white prints as required for each phase of the work. Mark thereon all changes as work progresses and as changes occur. This shall include changes to existing fire protection systems, control systems, and low voltage control wiring.
 - .2 On a weekly basis, transfer information to reproducibles, revising reproducibles to show all work as actually installed.

- .3 Use different colour waterproof ink for each service.
- .4 Make available for reference purposes and inspection at all times.

1.14 WARRANTIES

- .1 In addition to guarantee specified in General Conditions, guarantee fire protection systems to be free from defects that may develop from failure to construct system in accordance with Contract Documents.
- .2 Provide certificates of warranty for each piece of equipment made out in favor of Owner. Clearly record "start-up" date of each piece of equipment on certificate. Include certificates as part of Operation and Maintenance Manual.
- .3 Warranty period shall start from date of ready for takeover. Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .3 Warranty Duration:
 - .1 One (1) year warranty period applies unless otherwise noted.
- .4 Warranty Coverage:
 - .1 Applies to parts and labour.

1.15 READY FOR TAKEOVER

- .1 Complete the following to the satisfaction of the consultant prior to request for ready for takeover:
 - .1 As-built Drawings
 - .2 Maintenance Manuals
 - .3 System Start up
 - .4 Instructions to Owners.

1.16 REVISION TO CONTRACT

- .1 Provide the following:
 - .1 Itemized list of material with associated costs.
 - .2 Labour rate and itemized list of labour for each item.
 - .3 Copy of manufacturers/supplier's invoice if requested.

1.17 DELIVERY, STORAGE, AND HANDLING

- .1 Follow Manufacturer's directions in delivery, storage, and protection, of equipment and materials. Contractor to include all costs associated with delivery storage and handling in tender price.
- .2 Deliver equipment and material to site and tightly cover and protect against dirt, water, chemical, and other environment damaging conditions but have readily accessible for inspection. Store items subject to moisture damage (such as controls) in dry, heated space.
- .3 Remove any damaged materials from site.

1.18 DESIGNATED SUBSTANCES AND HAZARDOUS MATERIALS

- .1 If designated substances and/or hazardous materials are suspected or identified cease all work in the immediate area in accordance with OHSA and notify Consultant.
- .2 Each Contractor and on site employee of the Contractor shall have "asbestos awareness training".
- .3 The Contractor shall ensure that employees who may come into contact with designated substances and/or hazardous materials due to the nature of the work that they perform, have received training that enables them to recognize designated substances and/or hazardous materials and that enables them to react in accordance with the Occupational Health and Safety Act and regulations thereto should contact with designated substances and/or hazardous materials occur during the course of their work.
- .4 It is the responsibility of the Contractor to review the designated substances and/or hazardous materials book in the building prior to starting any work.
- .5 Existing occupied buildings (depending upon their age) may contain designated substances and/or hazardous materials in thermal insulating materials and some manufactured products, such as vinyl asbestos floor tile. Any insulating materials on pipes, fittings, boilers, tanks, ductwork, etc. may contain designated substances and/or hazardous materials and shall not be disturbed.
- .6 A survey of each building documenting the location and condition of designated substances and/or hazardous containing materials is available for your mandatory review prior to commencing any work on premises.

1.19 PHASING OF WORK

- .1 This work for this project shall be constructed in phases. Refer to the architectural drawings for phasing information and details. Misinterpretation of the drawings with respect to the extent of the phasing of the work shall not relieve the Contractor of the work required to complete the entire contract.
- .2 Provide all necessary services or temporary services to suit phasing of construction with respect to all fire protection systems.
- .3 Life safety systems in the building are to remain fully operational in occupied areas for building staff and occupants during renovations.
- .4 Provide all necessary tests and certificates at completion of each phase to suit requirements of local authorities and Consultants for occupancy of completed areas.

1.20 CONFINED SPACES

- .1 Certain areas of the building may be defined as a "Confined Space". Any personnel working in these areas must have confined space training, appropriate equipment and undertake all work in conformance with appropriate codes and standards.
- .2 Refer to building documentation for any spaces deemed "Confined Space".

1.21 TESTS

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

- .2 Insulate or conceal work only after testing and approval by Consultant.
- .3 Conduct tests in presence of Consultant.
- .4 Bear costs including retesting and making good.
 - .1 Test fire systems in accordance with authorities having jurisdiction and as specified elsewhere.
- .5 Test fire systems in accordance with authorities having jurisdiction (AHJ) NFPA requirements and as specified elsewhere.
- .6 Equipment: test as specified in relevant sections.
- .7 Prior to tests, isolate all equipment or other parts which are not designed to withstand test pressures or test medium.

1.22 TRIAL USAGE

- .1 Consultant or owner may use equipment and systems for test purposes prior to acceptance. Supply labour, material, and instruments required for testing.
- .2 Trial usage to apply to all fire protection.

1.23 ELECTRICAL

- .1 Electrical work to conform to Electrical Division including the following:
 - .1 Power wiring and conduit is specified in Electrical Division except for conduit, wiring and connections below 50 V which are related to control systems. Follow Electrical Division for installation methods, quality of materials, and workmanship.
 - .2 Electrically operated equipment shall be C.S.A. approved label. Special Inspection Label of Provincial Authority having jurisdiction will be accepted in lieu of C.S.A. approval. Each motor shall have an approved starter. Starter will be supplied and installed by Electrical Division unless otherwise indicated.

1.24 PIPING AND EQUIPMENT SUPPORTS

- .1 Equipment supports supplied by equipment manufacturer shall follow the manufacturer's recommendation.
- .2 Piping and equipment supports not supplied by equipment manufacturer: fabricate from structural grade steel meeting requirements of - Structural Steel Section. Submit structural calculations with shop drawings.

1.25 SLEEVES

- .1 Pipe sleeves: at points where pipes pass through masonry, concrete or fire rated assemblies and as indicated. Grout sleeves in place.
- .2 Schedule 40 steel pipe.
- .3 Sleeves with annular fin continuously welded at midpoint:
 - .1 Through foundation walls.
 - .2 Where sleeve extends above finished floor.
 - .3 Through fire rated walls and floors.

- .4 Sizes: minimum 6 mm (1/4") clearance all around, between sleeve and uninsulated pipe or between sleeve and insulation.
- .5 Terminate sleeves flush with surface of concrete and masonry walls, concrete floors on grade and 25 mm (1") above other floors.
- .6 Fill voids around pipes:
 - .1 Caulk between sleeve and pipe in foundation walls and below grade floors with waterproof fire retardant non-hardening mastic.
 - .2 Where sleeves pass through walls or floors, provide space for firestopping. Where pipes/ducts pass through fire rated walls, floors and partitions, maintain fire rating integrity.
 - .3 Ensure no contact between copper tube or pipe and ferrous sleeve.
 - .4 Fill future-use sleeves with lime plaster or other easily removable filler.
 - .5 Coat exposed exterior surfaces of ferrous sleeves with heavy application of zinc rich paint to CGSB 1-GP-181M+Amdt-Mar-78.
- .7 Provide minimum 20 gauge duct sleeves where ducts pass through masonry concrete or fire rated assemblies. Maintain minimum 25 mm clearance all around or to the requirements of the authority having jurisdiction. Seal at wall as indicated.

1.26 FIRE STOPPING

- .1 This contractor shall work with all other contractors on the project in providing one common method of fire stopping all penetrations made in fire rated assemblies.
- .2 Approved fire stopping and smoke seal material in all fire separations and fire ratings within annular space between pipes, ducts, insulation and adjacent fire separation and/or fire rating.
- .3 Do not use cementitious or rigid seals around penetrations for pipe or other fire protection items piercing walls, floors, etc.
- .4 Insulated pipes and ducts: ensure integrity of insulation and vapour barrier at fire separation.
- .5 Provide materials and systems capable of maintaining effective barrier against flame, smoke and gases. Ensure continuity and integrity of fire separation.
- .6 Comply with the requirements of CAN4-S115-M35, and do not exceed opening sized for which they have been tested.
- .7 Systems to have an F or FT rating (as applicable) not less than the fire protection rating required for closures in a fire separation. Provide "fire wrap" blanket around services penetrating fire walls. Extent of blanket must correspond to ULC recommendations.
- .8 The fire stopping materials are not to shrink, slump or sag and to be free of asbestos, halogens and volatile solvents.
- .9 Firestopping materials are to consist of a component sealant applied with a conventional caulking gun and trowel.
- .10 Fire stop materials are to be capable of receiving finish materials in those areas which are exposed and scheduled to receive finishes. Exposed surfaces are to be acceptable to consultant prior to application of finish.

- .11 Firestopping shall be inspected and approved by local authority prior to concealment or enclosure.
- .12 Install material and components in accordance with ULC certification, manufacturers instructions and local authority.
- .13 Submit product literature and installation material on fire stopping in shop drawing and product data manual. Maintain copies of these on site for viewing by installers and consultant.
- .14 Manufacturer of product shall provide certification of installation. Submit letter to the consultant.
- .15 Acceptable alternate manufacturers to approval of local authority:
 - .1 Minnesota Mining and Manufacturing
 - .2 Fyresleeve Industries Inc.
 - .3 General Electric Pensil Firestop Systems
 - .4 International Protective Coatings Corp.
 - .5 Rectorseal Corporation (Metacaulk)
 - .6 Proset Systems
 - .7 3M
 - .8 AD Systems
 - .9 Hilti
- .16 Ensure firestop manufacturer representative performs onsite inspections and certifies installation. Submit inspection reports/certification at time of substantial completion.

1.27 ESCUTCHEONS

- .1 On pipes and ductwork passing through walls, partitions, floors and ceilings in exposed finished areas and on water and drain pipes inside millwork and cabinets.
- .2 Chrome or nickel plated brass or Type 302 stainless steel, one piece type with set screws.
- .3 Outside diameter to cover opening or sleeve.
- .4 Inside diameter to fit around finished pipe.

1.28 PAINTING

- .1 Refer to Section Interior Painting and specified elsewhere.
- .2 Apply at least one coat of corrosion resistant primer paint to ferrous supports and site fabricated work.
- .3 Apply two coats of paint to exposed piping service in mechanical room, electrical, and service rooms. Base colour shall be red.
- .4 Prime and touch up marred finished paintwork to match original.
- .5 Restore to new condition, or replace equipment at discretion of consultant, finishes which have been damaged too extensively to be merely primed and touched up.

1.29 ACCESS DOORS

- .1 Provide access doors to concealed fire protection equipment for operating, inspecting, adjusting and servicing.
- .2 Flush mounted 600 x 600 mm (24" x 24") for body entry and 300 x 300 mm (12" x 12") for hand entry unless otherwise noted. Doors to open 180°, have rounded safety corners, concealed hinges, screwdriver latches and anchor straps.
- .3 Material:
 - .1 Special areas such as tiled or marble surfaces: use stainless steel with brushed satin or polished finish as directed by Consultant.
 - .2 Remaining areas: use prime coated steel.
 - .3 Fire rated areas: provide ULC listed access doors.
 - .4 Washrooms or high moisture area ceilings: Aluminum with mill finish suitable for painting.
- .4 Installation:
 - .1 Locate so that concealed items are accessible.
 - .2 Locate so that hand or body entry (as applicable) is achieved.
- .5 Acceptable Manufacturers:
 - .1 Le Hage
 - .2 Zurn
 - .3 Acudor
 - .4 Nailor Industries Inc.

1.30 REPAIRS, CUTTING, AND RESTORATION

- .1 Patch and repair walls, floors, ceilings, and roofs with materials of same quality and appearance as adjacent surfaces unless otherwise shown. Surface finishes shall exactly match existing finishes of same materials.
- .2 Each Section of this Division shall bear expense of cutting, patching, and repairing to install their work and/or replacing of work of other Sections required because of its fault, error, tardiness, or because of damage done by it.
- .3 Cutting, patching, repairing, and replacing pavements, sidewalks, roads, and curbs to permit installation of work of this Division is responsibility of Section installing work.
- .4 All patching, painting and making good of the existing walls, floors, ceilings, partitions and roof will be at the expense of this Contractor, but performed by the Contractor specializing in the type of work involved unless otherwise noted.

1.31 EXISTING SYSTEMS

- .1 Connections into existing systems to be made at time approved by Consultant. Request written approval of time when connections can be made.
- .2 Be responsible for damage to existing plant by this work.

1.32 CLEANING

- .1 Clean interior and exterior of all systems including strainers. Vacuum interior of ductwork and air handling units prior to turn over to owner.
- .2 In preparation for final acceptance, clean and refurbish all equipment and leave in operating condition including replacement of all filters in all air and piping systems.

1.33 DISCONNECTION AND REMOVAL

- .1 Disconnect and/or remove equipment, piping, etc. as indicated.
- .2 Cap and conceal all redundant and obsolete connections.

1.34 INTEGRATED LIFE SAFETY SYSTEMS TESTING

- .1 Fire protection systems in this building, including but not limited to flow switches, valves, fire pumps, etc. will be subject to Integrated Life Safety Systems testing.
- .2 The Fire Protection Contractor shall co-ordinate with the Integrated Life Safety Systems Testing Agent as follows:
 - .1 Confirm which fire protection systems are to be included as part of the testing process.
 - .2 Verify in writing to the Integrated Life Safety Systems Testing Agent that fire protection commissioning of the affected systems/devices is complete prior to the scheduled testing date(s).
 - .3 Participate in the Integrated Life Safety Systems Testing to confirm proper operation of all associated systems.
 - .4 This Contractor shall work with the Integrated Life Safety Systems Testing Agent to reset all systems back to normal operating mode after the testing is complete.
- .3 Include all costs associated with Integrated Life Safety System Testing in the tender value.
- .4 Refer to Division 1/Division 26 Integrated Life Safety Systems Testing specifications for additional information/requirements.

1.35 IDENTIFICATION OF SYSTEMS

- .1 Identify contents by background colour marking, pictogram (as necessary), legend, direction of flow by arrows. To CAN/CGSB 24.3 except where specified otherwise.
- .2 Background colour marking and legends for piping systems:

CONTENTS	BACKGROUND COLOUR MARKING	
	LEGEND	
Fire protection water	Red	FIRE PROT. WTR
Sprinklers	Red	SPRINKLERS

1.36 FUNCTIONAL PERFORMANCE TESTS

- .1 This Contractor shall be responsible for the Functional Performance Tests. These tests ensure that all equipment and systems operate in accordance with design intent. Test the systems through all possible modes of operation.
- .2 The function performance test shall be:
 - .1 Test piping systems.
 - .2 Test all valves and flow switches.
 - .3 Test flow and record flow from end of inspector's test port.
 - .4 Test flow from all standpipe systems at the most remote and highest hose connection.
 - .5 Test flow thru all backflow preventors.
 - .6 Test flow thru all fire pumps.
 - .7 Other test that maybe a requirement of NFPA.
- .3 All test shall be recorded and presented to the Consultant and Owner.
- .4 Include all test results in the Operation and Maintenance Manuals.

END OF SECTION

Part 1 General

1.1 OCCUPANCY REQUIREMENTS

- .1 The contractor shall provide the following documentation to the consultant's satisfaction prior to receiving occupancy. Failure to provide the proper documentation will result in the occupancy not being granted. List of required documentation:

- .1 Final Certificates (required prior to consultant's release of conformance letter):
- .1 NFPA-13 Contractors Material and Test Certificate (sprinkler)
 - .2 NFPA-13 Fire Protection Bypass Flow Test
 - .3 Sprinkler Design Engineers' Letter
 - .4 System has been tested with the Integrated Testing Contractor.
 - .5 Engineer's seismic restraint letter.

Part 2 Not Used

Part 3 Not Used

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ANSI/ASME B40.100, Pressure Gauges and Gauge Attachments.

1.2 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with general requirements.
- .2 Submit manufacturer's product data for following items:
 - .1 Pressure gauges
 - .2 Stop cocks
 - .3 Siphons.

Part 2 Products

2.1 GENERAL

- .1 Design point to be at mid point of scale or range.
- .2 Ranges: suitable for application.

2.2 PRESSURE GAUGES

- .1 115 mm (4 1/2"), dial type: to ANSI/ASME B40.100, Grade 2A, stainless steel phosphor bronze bourdon tube having 0.5% accuracy full scale unless otherwise specified.
 - .1 Acceptable Manufacturers:
 - .1 Winters
 - .2 Trerice
 - .3 Wiess.
- .2 Provide:
 - .1 Snubber for pulsating operation.
 - .2 Gasketed pressure relief back with solid front.
 - .3 Bronze stop cock.

Part 3 Execution

3.1 GENERAL

- .1 Install so they can be easily read from floor or platform. If this cannot be accomplished, install remote reading units.
- .2 Install between equipment and first fitting or valve.

3.2 PRESSURE GAUGES

- .1 Install in following locations:
 - .1 Upstream and downstream of backflow preventors.
 - .2 In other locations as indicated.
- .2 Install gauge cocks for balancing purposes, elsewhere as indicated.

3.3 NAMEPLATES

- .1 Install engraved lamacoid nameplates as specified elsewhere identifying medium.

END OF SECTION

Part 1 General

1.1 APPLICATION

- .1 Seismic restraint is becoming more prominent with improved soil testing equipment. Seismic requirement is not site specific by geographical area but determined by site soil conditions.
- .2 Where the structural engineer or architect documents have $I_e \cdot S_a(0.2) \cdot F_a < 3.5$ seismic is not required on the fire protection, mechanical, electrical, or plumbing systems.
- .3 Where the structural engineer or architect documents have $I_e \cdot S_a(0.2) \cdot F_a \geq 3.5$ seismic is required on the fire protection, mechanical, electrical, or plumbing systems.
- .4 Seismic will always be required on fire protection systems when required by NFPA codes.
- .5 Seismic will always be required on any "Disaster Relief Building." For example, hospitals, police stations, ambulance building, etc.
- .6 When it is unclear in the tender documents request information from the structural engineer or architect for clarification.

1.2 SECTION INCLUDES

- .1 Seismic requirements for single rod hanger support for conduit, pipe and other similar systems.
- .2 Seismic requirements for trapeze type supports for cable tray, conduit, pipe and other similar systems.
- .3 Seismic requirements for all equipment and piping.

1.3 RELATED WORK SPECIFIED ELSEWHERE

- .1 Vibration Isolation Measures.

1.4 REFERENCE STANDARDS

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 National Building Code of Canada (NBC).
- .3 Canadian Standards Association.
 - .1 CSA S832, Seismic Risk Reduction of Operation and Functional Components (OFCs) of Buildings.
 - .2 CAN/CSA-S16.1 Limit States Design of Steel Structures.
 - .3 CAN3-S136 Design of Cold Steel Structural Members.
 - .4 CSA W47.1 Certification of Companies for Fusion Welding of Steel.
 - .5 CSA W59 Welded Steel Construction.
- .4 Canadian Institute of Steel Construction.
- .5 Canadian General Standards Board.

- .6 Underwriter Laboratories of Canada.
- .7 Workers Compensation Board of BC.
- .8 American Society of Testing and Materials.
 - .1 ASTM A653/S653M, Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (galvannealed) by the Hot Dip Process.
 - .2 ASTM A879M Specification for Steel Sheet, Zinc Coated by the Electrolytic Process for Applications Requiring Designation of the Coating Mass on Each Surface.
 - .3 ASTM A307 Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 - .4 ASTM A325M Specification for Structural Bolts, Heat Treated 830MPa Minimum Tensile Strength.
- .9 All local codes.
- .10 NFPA-13: Installation of Fire Sprinkler Systems.
- .11 FEMA: Federal Emergency Management Activity.
- .12 FEMA: Seismic Restraint Installation Manuals 412. 413. & 414.
 - .1 FEMA 412: Installing Seismic Restraints for Mechanical Equipment.
 - .2 FEMA 413: Installing Seismic Restraints for Electrical Equipment.
 - .3 FEMA 414: Installing Seismic Restraints for Duct and Pipe.

1.5 DEFINITIONS

- .1 A_v : Effective peak velocity related acceleration coefficient BOCA, SBC Code.
- .2 S_1 : Mapped Long Period Seismic Acceleration Coefficient IBC, TI-809-04, ASCE7.
- .3 S_s : Mapped Short Period Seismic Acceleration Coefficient IBC, TI-809-04, ASCE7.
- .4 v : Zonal Velocity Coefficient NBC-Canada.
- .5 VISCMA: The Vibration Isolation and Seismic Control Manufacturers Association has developed Testing and Rating Standards for Seismic Restraint Components that comply with Code and ASHRAE based requirements.
- .6 VISCMA 102-2007: Static Qualification Standards for Obtaining a VISCMA Compliant Seismic Component Rating.
- .7 Z : Seismic Zone defines Seismic Coefficient C_a used by UBC Code.

1.6 PERFORMANCE REQUIREMENTS

- .1 Design Ground Acceleration Coefficient (A_v , S_s , v , or Z depending on Code = X.XX).
- .2 (If IBC or TI-809-04) Design Long Period Ground Acceleration Coefficient (S_1 = X.XX).
- .3 Design Soil Type = (S_a , S_b , S_c , S_d) as appropriate. (If NBC Canada, the Foundation Factor).
- .4 Importance or Performance Factor appropriate to structure = I_p = X.XX.

- .5 If UBC Zone 4, Proximity to Fault and, if less than 10km, Fault Type.
- .6 Schedule or drawings indicating critical ($I_p = 1.5$) Duct/Piping systems, including systems whose importance factor may be increased by proximity to critical components.

1.7 DESCRIPTION OF SYSTEM

- .1 It shall be understood that the requirements of this seismic restraint section are in addition to other requirements as specified elsewhere for the support and attachment of equipment and fire protection services, and for the vibration isolation of same equipment. Nothing on the project drawings or specifications shall be interpreted as justification to waive the requirements of this seismic restraint section.
- .2 The work under this section shall include furnishing all labour, materials, tools, appliances, and equipment, and performing all operations necessary for the complete execution of the installation of seismic snubber restraint assemblies as shown, detailed, and/or scheduled on the drawing and/or specified in this section of the specifications.
- .3 All seismic snubber restraint assemblies shall meet the following minimum requirements:
 - .1 The snubber/restrained isolator for isolated equipment shall include a resilient element that will ensure that no un-cushioned shock can occur (this does not include cable restraints).
 - .2 It shall be possible to visually inspect the resilient material for damage and allow for replacement, if necessary.
 - .3 All snubbers are to include a maximum air gap of 0.25 in (6 mm).
 - .4 Seismic restraint systems shall be designed to offer seismic restraint in all directions, unless otherwise noted.
 - .5 Seismic restraint capacities to be verified by an independent test laboratory or certified by a registered Professional Engineer to ensure that the design intent of this specification is realized. Verification shall be by one of the following methods:
 - .1 An NRTL (National Recognized Testing Laboratory), or laboratory recommended by VISCMA.
 - .2 Certified by a Professional Engineer with at least 5 years of experience, using industry standard methods of analysis, which employ common engineering practices. Adherence to the ratings standard within ASHRAE SPC171 and VISCMA 102-2007 is required.
 - .3 By a nationally recognized agency, such as VISCMA, that has reviewed and approved the restraint.

1.8 SYSTEM DESIGN

- .1 Seismic restraint manufacturer shall be responsible for the structural design of attachment hardware as required to attach snubbers/restraints to both the equipment and supporting structure on vibration isolated equipment, or to directly attach equipment to the building structure for non-isolated equipment.

- .2 The Contractor shall furnish, to the seismic restraint manufacturer, a complete set of approved shop drawings of all equipment that is to be restrained, from which the selection and design of seismic restraint devices and/or attachment hardware will be completed. The shop drawings furnished shall include, at a minimum, basic equipment layout, length, and width dimensions, and installed operating weights of the equipment to be restrained.
- .3 All piping, ductwork and equipment is to be restrained to meet code requirements. At a minimum, the seismic restraint manufacturer shall provide documentation on maximum restraint spacing for various restraint sizes and anchors, as well as "worst case" reaction loads for each restraint and/or anchor size.
- .4 The Contractor shall ensure that all housekeeping pads used are adequately reinforced and are properly dowelled to the building structure, so as to withstand calculated seismic forces. In addition, the size of the housekeeping pad is to be coordinated with the seismic restraint manufacturer to ensure that adequate edge distances exist in order to obtain the desired equipment anchor capacities.

1.9 SEISMIC BRACING AND SUPPORT DESIGN REQUIREMENTS

- .1 Seismic restraint designer shall co-ordinate all attachments with the structural engineer of record.
- .2 Design analysis shall include calculated dead loads, static seismic loads, and capacity of materials utilized for the connection of the equipment or system to the structure.
- .3 Analysis shall detail anchoring methods, bolt diameter, and embedment depth.
- .4 All seismic restraint devices shall be designed to accept without failure the forces calculated per the applicable building code and as summarized in Section 3.01.
- .5 Friction from gravity loads shall not be considered resistance to seismic forces.
- .6 Fire protection systems shall meet the requirements of NFPA-13 and NFPA-14. Sway bracing used for seismic restraint purposes must be fitted with provisions to resist the vertical force component of the diagonal brace. Single diagonal brace for seismic restraint will not be approved.

1.10 QUALITY ASSURANCE

- .1 The Contractor shall provide pre-engineered seismic restraint systems to meet total design lateral force requirements for support and restraint of piping, conduit, cable trays and other similar systems and equipment where required by the applicable building code.
- .2 System Supports/Restraints: Firms regularly engaged in the manufacture of products of the types specified in this section, whose products have been in satisfactory use in similar service for not less than 5 years.
- .3 Bolted framing channels and fittings shall have the manufacturers name, part number, and material heat code identification number stamped in the part itself for identification. Material certification sheets and test reports must be made available by the manufacturer upon request.

- .4 Only companies experienced in performing the work of this section shall do the installation.
- .5 All seismic restraint installations shall be independently reviewed by the Owners Representative for compliance with project specifications.

1.11 SUBMITTALS

- .1 Product Data: include Seismic Rating Curve for each seismically rated isolator or restraint component.
- .2 Samples: the Contractor shall submit samples of specified seismic snubber devices for approval.
- .3 Shop Drawings shall include the following:
 - .1 Design Calculations: Calculate requirements for selecting seismically rated vibration isolators and seismic restraints. Certification documents to be signed and sealed by a qualified Professional Engineer with at least 5 years of experience in the design of seismic restraints. Professional engineer shall have local jurisdiction and provide periodic field review and final certification upon completion of the project. All costs and fees associated with the engineering shall be the responsibility of this contractor.
 - .2 Vibration Isolation Bases: Dimensional drawings including anchorage and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads.
 - .3 Seismic-Restraint Details: Detailed submittal drawings of seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors. Include ratings for loads.
 - .4 Equipment Manufacturer Seismic Qualification Certification: The Equipment Manufacturer must submit certification that each piece of provided equipment will withstand seismic forces identified in "Performance Requirements" Article above. Include the following:
 - .1 Basis for Certification: Indicate whether the "withstand" certification is based on actual test assembled components or on calculations.
 - .2 Indicate the equipment is certified to be durable enough to:
 - .1 structurally resist the design forces and/or
 - .2 will remain functional after the seismic event.
 - .5 Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - .6 Detailed description of the assumed equipment anchorage devices on which the certification is based.

1.12 DELIVERY, STORAGE, AND HANDLING

- .1 Deliver strut systems, pipe hangers and components carefully to avoid breakage, denting, and scoring finishes. Do not install damaged equipment.
- .2 Store strut systems, pipe hangers and components in original cartons and in clean dry space; protect from weather and construction traffic.

1.13 WORK FURNISHED BUT NOT INSTALLED

- .1 The materials and systems specified in this section shall be purchased by the fire protection Contractor from a single seismic snubber restraint materials manufacturer to assure sole source responsibility for the performance of the seismic restraints used.
- .2 The materials and systems specified in this section can, at the Contractor's option, be installed by the subcontractor who installs the seismic restraint systems.

1.14 COORDINATION

- .1 Coordinate size, shape, reinforcement and attachment of all housekeeping pads supporting seismically rated equipment. Concrete shall have a minimum compressive strength of 3,000 psi or as specified by the consultant.
- .2 Coordinate with seismic restraint manufacturer to locate and size structural supports underneath seismically restrained equipment (e.g. roof curbs, cooling towers, and other similar equipment).

1.15 INSTALLATION

- .1 Installation of all seismic restraint materials specified herein shall be accomplished following the manufacturer's written instructions. Installation instructions shall be submitted to the engineer for approval prior to the beginning of the work.

Part 2 Products

2.1 MATERIALS

- .1 To the requirements of NFPA.

Part 3 Execution

3.1 GENERAL INSTALLATION

- .1 Installation of all seismic restraint materials specified in this section shall be accomplished as per the manufacturer's written instructions.
- .2 Refer to FEMA Manuals 412, 413, and 414 for typical industry standard installation guidelines.
- .3 Upon completion of installation of all seismic restraint materials and before start-up of restrained equipment, all debris shall be cleaned from beneath all protected equipment, leaving equipment free to contact snubbers/restraints.
- .4 Torque anchor bolts according to anchor manufacturer's written instructions to resist seismic forces.
- .5 All seismic restraint systems shall be installed in strict accordance with the manufacturer's seismic restraint guidelines manual and all certified submittal data.
- .6 Prior to installation, bring to the architect's/engineer's attention any discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection.

- .7 Brace support rods when necessary to accept compressive loads. Welding of compressive braces to the vertical support rods is not acceptable.
- .8 Seismic restraints shall be mechanically attached to the structural system. Looping restraints around the system is not acceptable.
- .9 Do not brace a system to two independent structures such as ceiling and wall.
- .10 Provide appropriately sized openings in walls, floors, and ceilings for anticipated seismic movement. Provide fire seal systems in fire-rated walls.
- .11 Seismic restraint cables shall be adjusted such that they are not visibly slack, or the flexibility is approximately 25mm under thumb pressure for a 1500mm cable length (equivalent ratio for other cable lengths).
- .12 All seismic restraint cables shall be at least 25mm clear of all other equipment and services.

3.2 FIRE PROTECTION PIPING

- .1 Fire protection, sprinkler piping, and related equipment is considered as “Life Safety Equipment” and is to be seismically restrained per guidelines as published by NFPA (National Fire Protection Association).

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 NFPA 13 latest edition, Installation of Sprinkler Systems.
- .3 Ontario Fire Code.
- .4 Ontario Building Code.
- .5 Factory Mutual guidelines.

1.2 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with general requirements in accordance with NFPA 13, working plans and design requirements.
- .2 Shop drawings shall be approved by authority having jurisdiction prior to submission.
- .3 Submit to Consultant for general review and information only.
- .4 Submitted drawings shall be reproducible. Do not submit marked up prints.
- .5 Drawings shall be in AutoCad format.

1.3 SAMPLES

- .1 Submit samples in accordance with general requirements.
- .2 Submit samples of following:
 - .1 Each type of sprinkler head.
 - .2 Signs.

1.4 ENGINEERING DESIGN CRITERIA

- .1 Design system in accordance with Ontario Fire Marshall, local authority having jurisdiction, Owner's underwriters as required, and NFPA 13, NFPA 20, and NFPA 45 using following parameters:
 - .1 To suit occupancy as indicated.
 - .2 Pipe size and layout: Hydraulic design.
 - .3 Conduct flow and pressure test of water supply in vicinity of project to obtain criteria for bases of design in accordance with NFPA 13. Indicate location and flow on shop drawings.
 - .4 System zoning as indicated in accordance with NFPA 13.
 - .5 Provide complete drawings and calculations stamped by a qualified professional engineer registered in the Province of Ontario.
 - .6 Professional Engineer shall provide on site review and certification for local building code review.
- .2 System shall be approved by Ontario Fire Marshall, local authority, and Owner's underwriter prior to shop drawing submission.

1.5 COMMISSIONING & INTEGRATED TESTING OF FIRE PROTECTION & LIFE SAFETY SYSTEMS

- .1 Sprinkler Contractor to perform services with the Fire Commissioning Agent (FCA) to meet their requirements for administration, verification, and final sign-off.
- .2 The Fire Commissioning Agent (FCA) is being retained by the Electrical Contractor, however; this Contractor's work to satisfy the FCA requirements shall be included in the tender price.
- .3 The Sprinkler Contractor at a minimum must include for:
 - .1 Providing FCA with all documentation of design and shop drawings.
 - .2 Provide documents for sequence of operation and maintenance of system.
 - .3 Movement of all valves and accessories to confirm Alarm/Supervisory/Trouble at the fire panel.
 - .4 Create flow at all initiating devices to verify detection at the fire panel.
 - .5 Testing and operation of any fire pumps.
 - .6 Other items that may be requested by the FCA.
 - .7 Re-commissioning of any items that may have failed.
 - .8 Putting the system back into proper operation after tests are completed.
- .4 All work is to be performed in accordance with NFPA 3 2010 Edition. Special consideration to be given to Figure A3.3.16 (b) for Sequence of Operation Form required to be completed in conjunction with the FCA and submitted to the Consultant's prior to occupancy.
- .5 The work to be performed by this Contractor is also described in NFPA 3 table A.5.1.1 as labelled "Construction Stage" and "Occupancy Stage".

1.6 MAINTENANCE DATA

- .1 Provide maintenance data for incorporation into manual specified in general requirements.

1.7 MAINTENANCE MATERIALS

- .1 Provide maintenance materials in accordance with general requirements.
- .2 Provide spare sprinklers and tools as required by NFPA 13.

1.8 QUALIFICATIONS

- .1 Contractor to be specialist in performing work of this section and have **at least 3 years'** successful experience in this size and type of project.

1.9 PERMITS AND FEES

- .1 Obtain and pay for all permits, fees, and inspections as required by authority having jurisdiction.

1.10 EQUIPMENT

- .1 ULC listed and labeled.

1.11 STORAGE

- .1 Store in original packaging with manufacturers' labels and seals intact.
- .2 Store in dry secure location.
- .3 Damaged material and/or equipment shall be replaced.

Part 2 Products

2.1 PIPE, FITTINGS, AND VALVES

- .1 Pipe and Fittings:
 - .1 25 mm (1"): Schedule 40 steel pipe with screwed fittings.
 - .2 32 mm (1¼") to 50 mm (2"):
 - .1 Schedule 40 steel pipe with screwed fittings or,
 - .2 Schedule 10 steel pipe with roll grooved fittings.
 - .3 65 mm (2½") and larger: Schedule 10 steel pipe with roll grooved fittings.
- .2 Valves:
 - .1 ULC listed for fire protection service.
 - .2 Up to NPS 2: bronze, screwed ends, OS&Y gate.
 - .3 NPS 2 1/2 and over: cast iron, flanged or roll grooved ends, indicating butterfly valve.
 - .4 Swing check valves.
 - .5 Ball drip.
- .3 Pipe hangers:
 - .1 ULC listed for fire protection services.
- .4 End switches:
 - .1 Provide on all isolating valves.
 - .2 Coordinate voltage and location with Fire Alarm Contractor.
- .5 Flow switches:
 - .1 Provide where indicated and required.
 - .2 Coordinate voltage and location with Fire Alarm Contractor.

2.2 SPRINKLER HEADS

- .1 General: to NFPA 13 and ULC listed for fire services.
- .2 Indicate type and location of sprinkler heads on drawings. Co-ordinate sprinkler heads location with other trades.
- .3 Locate sprinkler heads in acoustic tile ceiling in centre of tile.

- .4 Provide sprinkler heads as follows:
 - .1 Upright bronze: Exposed with no ceilings.
 - .2 Concealed fusible link type brass pendent with ring and cup in ceiling and brass coverplate. Coverplate finish selected by Consultant. Concealed heads installed in unsupervised areas (corridors, washrooms).
 - .3 White semi-recessed fusible link type brass pendent with adjustable, recessed escutcheon ring and cup. Sprinkler and escutcheon cup. Finish selected by Consultant. Semi-recessed heads installed in supervised areas (classrooms, offices, seminar rooms, etc.).
 - .4 Sprinkler heads with O-ring design shall not be used.
 - .5 Provide guards on upright sprinkler heads in all storage rooms, in the gymnasium and on heads below 1800 mm AFF.
- .5 Provide sprinkler heads under all equipment/ductwork over 1200 mm wide.

2.3 WATERFLOW DETECTORS (WFD)

- .1 Provide, where shown, waterflow detectors, complete with vane type sensor to actuate two single pole, double throw snap action switches when waterflow exceeds a sustained 0.63 L/s (10 gpm) flow.
- .2 Provide a built-in pneumatic retard device, with automatic reset to reduce false alarms. The time delay shall be field adjustable from 0 to 70 seconds.
- .3 Provide local wiring at WFD. Refer to Electrical Division for alarm wiring to fire alarm system.
- .4 WFD shall be suitable for 1750 kPa (250 psig) service pressure.

2.4 SUPERVISORY SWITCHES

- .1 General: to NFPA 13 and ULC listed for fire service.
- .2 Valves:
 - .1 Mechanically attached to valve body, with normally open and normally closed contacts and supervisory capability.
- .3 Flow switch type:
 - .1 With normally open and normally closed contacts and supervisory capability.
- .4 Pressure alarm switch:
 - .1 With normally open and normally closed contacts and supervisory capability.

2.5 PRESSURE GAUGES

- .1 ULC listed.
- .2 Shall have maximum limit of not less than twice normal working pressure at point where installed.

2.6 SIGNS

- .1 Signs for control drain and test valves: to NFPA 13.
- .2 Provide exterior signage for Fire Department connection. Location of signage and text shall be to the approval of the local authority having jurisdiction.

2.7 SPARE PARTS CABINET

- .1 For storage of maintenance materials, spare sprinkler heads and special tools.
- .2 Include all types and temperature ratings of sprinkler heads installed.
- .3 Construct to sprinkler head manufacturers standard.
- .4 Install where directed on site or next to alarm valve.

2.8 INSPECTORS TEST CONNECTIONS

- .1 Provide where indicated and to requirements of local authority.
- .2 Discharge to building exterior to acceptance of Consultant.
- .3 Provide suitable signage to satisfaction of authority having jurisdiction and Consultant.

2.9 DOCUMENTATION

- .1 Prepare documentation as indicated.
- .2 Provide documentation based on tender documents. Coordinate sprinkler drawings with all trades.
- .3 Provide one hard copy and one electronic copy of As Built drawings acceptable to Consultant prior to final payment.

2.10 UNIT PRICES

- .1 Provide unit prices as follows.
 - .1 Additional sprinkler head including hangers, 3.6 m piping and two elbows.
 - .2 Delete sprinkler head including hangers, 3.6 m piping and two elbows.

2.11 UNDERWRITERS APPROVED GATE VALVE

- .1 NPS 65 – 350 mm (2 1/2" - 14"), OS&Y:
 - .1 Approvals: UL and FM approved for fire service.
 - .2 UL and FM Label: on valve yoke.
 - .3 Body, Bonnet: cast iron to ASTM A 126 Class B. Wall thicknesses to ANSI B 16.1 and ULC 262(B).
 - .4 Bonnet bushing, yoke sleeve: bronze, to FM requirements.
 - .5 Packing gland: bronze.
 - .6 Stem: manganese bronze. Diameter to ULC C-262(B).
 - .7 Stuffing box dimensions, gland bolt diameter: to ULC C 262(B).
 - .8 Bosses for bypass valve, drain: on NPS 100 mm (4") and over.

- .9 Disc: solid taper wedge. Up to NPS 80 mm (3"): bronze. NPS 100 mm (4") and over: cast iron with bronze disc rings.
- .10 Disc seat ring: self-aligning, Milwood undercut on NPS 80 mm (3").
- .11 Complete with lock and chain where indicated.
- .12 Complete with supervisory valves where indicated.
- .13 Pressure rating:
 - .1 NPS 65 – 300 mm (2-1/2" - 12"): 1.7 MPa (250 psi) CWP
 - .2 NPS 350 mm (14"): 1.2 MPa (175 psi) CWP
- .14 Operator: Handwheel.

Part 3 Execution

3.1 INSTALLATION

- .1 Install, inspect and test to acceptance in accordance with NFPA 13 and FC 403.
- .2 Pipe a bypass complete with indicating valve, between Fire department connection and sprinkler main downstream of DCVA. Bypass shall be sized to allow flow test of system demand as per NFPA 13 forward flow test through the backflow preventor.
- .3 Testing to be witnessed by authority having jurisdiction.
- .4 Space hangers and support of sprinkler piping in accordance with N.F.P.A. regulations.
- .5 Hydrostatically test systems at 350kPa in excess of normal working pressure, but not less than 1.4 MPA for two hours without loss under supervision of authority having jurisdiction and NFPA requirements.
- .6 Provide hydraulic pump, temporary connections and labour required for tests.
- .7 Protect exposed work, in accordance with 'Painting' section.
- .8 Do not cover or conceal piping accessories or work prior to inspection and approval by authorities having jurisdiction.
- .9 Adjust equipment to satisfaction of authority having jurisdiction and Consultant.
- .10 Protect equipment during painting. Replace damaged and painted components.
- .11 Co-ordinate the sprinkler piping and equipment with that of other trades on the job. Mains and branches shall be run so as not to interfere with building's structure, mechanical, or electrical installations. Branch piping above ceilings is to run in joist space or minimum 300 mm above ceiling. Provide drops at head locations only. All exposed piping to run in joist space.
- .12 Guarantee that the systems and equipment be installed in accordance with all Local and Provincial by-laws and the rules and regulations of the Insurance Underwriters and the Building Code of Ontario.
- .13 Provide a flow test for each system on the remote inspectors test connection using methods approved by the local fire department and local water commission. Report the test results in writing to the Consultant.

3.2 WATER FLOW TEST

- .1 Provide a flow test to approval of local fire department and local water commission at nearest fire hydrant adjacent to building to determine water flow rate and pressure. Provide written test results with shop drawing submission.
- .2 Provide a forward flow test through the bypass to prove system demand can be provided through the backflow preventer.

END OF SECTION

Part 1 General

1.1 INSTRUCTIONS TO BIDDERS

- .1 The Supplemental Tender Form must be submitted to the architect and consultant (admin@deiassociates.ca) within 2 hours after tender closing. Contractors shall identify all sub-contractors he/she intends to use and must complete all information requested. The requisite information shall be given at the office of the Consultant. Contractor shall sign and date this page and initial and date each page thereafter.
- .2 Should the Plumbing Supplemental Form not be submitted then the contractor shall use Base Bid manufacturers as listed.
- .3 CONTRACTOR
I/We certify that I/We have the authority to bind the company.

COMPANY NAME

AUTHORIZED SIGNATURE

ADDRESS

PRINTED SIGNATURE

CITY

TITLE

TELEPHONE NUMBER

DATE

.4 SUB-CONTRACTORS

The Contractor shall state below the name of the Sub-contractors he intends to use, which shall not be changed without the consent of the Consultant.

Site Services

Insulation

BAS Controls

- .5 The Stipulated Bid Sum shall be for the base bid manufacturer or supplier equipment only, unless otherwise indicated. Where a choice of this equipment is given, this Contractor shall indicate the supplier or manufacturer he intends to use. Where no choice is indicated, the base bid supplier or equipment shall be used.

CONTRACTOR'S NAME: _____

DATE: _____

- .6 Equipment or materials manufactured by firms named in the following listing only shall be deemed equal to the equipment or material specified, provided the equipment or material will have capacity, performance, rating, construction, physical dimensions, accessories and features which, in the opinion of the Consultant, are equal to those of the specified equipment or material. The Plumbing Contractor shall not indicate equipment, materials or suppliers which are not listed. If this is done, the base bid supplier shall be used.
- .7 Where modifications to the work of other trades are required as a result or part of the alternative offered, include the cost of said modifications in the work.
- .8 Submit the following list of Base Bid and alternative suppliers in accordance with the bid requirements:

Spec. Reference Section	Equipment	Base Bid	Acceptable Alternate Manufacturer Or Supplier	Indicate Manufacturer Or Supplier
22 05 19	Direct Reading Thermometers	Trerice	Winters 91T Wiess	
22 05 19	Remote Reading Thermometers	Trerice	Winters 91T	
22 05 19	Pressure Gauges	Winters 91T	Trerice Weiss	
22 05 31	Expansion Compensators (EXP) (2"-4")	Metraflex HP	Mark David Canada Senior Flexonics	
22 05 31	Expansion Compensators (EXP) (6"-16")	Metraflex Metragator	Mark David Canada Senior Flexonics	
22 05 34	Plumbing Bases, Hangers, and Supports (Indoor)	Grinnell	Anvil Myatt Taylor	
22 05 48	Plumbing Seismic Restraint	Kinetics Noise Control Inc.	Copper 'B' Line Unistrut Building Systems Mason Industries	
22 07 19	Thermal Insulation for Plumbing Piping	Johns Manville	Knauf Manson Owens Corning	

CONTRACTOR'S NAME: _____

DATE: _____

Spec. Reference Section	Equipment	Base Bid	Acceptable Alternate Manufacturer Or Supplier	Indicate Manufacturer Or Supplier
22 11 16 Domestic Water Piping	Valves	Milwaukee	Crane Neuman Hattersley Kitz	
22 11 16 Domestic Water Piping	Butterfly Valves	Victaulic Series 608		
22 11 31	Non Freeze Wall Hydrants (Recessed, Encased)	Zurn Z-1300	Mifab MHY-20 Ancon HY-725 Contour C7100	
22 11 31	Strainers NPS 50 mm (2") and Under, Bronze Body, Screwed Ends, with Brass Cap	Watts Series 777SI	Crane/Powers Colton 125 YTB Wilkins S Series	
22 11 31	Strainers NPS 65 mm (2½") and Over, Cast Iron Body, Flanged Ends, with Bolted Cap	Watts 77F-D (77F-D-FDA for water service)	Crane/Powers Colton 125 YTB Wilkins FS Series	
22 13 13	Drainage Supplies	Zurn	Ancon Smith Mifab Watts Contour Enpoco Jay R. Smith Polydrain	
22 14 26	Storm Drains	Zurn	Mifab Watts Jay R. Smith Ancon Contour Smith	

CONTRACTOR'S NAME: _____

DATE: _____

Spec. Reference Section	Equipment	Base Bid	Acceptable Alternate Manufacturer Or Supplier	Indicate Manufacturer Or Supplier
22 44 13	Fixture Carriers	Zurn	Smith Ancon	
22 44 13	Plumbing Fixtures	Delta	McGuire	
22 11 22	Domestic Water Circulation Pump	Bell & Gossett	Armstrong Taco	
22 11 31	Water Meters	Neptune		
22 13 13	Trap Seal Stations	Mifab	Watts Zurn	
22 13 13	Solenoid Valves (Header Trap Seal Primer)	Asco		
22 33 33	Electric Domestic Water Heater	A.O. Smith	Ruud Bradford White J. Wood Rheem Ruud	
22 36 13	Domestic Hot Water Expansion Tank	Amtrol ST-12C	Well-X-Trol	
22 37 13	Fire Extinguishers	Wilson & Cousins	National	
22 37 13	Fire Blanket	National	Wilson & Cousins	
22 36 13	Domestic Hot Water Circulating Pumps	Bell & Gosset	Armstrong Taco	
22 36 13	Thermostatic Water Controller (3 Port)	Symmons	Powers	

CONTRACTOR'S NAME: _____

DATE: _____

1.2 LABOUR RATES

- .1 The following labour rates shall apply for calculating the cost of credit or extras on Change Notices. The rates shall include any employee benefits. The labour rates do not include overhead and profit.

Superintendent	\$_____/hr
Journeymen	\$_____/hr
Labourers	\$_____/hr
Plumbers	\$_____/hr
Insulation	\$_____/hr
Other	\$_____/hr

1.3 PLUMBING TENDER PRICE (EXCLUDING HST)

- .1 Having carefully examined all Drawings and Specifications and the Addenda to the Drawings and Specifications, and having carefully examined the sites and all conditions affecting the work, we, the undersigned thereby offer to provide all plant, labour, materials and incidentals required to complete the work of all trades for: All the work specified for herein for

the Total Stipulated Price of: \$_____

(in writing)

in lawful money of Canada; included in which are all applicable excise taxes, custom duties, freight, exchange, and all other charges. HST is not included.

END OF SECTION

CONTRACTOR'S NAME:_____

DATE:_____

Part 1 General

1.1 GENERAL PROVISIONS

- .1 This section covers items common to all sections of Plumbing Division.
- .2 Conform to Division 1 General Conditions.
- .3 Furnish labour, materials, and equipment necessary for completion of work as described in contract documents.
- .4 Unless specifically indicated, all materials and equipment provided under this contract shall be new and shall be manufactured in the project year.
- .5 The term "Mechanical Contractor" shall remain active and shall mean a "single contractor" performing plumbing, drainage, heating, cooling, ventilation, and control services.
- .6 When quoting as a subcontractor this contractor shall explicitly state the services they are providing i.e. Mechanical (all services), Plumbing (water and drainage systems) or HVAC (including hydronic and air systems).
- .7 Contractors shall be explicit to identify whether Fire Protection is included or omitted from the mechanical scope.

1.2 INTENT

- .1 Mention herein or indication on Drawings of articles, materials, operations or methods requires: supply of each item mentioned or indicated, of quality, or subject to qualifications noted; installation according to conditions stated: and, performance of each operation prescribed with furnishing of necessary labour, equipment, and incidentals for plumbing work.
- .2 Where used, words "Section" and "Division" shall also include other Subcontractors engaged on site to perform work to make building and site complete in all respects.
- .3 Where used, word "supply" shall mean furnishing to site in location required or directed complete with accessory parts.
- .4 Where used, word "install" shall mean secured in place and connected up for operation as noted or directed.
- .5 Where used, word "provide" shall mean supply and install as each is described above.

1.3 TENDERS AND BONDING

- .1 Complete Supplemental Tender Form including list of equipment and materials to be used on this project and forming part of tender documents.
- .2 Submit Supplemental Tender Form as noted.
- .3 Submit tender based on specified described equipment or Alternates listed.
- .4 State in Tender, names of all Subcontractors proposed for work under this Division.

1.4 REGULATIONS, PERMITS, AND FEES

- .1 All materials and quality of work shall meet all current and latest Provincial, Municipal and Fire Marshall requirements, regulations, codes, and by-laws in force in the area of the project.
- .2 Each contractor shall give all necessary notices, obtain all necessary permits, and pay all fees in order that the work shown or specified may be carried out. Each contractor shall furnish any certificates necessary as evidence that the work installed conforms with the laws and regulations of all authorities having jurisdiction.
- .3 In the event that changes, or alterations are required on completed work by authorized inspectors, these changes shall be made at the contractor's expense.
- .4 Special equipment which does not have a standard CSA label shall be inspected by the local electrical authority having jurisdiction and the Approval Certificate shall be submitted to the Consultant as soon as possible. All costs and fees for inspections shall be borne by this contractor.

1.5 DRAWINGS

- .1 The drawings and this specification have been assembled together as a responsibility of the consultant. The same is true for the other consultants, i.e. architect, structural engineer, civil engineer, fire protection engineer, electrical engineer, etc.
- .2 The drawings and specifications are not assembled together for responsibility/division between subcontractors. The division of work between subcontractors remains the responsibility of the buildings' contractor (also known as the prime contractor or general contractor).
- .3 All subcontractors are encouraged to perform work amicably utilizing all of the drawings and specifications published by all of the consultants.
- .4 Plumbing and Mechanical Drawings do not show structural and related details. Take information involving accurate measurement of building from building drawings, or at building. Make, without additional charge, any necessary changes, or additions to runs of piping to accommodate structural conditions. Location of pipes, ducts, conduits and other equipment may be altered by Consultant without extra charge provided change is made before installation and does not necessitate major additional material.
- .5 As work progresses and before installing piping, ductwork, heating units, registers, diffusers, fixtures and any other fittings and equipment which may interfere with interior treatment and use of building, provide detail drawings, or obtain directions for exact location of such equipment and fittings.
- .6 Plumbing and Mechanical Drawings indicate general location and route of pipes, ducts and conduits which are to be installed. Where required work is not shown or only shown diagrammatically, install same at maximum height in space to conserve head room (minimum 2200 mm (88") clear) and interfere as little as possible with free use of space through which they can pass. Follow building lines, conceal piping, conduits and ducts in furred spaces, ceilings and walls unless specifically shown otherwise. Install work close to structure so furring will be small as practical.

- .7 Install piping and ductwork to clear structural members and any fireproofing. Locate plumbing work to permit installation of specified insulation. Do not remove or damage structural fireproofing. Leave space to permit fireproofing and insulation to be inspected and repaired.
- .8 Before commencing work, check and verify all sizes, locations, grade and invert elevations, levels, and dimensions to ensure proper and correct installation. Verify existing/municipal services.
- .9 Locate all plumbing, mechanical, and electrical equipment in such a manner as to facilitate easy and safe access to and maintenance and replacement of any part.
- .10 In every place where there is indicated space reserved for future or other equipment, leave such space clear, and install piping and other work so that necessary installation and connections can be made for any such apparatus. Obtain instructions whenever necessary for this purpose.
- .11 Relocate equipment and/or material installed but not co-ordinated with work of other Sections and/or installed incorrectly as directed, without extra charge.
- .12 Where drawings are done in metric and product not available in metric, the corresponding imperial trade size shall be utilized.

1.6 INTERFERENCE AND COORDINATION DRAWINGS

- .1 Prepare interference and equipment placing drawings to ensure that all components will be properly accommodated within the constructed spaces provided.
- .2 Prepare drawings to indicate co-ordination and methods of installation of a system with other systems where their relationship is critical. Ensure that all details of equipment apparatus, and connections are coordinated.
- .3 Ensure that clearances required by jurisdictional authorities and clearances for proper maintenance are indicated on drawings.
- .4 Upon consultant's request submit copies of interference drawings to consultant.
- .5 Due to the nature of the building and the complexity of the building systems provide the following:
 - .1 Interference drawings, showing coordination of architectural, structural, plumbing, mechanical, and electrical systems for the consultant's review prior to fabrication.
 - .2 Detailed layout drawings, clearly showing fasteners and hangers.
- .6 Provide CAD drawings (minimum file version AutoCAD 2013) in addition to hard copies.

1.7 QUALITY ASSURANCE

- .1 Perform work in accordance with applicable provisions of local Plumbing Code, Gas Ordinances, and adoptions thereof for all plumbing systems. Provide materials and labor necessary to comply with rules, regulations, and ordinances.
- .2 In case of differences between building codes, provincial laws, local ordinances, utility company regulations, and Contract Documents, the most stringent shall govern. Promptly notify Consultant in writing of such differences.

1.8 ALTERNATES AND SUBSTITUTIONS

- .1 Throughout Plumbing and Mechanical Division are lists of "Alternate Equipment" manufacturers acceptable to Consultant if their product meets characteristics of specified described equipment. Submitted Bids shall be based on the supply of named articles and or products as specified in the Bid Documents.
- .2 Each bidder may elect to use "Alternate Equipment" from lists of Alternates where listed. Include for any additional costs including all costs for revisions to electrical contract to suit Alternate used. Prices are not required in Tender for Alternates listed except where specifically noted as "Separate Price". Complete the Supplementary Tender Form.
- .3 When two or more suppliers/manufacturers are named in the Bid Documents, only one supplier/manufacturer of the products named will be acceptable; however, it is the responsibility of this Division to ensure "Alternate Equipment" fits space allocated and gives performance specified. If an "Alternate Equipment" nor "equal" specified product unit is proposed and does not fit space allotted in Consultant's opinion, supply of specified described equipment will be required without change in Contract amount. Should electrical characteristics for "alternate" or "equal" equipment differ from equipment specified it shall be the responsibility of the equipment manufacturer to pay all costs associated with the revisions to the electrical contract. Only manufacturers listed will be accepted for their product listing. All other manufacturers shall be quoted as substitution stating conditions and credit amount.
- .4 If item of material specified is unobtainable, state in Tender proposed substitute and amount added or deducted for its use. Extra monies will not be paid for substitutions after Contract has been awarded.
- .5 If pipe or item, of size or weight indicated, is unobtainable, supply next larger size or heavier weight without additional charge.

1.9 EXAMINATION

- .1 Site Reviews
 - .1 Examine premises to understand conditions which may affect performance of work of this Division before submitting proposals for this work.
 - .2 No subsequent allowance for time or money will be considered for any consequence related to failure to examine site conditions.
- .2 Drawings:
 - .1 Plumbing and Mechanical Drawings show general arrangement of piping, ductwork, equipment, etc. Follow as closely as actual building construction and work of other trades will permit.
 - .2 Consider Architectural and Structural Drawings part of this work insofar as these drawings furnish information relating to design and construction of building. These drawings take precedence over Plumbing, Mechanical, and Fire Protection Drawings.

- .3 Because of small scale of Drawings, it is not possible to indicate all offsets, fittings, and accessories, which may be required. Investigate structural and finish conditions affecting this work and arrange work accordingly, providing such fittings, valves, and accessories required to meet conditions.
- .3 Ensure that items to be furnished fit space available. Make necessary field measurements to ascertain space requirements including those for connections and furnish and install equipment of size and shape so final installation shall suit true intent and meaning of Contract Documents. If approval is received by Addendum or Change Order to use other than originally specified items, be responsible for specified capacities and for ensuring that items to be furnished will fit space available.

1.10 SEQUENCING SCHEDULING AND COORDINATION

- .1 It is understood that while Drawings are to be followed as closely as circumstances permit, this Division will be held responsible for installation of systems according to the true intent and meaning of Contract Documents. Anything not clear or in conflict will be explained by making application to Consultant. Should conditions arise where certain changes would be advisable, secure Consultant's approval of these changes before proceeding with work.
- .2 Coordinate work of various trades in installing interrelated work. Before installation of plumbing items, make proper provision to avoid interferences in a manner approved by Consultant. Each Contractor shall refer to all sections of the specification for their responsibilities with other trades. Changes required in work specified in Plumbing Division caused by neglect to do so shall be made at no cost to Owner.
- .3 Arrange pipes, ducts, and equipment to permit ready access to valves, unions, traps, starters, motors, control components, and to clear openings of doors and access panels.
- .4 Furnish and install inserts and supports required by Plumbing Division unless otherwise noted. Furnish sleeves, inserts, supports, and equipment that are an integral part of other Divisions of the Work to Sections involved in sufficient time to be built into construction as the Work proceeds. Locate these items and see that they are properly installed. Expense resulting from improper location or installation of items above shall be borne by Plumbing Division.
- .5 Be responsible for required excavation, backfilling, cutting, and patching incident to work of this Division and make required repairs afterwards to satisfaction of Consultant. Cut carefully to minimize necessity for repairs to existing work. Do not cut beams, columns, or trusses.
 - .1 Patch and repair walls, floors, ceilings, and roofs with materials of same quality and appearance as adjacent surfaces unless otherwise shown. Surface finishes shall exactly match existing finishes of same materials.
 - .2 Each Section of this Division shall bear expense of cutting, patching, repairing, and replacing of work of other Sections required because of its fault, error, tardiness, or because of damage done by it.
 - .3 Cutting, patching, repairing, and replacing pavements, sidewalks, roads, and curbs to permit installation of work of this Division is responsibility of Section installing work.

- .6 Adjust locations of pipes, ducts, equipment, fixtures, etc., to accommodate work from interferences anticipated and encountered. Determine exact route and location of each pipe and duct prior to fabrication.
 - .1 Make offsets, transitions, and changes in direction of pipes, ducts, and electrical raceways as required to maintain proper head room and pitch of sloping lines whether or not indicated on Drawings.
 - .2 Furnish and install traps, air vents, sanitary vents, pull boxes, etc., as required to affect these offsets, transitions, and changes in direction.
- .7 Slots and openings through floors, walls, ceilings, and roofs shall be provided by this contractor but performed by a trade specializing in this type of work. This Division shall see that they are properly located and do any cutting and patching caused by its neglect to do so.

1.11 REQUEST FOR INFORMATION (RFI) PROCEDURES

- .1 RFIs shall be submitted to the consultant minimum two (2) weeks prior to answer being required. Failure to submit an RFI in a timely manner will forfeit delay claims and schedule extension requests by the contractor.
- .2 All RFIs will be submitted with the following information:
 - .1 RFI number
 - .2 Name of project
 - .3 Date of initiation
 - .4 Date response required by (minimum two (2) weeks)
 - .5 Subject
 - .6 Submitter's name
 - .7 Drawing/specification reference
 - .8 Photograph of the issue (if applicable)
 - .9 Description of the issue
 - .10 Contractor's proposed resolution

1.12 CONTRACT BREAKDOWN

- .1 Provide breakdown of contract exclusive of HST to acceptance of consultants prior to first draw submission.
- .2 Provide labour and material cost for each item.
- .3 Breakdown shall indicate total contract amount.
- .4 Contract breakdown shall be as follows as a minimum.
 - .1 Mobilization and shop drawings (max. \$2,000.00)
 - .2 Demolition
 - .3 Inside buried plumbing and drainage
 - .4 Above grade rough-in plumbing and drainage
 - .5 Roof drainage system
 - .6 Plumbing fixtures

- .7 Plumbing equipment
- .8 Specialty piping
- .9 Piping insulation
- .10 Firestopping
- .11 Plumbing contractor closeout requirements (min. of 3% for the first \$500,000.00, 1% from \$500,000.00 to \$5,000,000.00, and 0.5% beyond. Shall not be less than \$5,000.00).
- .5 Progress claims, when submitted are to be itemized against each item of the contract breakdown, this shall be done in table form showing contract amount, work complete to date, previous draw, amount this draw and balance.
- .6 **Mobilization amount may only be drawn when all required shop drawings have been reviewed by the consultant.**

1.13 COMMISSIONING CONTRACT BREAKDOWN

- .1 This contractor shall work with the plumbing and HVAC system commissioning contractor as specified elsewhere.

1.14 SHOP DRAWINGS AND PRODUCT DATA

- .1 Furnish complete catalog data for manufactured items of equipment to be used in the Work to Consultant for review within 14 days after award of Contract.
- .2 Upon receipt of reviewed shop drawing, product is to be ordered immediately.
- .3 Provide a complete list of shop drawings to be submitted prior to first submission.
- .4 Before submitting to the Consultant, review all shop drawings to verify that the products illustrated therein conform to the Contract Documents. By this review, the Contractor agrees that it has determined and verified all field dimensions, field construction criteria, materials, catalogue numbers, and similar data and that it has checked and coordinated each shop drawing with the requirements of the work and of the Contract Documents. The Contractor's review of each shop drawings shall be indicated by stamp, date and signature of a qualified and responsible person possessing by the appropriate authorization.
- .5 If material or equipment is not as specified or submittal is not complete, it will be rejected by Consultant.
- .6 Additional shop drawings required by the contractor for maintenance manuals, site copies etc., shall be photocopies of the "reviewed" shop drawings. All costs to provide additional copies of shop drawings shall be borne by the contractor.
- .7 Catalog data or shop drawings for equipment, which are noted as being reviewed by Consultant or their Engineer shall not supersede Contract Documents.
- .8 Review comments of Consultant shall not relieve this Division from responsibility for deviations from Contract Documents unless Consultant's attention has been called to such deviations in writing at time of submission, nor shall they relieve this Division from responsibility for errors in items submitted.

- .9 Check work described by catalog data with Contract Documents for deviations and errors.
- .10 Shop drawings and product data shall show:
 - .1 Mounting arrangements.
 - .2 Operating and maintenance clearances. e.g., access door swing spaces.
- .11 Shop drawings and product data shall be accompanied by:
 - .1 Detailed drawings of bases, supports, and anchor bolts.
 - .2 Acoustical sound power data, where applicable.
 - .3 Points of operation on performance curves.
 - .4 Manufacturer to certify as to current model production.
 - .5 Certification of compliance to applicable codes.
- .12 State sizes, capacities, brand names, motor HP, accessories, materials, gauges, dimensions, and other pertinent information. List on catalog covers page numbers of submitted items. Underline applicable data.
- .13 Shop drawings shall be submitted electronically as per the following directions:
 - .1 Electronic Submissions:
 - .1 Electronically submitted shop drawings shall be prepared as follows:
 - .1 Use latest software to generate PDF files of submission sheets.
 - .2 Scanned legible PDF sheets are acceptable. Image files are not acceptable.
 - .3 PDF format shall be of sufficient resolution to clearly show the finest detail.
 - .4 PDF page size shall be standardized for printing to letter size (8.5"x11"), portrait with no additional formatting required by the consultant. Submissions requiring larger detail sheets shall not exceed 11"x17".
 - .5 Submissions shall contain multiple files according to section names as they appear in Specification.
 - .6 File names shall include consultant project number and description of shop drawing section submitted.
 - .7 Each submission shall contain an index sheet listing the products submitted, indexed in the same order as they appear in the Specification. Include associated PDF file name for each section.
 - .8 On the shop drawing use an "electronic mark" to indicate what is being provided.
 - .9 **Each file shall bear an electronic representation of the "company stamp" of the contractor. If not stamped the file submission will not be reviewed.**

- .2 Email submissions shall include subject line to clearly identify the consultants project number and the description of the shop drawings submitted.
- .3 Electronic attachments via email shall not exceed 10MB. For submissions larger than 10MB, multiple email messages shall be used. Denote related email messages by indicating "1 of 2" and "2 of 2" in email subject line for the case of two messages.
- .4 Electronic attachments via web links (URL) shall directly reference PDF files. Provide necessary access credentials within link or as username/password clearly identified within body of email message.
- .5 On site, provide one (1) copy of the "reviewed" shop drawings in a binder as noted above.
- .6 Contractor to print copies of "reviewed" shop drawings and compile into maintenance manuals in accordance with requirements detailed in this section.

1.15 EQUIPMENT NAMEPLATE DATA

- .1 Between the manufactures design published literature, the shop drawing submission literature, and the nameplate data on the equipment, they can all read differently.
- .2 Most of the confusion and differences are coming out of the electrical power installation.
- .3 The contractors installing and connecting the equipment are responsible for the coordination of this data through the construction period.
- .4 The contractors shall share and/or request this information through out the project and monitor/make adjustments, provide recommendations accordingly based on any discrepancies.
- .5 The contractors are responsible for any cost associated with the changing data.
- .6 The final installation must meet the "Nameplate Data" on the equipment on site.

1.16 OPERATION AND MAINTENANCE MANUAL

- .1 Provide operation and maintenance data for incorporation into manual as in submittals' requirements.
- .2 Operation and maintenance manual to be approved by, and final copies deposited with, Consultant before final inspection.
- .3 Submit one (1) copy of Operation and Maintenance Manual to Consultant for approval. Submission of individual data will not be accepted unless directed by Consultant. Submission can be done electronically in PDF format or as a hard copy.
 - .1 Electronic submission/PDF file is required to be bookmarked. Any submission received without bookmarking will be immediately returned as unacceptable.
 - .2 Hard copy submission shall be in a three-ring binder (minimum 50 mm (2") ring) and labelled as 'Operation and Maintenance Manual' with project name and location. Dividers are to be used for binder organization.
- .4 Make changes as required and re-submit as directed by Consultant.

- .5 Operation data to include:
 - .1 Control schematics for each system including environmental controls.
 - .2 Description of each system and its controls.
 - .3 Operation instruction for each system and each component.
 - .4 Description of actions to be taken in event of equipment failure.
 - .5 Valves schedule and flow diagram.
 - .6 Colour coding chart.
 - .7 Spare parts equipment list.
 - .8 Manufacturers standard or extended warranty information.
- .6 Maintenance data shall include:
 - .1 Servicing, maintenance, operation, and trouble-shooting instructions for each item of equipment.
 - .2 Data to include schedules of tasks, frequency, tools required and task time.
- .7 Performance data to include:
 - .1 Equipment manufacturer's performance data sheets with point of operation as left after commissioning is complete.
 - .2 Equipment performance verification test results.
 - .3 Special performance data as specified elsewhere.
 - .4 Testing, adjusting and balancing reports as specified in Testing, Adjusting and Balancing Section.
 - .5 Copy of all substantial performance final certificates.
- .8 Miscellaneous data to include:
 - .1 Letter of contractor's warranty and guarantee.
 - .2 Index sheet.
 - .3 Tabbed format for each section.
 - .4 Manufacturers approved shop drawings.
 - .5 Spare parts list and source.
 - .6 List of Manufacturers and suppliers address for each piece of equipment.
- .9 Final Submittals:
 - .1 Upon acceptance of Operation and Maintenance Manual by the Consultant, provide the following:
 - .1 Provide two (2) copies of final Operation and Maintenance Manuals, as well as a PDF file of the entire approved manual on a USB stick. Only one (1) USB stick is to be provided containing both the approved manual and as-built drawings.

1.17 AS-BUILT DRAWINGS

- .1 Site records:
 - .1 Contractor shall provide two (2) sets of reproducible plumbing drawings. Provide sets of white prints as required for each phase of the work. Mark thereon all changes as work progresses and as changes occur. This shall include changes to existing plumbing systems, control systems, and low voltage control wiring.
 - .2 On a weekly basis, transfer information to reproducibles, revising reproducibles to show all work as actually installed.
 - .3 Use different colour waterproof ink for each service.
 - .4 Make available for reference purposes and inspection at all times.
- .2 As-built drawings submittal for TAB and review:
 - .1 Prior to start of Testing, Adjusting, and Balancing (TAB), finalize production of as-built drawings.
 - .2 Identify **each drawing** in lower right-hand corner in letters at least 3 mm (1/8") high as follows: - "AS-BUILT DRAWINGS: THIS DRAWING HAS BEEN REVISED TO SHOW PLUMBING SYSTEMS AS INSTALLED" (Company Name) (Signature of Contractor) (date).
 - .3 TAB to be performed using as-built drawings.
 - .4 Submit copy to Consultant for review and approval. When returned, make corrections as directed.
- .3 As-built drawings final submittal:
 - .1 Once approved, submit completed, reproducible paper as-built drawings as well as a scanned PDF file copy on USB stick with Operation and Maintenance Manuals.

1.18 WARRANTIES

- .1 In addition to guarantee specified in General Conditions, guarantee plumbing systems to be free from noise in operation that may develop from failure to construct system in accordance with Contract Documents.
- .2 Provide certificates of warranty for each piece of equipment made out in favor of Owner. Clearly record "start-up" date of each piece of equipment on certificate. Include certificates as part of Operation & Maintenance Manual.
- .3 If plumbing sub-contractor with offices located more than 80 km (50 miles) from Project site is used, provide service/warranty work agreement for warranty period with local plumbing sub-contractor approved by Consultant. Include copy of service/warranty agreement in warranty section of Operation & Maintenance Manual.

Warranty period shall start from date of ready for takeover. Warranty start date based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .4 Warranty Duration:
 - .1 One (1) year warranty period applies unless otherwise noted.

- .5 Warranty Coverage:
 - .1 Applies to parts and labour.

1.19 READY FOR TAKEOVER

- .1 Complete the following to the satisfaction of the consultant prior to request for ready for takeover.
 - .1 As-built Drawings
 - .2 Maintenance Manuals
 - .3 System Start up
 - .4 TAB Reports
 - .5 Plumbing Systems Commissioning
 - .6 Instructions to Owners

1.20 REVISION TO CONTRACT

- .1 Provide the following:
 - .1 Itemized list of material with associated costs.
 - .2 Labour rate and itemized list of labour for each item.
 - .3 Copy of manufacturers/supplier's invoice if requested.

1.21 DELIVERY, STORAGE, AND HANDLING

- .1 Follow Manufacturer's directions in delivery, storage, and protection, of equipment and materials. Contractor to include all costs associated with delivery storage and handling in tender price.
- .2 Deliver equipment and material to site and tightly cover and protect against dirt, water, and chemical or environmental damages but have readily accessible for inspection. Store items subject to moisture damage (such as controls) in dry, heated space.
- .3 Remove all damaged materials from site.

1.22 DESIGNATED SUBSTANCES AND HAZARDOUS MATERIALS

- .1 If designated substances and/or hazardous materials are suspected or identified cease all work in the immediate area in accordance with OHSA and notify consultant.
- .2 Each contractor and on site employee of the contractor shall have "asbestos awareness training".
- .3 The Contractor shall ensure that employees who may come into contact with designated substances and/or hazardous materials due to the nature of the work that they perform, have received training that enables them to recognize designated substances and/or hazardous materials and that enables them to react in accordance with the Occupational Health and Safety Act and regulations thereto should contact with designated substances and/or hazardous materials occur during the course of their work.
- .4 It is the responsibility of the contractor to review the designated substances and/or hazardous materials book in the building prior to starting any work.

- .5 Existing occupied buildings (depending upon their age) may contain designated substances and/or hazardous materials in thermal insulating materials and some manufactured products, such as vinyl asbestos floor tile. Any insulating materials, on pipes, fittings, boilers, tanks, ductwork, etc. may contain designated substances and/or hazardous materials and shall not be disturbed.
- .6 A survey of each building documenting the location and condition of designated substances and/or hazardous materials -containing materials is available for your mandatory review prior to commencing any work on premises.

1.23 PHASING OF WORK

- .1 This work for this project shall be constructed in phases. Refer to the architectural drawings for phasing information and details. Misinterpretation of the drawings with respect to the extent of the phasing of the work shall not relieve the contractor of the work required to complete the entire contract.
- .2 Provide all necessary services or temporary services to suit phasing of construction with respect to all plumbing services and fire protection.
- .3 Life safety systems in the building are to remain fully operational in occupied areas for building staff and occupants during renovations.
- .4 Provide all necessary tests and certificates at completion of each phase to suit requirements of local authorities and consultants for occupancy of completed areas.

1.24 CONFINED SPACES

- .1 Certain areas of the building may be defined as a "Confined Space". Any personnel working in these areas must have confined space training, appropriate equipment and undertake all work in conformance with appropriate codes and standards.
- .2 Refer to building documentation for any spaces deemed "Confined Space".

1.25 ENERGY EFFICIENCY

- .1 The systems of this building must achieve the energy efficiency levels by conforming to ANSI/ASHRAE/IESNA 90.1 "Energy Standard for Buildings Except Low-Rise Residential Buildings" and Chapter 2 of Division 3 of SB-10 prescriptive method from the Ontario Building Code.
- .2 All equipment, products, and installations must conform to the Codes and Standards.

END OF SECTION

Part 1 General

1.1 OCCUPANCY REQUIREMENTS

- .1 The contractor shall provide the following documentation to the consultant's satisfaction prior to receiving occupancy. Failure to provide the proper documentation will result in the occupancy not being granted. List of required documentation:
 - .1 Final Certificates (required prior to consultant's release of conformance letter).
 - .1 Potable Water Test (Refer to domestic water piping – Copper section – Part 3)
 - .2 Backflow Test Certificate (for all testable devices)
 - .3 Seismic Restraint Engineers' Letter

Part 2 Products

2.1 Not Used

Part 3 Execution

3.1 Not Used

END OF SECTION

Part 1 General

1.1 TESTS

- .1 Give 48 hours written notice of date for tests.
- .2 Insulate or conceal work only after testing and approval by Consultant.
- .3 Conduct tests in presence of Consultant.
- .4 Bear costs including retesting and making good.
- .5 Piping:
 - .1 General: maintain test pressure without loss for 4 h unless otherwise specified.
 - .2 Test drainage, waste and vent piping to Ontario Building Code and authorities having jurisdiction.
 - .3 Test domestic hot, cold and recirculation water piping at 1-1/2 times system operating pressure or minimum 860 kPa (124.8 psi), whichever is greater.
- .6 Equipment: test as specified in relevant sections.

1.2 SYSTEM START UP

- .1 Provide adjusting testing and start up of all equipment prior to testing and balancing (TAB) specified elsewhere.
- .2 Provide consultant with written notice verifying all equipment operation and installation is complete.
- .3 Start up shall be in presence of the following: owner or representative, contractor, building automation systems (BAS) contractor, and manufacturer's representative. Each person shall witness and sign off each piece of equipment. Consultant's attendance will be determined by consultant.
- .4 Simulate system start up and shut down and verify operation of each piece of equipment.
- .5 Arrange with all parties and provide 72 hours notice for start up procedure.
- .6 Arrange with building automation systems contractor to sequence all components and ensure system operation.

1.3 COMMISSIONING

- .1 Coordinate and direct each step of the commissioning process and recommend acceptance or non-acceptance to the Owner/Owner's Representative.
- .2 Prepare, in writing, documentation of any deficiencies discovered during the commissioning process. Submit to consultant and Owner/Owner's Representative.
- .3 The Commissioning Process is detailed in *ASHRAE Guideline 1-1996 HVAC Commissioning Process*. The commissioning plan may be modified to reflect the actual construction schedule and design.

- .4 Provide a pre-functional test of all plumbing system and sub-system elements, including control devices, shall be checked for the following:
 - .1 Verify that each element has been properly installed, properly identified, and that all connections (including electrical) have been made correctly.
 - .2 Verify that each element has been checked for proper lubrication, drive rotation, belt tension, control sequence, flow direction, or other conditions which may cause damage or reduce system performance.
 - .3 Verify that tests, meter readings, and specific plumbing/mechanical/electrical performance characteristics agree with those required by equipment or system manufacturer.
 - .4 Controls calibration to be completed in accordance with the specification.
 - .5 The TAB shall be done in accordance with the specifications.
- .5 Reports:
 - .1 The contractor shall be responsible for recording, documenting, and maintaining detailed inspection and testing data on the test documentation reports. The data record shall be comprehensive and concise.
 - .2 All data must be recorded as soon as possible during the course of the inspection and testing.
 - .3 All documentation shall have the date, time, and names of persons participating in the inspection and testing.
- .6 Plumbing System Execution:
 - .1 Operate equipment and systems shall be tested in the presence of the owner's representative and the consultant to demonstrate compliance with specified requirements. To minimize the time of Commissioning Team members, testing shall be done in four seasonal single blocks of time insofar as possible.
 - .2 Notify the consultant, in writing, fourteen (14) days prior to tests scheduled under requirements of this Section.
 - .3 Testing shall be conducted under specified design operating conditions as recommended or approved by the consultant.
 - .4 All elements of systems shall be tested to demonstrate that total systems satisfy all requirements of these Specifications. Testing shall be accomplished on hierarchical basis. Test each piece of equipment for proper operation, followed by each sub-system, followed by entire system, followed by any inter-ties of other major systems.
 - .5 All special testing materials and equipment shall be provided by the appropriate contractor.
 - .6 Provide three copies of all test reports and records to the consultant.
- .7 The verification testing procedures shall address all operating characteristics of all plumbing equipment and systems.

1.4 DEMONSTRATION AND OPERATING AND MAINTENANCE INSTRUCTION

- .1 Supply tools, equipment and personnel to demonstrate and instruct operating and maintenance personnel in operating, controlling, adjusting, trouble-shooting and servicing of all systems and equipment during regular work hours, prior to acceptance.
- .2 Plumbing contractor to schedule and coordinate the demonstration all on the same day, starting at a pre-approved time and continuing consequently until complete.
- .3 Where specified elsewhere in this Division, qualified manufacturers' representatives who are knowledgeable about the project to provide demonstrations and instructions.
- .4 Use operation and maintenance manual, as-built drawings, audio visual aids, etc. as part of instruction materials.
- .5 Instruction duration time requirements as specified in appropriate sections.
- .6 Where deemed necessary, Consultants may record these demonstrations on video tape for future reference.

1.5 TRIAL USAGE

- .1 Consultant or owner may use equipment and systems for test purposes prior to acceptance. Supply labour, material, and instruments required for testing.
- .2 Trial usage to apply to following equipment and systems:
 - .1 Domestic water
 - .2 Plumbing and drainage.

1.6 DEFICIENCIES

- .1 During the course of construction, the consultants will monitor construction and provide written reports of work progress, discussions, and instruction to correct work.
- .2 Instruction to correct work shall be done within the work period before the next review.
- .3 The contractor shall not conceal any work until inspected.
- .4 The contractor shall expedite 100% complete rough-in work and have inspected prior to concealing services and equipment especially above ceiling.
- .5 Upon completion of the project the consultant will do a final review. Upon receiving the final inspection report, the contractor must correct and sign back the inspection report indicating the deficiencies are completed. A re-inspection will only be done once consultant receives this in writing.

1.7 EQUIPMENT INSTALLATIONS

- .1 Unions or flanges: provide for ease of maintenance and disassembly.
- .2 Space for servicing, disassembly and removal of equipment and components: provide as recommended by manufacturer or as indicated.
- .3 Equipment drains: pipe to floor drains.
- .4 Install equipment, rectangular cleanouts and similar items parallel to or perpendicular to building lines.

1.8 MOUNTING HEIGHTS

- .1 Mounting height of equipment is from finished floor to equipment unless specified or indicated otherwise. Coordinate with block coursing (if applicable).
- .2 If mounting height of equipment is not specified or indicated, verify before proceeding with installation.
- .3 Install plumbing equipment at following heights unless indicated otherwise.
 - .1 Standard water closets 350 (14") to top of bowl
 - .2 Barrier-free water closets 400 (16") to top of bowl
 - .3 Barrier-free water closets 450 (18") to top of seat lid
 - .4 Wall hung lavatory 787 (31") to rim
 - .5 Barrier-free wall hung lavatory 840 (33") max to top of rim
737 (29") min underside of rim front
685 (27") clear at 400 (8") from basin front
350 (14") min clear under waste trap
 - .6 Hose bibbs +/- 600 (24")
 - .7 Barrier-free shower seat +/- 470 (18.5")
Not less than 686 (27") under unit
 - .8 Backflow preventors 900 – 1200 (3'– 4') to centerline of unit

Also follow direction of architectural drawings and where discrepancies occur clarify prior to rough-in.

1.9 ANCHOR BOLTS AND TEMPLATES

- .1 Supply anchor bolts and templates for installation by other Divisions.

1.10 PROTECTION OF OPENINGS

- .1 Protect equipment and systems openings from dirt, dust, and other foreign materials with materials appropriate to system.

1.11 ELECTRICAL

- .1 Electrical work to conform to Electrical Division including the following:
 - .1 Supplier and installer responsibility and related plumbing responsibility is indicated in Equipment Schedule on plumbing/mechanical and/or electrical drawings.
 - .2 Power wiring and conduit is specified in Electrical Division except for conduit, wiring and connections below 50 V which are related to control systems. Follow Electrical Division for quality of materials and workmanship.
 - .3 Electrically operated equipment shall be C.S.A. approved label. Special Inspection Label of Provincial Authority having jurisdiction will be accepted in lieu of C.S.A. approval. Each motor shall have an approved starter. Starter will be supplied and installed by Electrical Division unless otherwise indicated.

1.12 CONTROL WIRING

- .1 Furnish and install all components, devices, and control wiring for all plumbing, fire protection, HVAC equipment, HVAC systems, lighting, and other electrical loads to make all equipment operable to satisfaction of owner and consultant and to manufacturer's requirements and recommendations.
- .2 All electrical wiring and installations shall comply with local and national electrical codes.
- .3 Supply and install wiring as required for all devices and systems. Install wiring in EMT conduit and otherwise comply with all requirements of the Electrical Division. Approved plenum wire may be used for sensor and network communication wiring where it complies with appropriate building codes and regulatory authorities.
- .4 All wiring concealed in walls and chases, and all exposed wiring shall be run in conduit.
- .5 Provide recessed conduit and backer boxes where controls are wall mounted. Surface mounted boxes and conduit are acceptable in service rooms.
- .6 Free-run plenum rated cable shall be run in cable hangers where provided by Electrical Division or tied neatly to pipe and duct hangers in the ceiling. Avoid wiring that droops. Follow building lines and do not run wiring "as the crow flies".

1.13 MOTORS

- .1 Provide high efficiency motors for plumbing equipment.
- .2 If delivery of specified motor will delay delivery or installation of any equipment, install motor approved by Consultant for temporary use. Final acceptance of equipment will not occur until specified motor is installed.
- .3 Motors under 373 W, (1/2 hp): speed as indicated, continuous duty, built-in overload protection, resilient mount, single phase, voltage as indicated.

1.14 PIPING AND EQUIPMENT SUPPORTS

- .1 Fabricate from structural grade steel meeting requirements of - Structural Steel Section. Submit structural calculations with shop drawings.
- .2 Mount base mounted equipment on chamfered edge housekeeping pads, minimum of 100 mm (4") high and 150 mm (6") larger than equipment dimensions all around. Concrete specified elsewhere.
- .3 Where housekeeping pads incorporate existing pads provide 10 mm dowels into existing pads. New pad height shall match existing.

1.15 SLEEVES

- .1 Pipe sleeves: at points where pipes pass through masonry, concrete or fire rated assemblies and as indicated. Grout sleeves in place.
- .2 Schedule 40 steel pipe.

- .3 Sleeves with annular fin continuously welded at midpoint:
 - .1 Through foundation walls.
 - .2 Where sleeve extends above finished floor.
 - .3 Through fire rated walls and floors.
- .4 Sizes: minimum 6 mm (1/4") clearance all around, between sleeve and uninsulated pipe or between sleeve and insulation.
- .5 Terminate sleeves flush with surface of concrete and masonry walls, concrete floors on grade and 25 mm (1") above other floors.
- .6 Fill voids around pipes:
 - .1 Caulk between sleeve and pipe in foundation walls and below grade floors with waterproof fire retardant non-hardening mastic.
 - .2 Where sleeves pass through walls or floors, provide space for firestopping. Where pipes/ducts pass through fire rated walls, floors and partitions, maintain fire rating integrity.
 - .3 Ensure no contact between copper tube or pipe and ferrous sleeve.
 - .4 Fill future-use sleeves with lime plaster or other easily removable filler.
 - .5 Coat exposed exterior surfaces of ferrous sleeves with heavy application of zinc rich paint to CGSB 1-GP-181M+Amdt-Mar-78.
- .7 Provide minimum 20 gauge duct sleeves where ducts pass through masonry concrete or fire rated assemblies. Maintain minimum 25 mm clearance all around or to the requirements of the authority having jurisdiction. Seal at wall as indicated.

1.16 FIRE STOPPING

- .1 This contractor shall work with all other contractors on the project in providing one common method of fire stopping all penetrations made in fire rated assemblies.
- .2 Approved fire stopping and smoke seal material in all fire separations and fire ratings within annular space between pipes, ducts, insulation and adjacent fire separation and/or fire rating.
- .3 Do not use cementitious or rigid seals around penetrations for pipe(s) or other equipment at all wall, floor, or ceiling penetrations.
- .4 Insulated pipes and ducts: ensure integrity of insulation and vapour barrier at fire separation.
- .5 Provide materials and systems capable of maintaining effective barrier against flame, smoke and gases. Ensure continuity and integrity of fire separation.
- .6 Comply with the requirements of CAN4-S115-M35, and do not exceed opening sized for which they have been tested.
- .7 Systems to have an F or FT rating (as applicable) not less than the fire protection rating required for closures in a fire separation. Provide "fire wrap" blanket around services penetrating fire walls. Extent of blanket must correspond to ULC recommendations.
- .8 The fire stopping materials are not to shrink, slump or sag and to be free of asbestos, halogens and volatile solvents.

- .9 Firestopping materials are to consist of a component sealant applied with a conventional caulking gun and trowel.
- .10 Fire stop materials are to be capable of receiving finish materials in those areas which are exposed and scheduled to receive finishes. Exposed surfaces are to be acceptable to consultant prior to application of finish.
- .11 Firestopping shall be inspected and approved by local authority prior to concealment or enclosure.
- .12 Install material and components in accordance with ULC certification, manufacturers instructions and local authority.
- .13 Submit product literature and installation material on fire stopping in shop drawing and product data manual. Maintain copies of these on site for viewing by installers and consultant.
- .14 Manufacturer of product shall provide certification of installation. Submit letter to the consultant.
- .15 Acceptable Alternate Manufacturers to approval of local authority:
 - .1 Minnesota Mining and Manufacturing
 - .2 Fryslieve Industries Inc.
 - .3 General Electric Pensil Firestop Systems
 - .4 International Protective Coatings Corp.
 - .5 Rectorseal Corporation (Metacaulk)
 - .6 Proset Systems
 - .7 3M
 - .8 AD Systems
 - .9 Hilti
- .16 Ensure firestop manufacturer representative performs onsite inspections and certifies installation. Submit inspection reports/certification at time of substantial completion.

1.17 ESCUTCHEONS

- .1 On pipes and ductwork passing through walls, partitions, floors and ceilings in exposed finished areas and on water and drain pipes inside millwork and cabinets.
- .2 Chrome or nickel plated brass or Type 302 stainless steel, one piece type with set screws.
- .3 Outside diameter to cover opening or sleeve.
- .4 Inside diameter to fit around finished pipe.

1.18 PAINTING

- .1 Refer to Section Interior Painting and specified elsewhere.
- .2 Apply at least one coat of corrosion resistant primer paint to ferrous supports and site fabricated work.

- .3 Apply two coats of paint to exposed piping service in service room(s). Base colour as specified in Pipe Identification Section.
- .4 Prime and touch up marred finished paintwork to match original.
- .5 Restore to new condition, or replace equipment at discretion of consultant, finishes which have been damaged too extensively to be merely primed and touched up.

1.19 ACCESS DOORS

- .1 Provide access doors to concealed plumbing equipment for operating, inspecting, adjusting and servicing.
- .2 Flush mounted 600 x 600 mm (24" x 24") for body entry and 300 x 300 mm (12" x 12") for hand entry unless otherwise noted. Doors to open 180°, have rounded safety corners, concealed hinges, screwdriver latches and anchor straps.
- .3 Material:
 - .1 Special areas such as tiled or marble surfaces: use stainless steel with brushed satin or polished finish as directed by Consultant.
 - .2 Remaining areas: use prime coated steel.
 - .3 Fire rated areas: provide ULC listed access doors.
 - .4 Washrooms or high moisture area ceilings: Aluminum with mill finish suitable for painting.
- .4 Installation:
 - .1 Locate so that concealed items are accessible.
 - .2 Locate so that hand or body entry (as applicable) is achieved.
- .5 Acceptable Manufacturers:
 - .1 Le Hage
 - .2 Zurn
 - .3 Acudor
 - .4 Nailor Industries Inc.

1.20 DIELECTRIC COUPLINGS

- .1 General:
 - .1 To be compatible with and to suit pressure rating of piping system.
 - .2 Where pipes of dissimilar metals are joined.
- .2 Pipes NPS 50 mm (2") and under: isolating unions.
- .3 Pipes NPS 65 mm (2 1/2") and over: isolating flanges.

1.21 DRAIN VALVES

- .1 Locate at low points and at section isolating valves unless otherwise specified.
- .2 Minimum NPS 20 mm (3/4") unless otherwise specified: bronze, with hose end male thread and complete with vacuum air breaker and chain with cap.

- .3 Drain valves on potable water systems shall be complete with vacuum breaker.

1.22 REPAIRS, CUTTING, AND RESTORATION

- .1 Patch and repair walls, floors, ceilings, and roofs with materials of same quality and appearance as adjacent surfaces unless otherwise shown. Surface finishes shall exactly match existing finishes of same materials.
- .2 Each Section of this Division shall bear expense of cutting, patching, and repairing to install their work and/or replacing of work of other Sections required because of its fault, error, tardiness, or because of damage done by it.
- .3 Cutting, patching, repairing, and replacing pavements, sidewalks, roads, and curbs to permit installation of work of this Division is responsibility of Section installing work.
- .4 All patching, painting and making good of the existing walls, floors, ceilings, partitions and roof will be at the expense of this Contractor, but performed by the Contractor specializing in the type of work involved unless otherwise noted.

1.23 EXISTING SYSTEMS

- .1 Connections into existing systems to be made at time approved by Consultant. Request written approval of time when connections can be made.
- .2 Be responsible for damage to existing plant by this work.

1.24 CLEANING

- .1 Clean interior and exterior of all systems including strainers.
- .2 In preparation for final acceptance, clean and refurbish all equipment and leave in operating condition.

1.25 DISCONNECTION AND REMOVAL

- .1 Disconnect and/or remove equipment, piping, etc. as indicated.
- .2 Cap and conceal all redundant and obsolete connections.
- .3 Provide a list of equipment to be removed to the owner, for his acceptance of same. Remove all equipment from site, which the owner does not retain.
- .4 Store equipment to be retained by owner on site where directed by consultant.

1.26 OWNER SUPPLIED EQUIPMENT

- .1 Connect to equipment supplied by the owner and make operable.

1.27 DEMOLITION

- .1 The general requirements are indicated on the drawings and on the outline specification in Division 1.
- .2 The general execution of the demolition is to be carried out in a clean and efficient manner.

- .3 Demolition of existing ceiling, walls etc., to facilitate removal of existing services or equipment or installation of new to be kept to a minimum and then restored to match existing.
- .4 All openings or holes created by removal of existing plumbing systems which are not being reused are to be patched with the same material surrounding surfaces.
- .5 All new holes and openings to facilitate plumbing systems are to be patched to match surrounding surfaces.
- .6 Protect all existing furnishings materials and equipment. Any damage occurring as a result of the work of this Division shall be repaired or replaced at the expense of this Division.
- .7 Where work involves breaking into or connecting to existing services, carry out work at times directed by the Owners in an expedient manner with minimum disruption to the facility and systems downtime.
- .8 Where unknown services are encountered, immediately advise Consultant and confirm findings in writing.
- .9 Where the location of any services has been shown on the plans, such information is not guaranteed. It is this Division's responsibility to verify locations, invert elevations, etc., immediately after moving on site. Should for any reason the information obtained necessitates changes in procedure or design, advise the Consultant at once. If verification of existing conditions is not done at the outset and any problems arise, the responsibility for same is entirely this Divisions.

1.28 VIDEO RECORDING OF NEW & EXISTING UNDERGROUND SERVICES

- .1 Prior to final acceptance of the new underground plumbing system and prior to pouring the floor this contractor shall retain a qualified contractor to video tape the new, existing and revised sanitary and storm drainage piping and branch piping. Transfer all videotape information to USB.
- .2 This contractor shall flush the new and existing storm and sanitary system to remove all debris prior to final video taping of systems.
- .3 Provide 1 copy of USB.
- .4 Identify video routing on As-built drawings.

1.29 LOCATION OF EXISTING UNDERGROUND SERVICES

- .1 This contractor shall locate existing services prior to starting any work in the affected area.
- .2 This contractor shall use a video camera for the existing storm and/or sanitary drainage at the indicated connection point to confirm location, size and invert of the existing piping.

1.30 EXISTING CONCRETE SLAB X-RAY/SCANNING

- .1 This contractor shall retain the services of a qualified company to provide and X-ray and/or scan of the existing buried services in wall and/or floors prior to starting any work in the affected area.

- .2 Failure to locate existing piping, conduit rebar etc., shall not relieve this contractor of repair of same prior to installing his service.
- .3 This contractor shall be responsible for all repairs and/or replacement of existing services caused by cutting the existing concrete slabs and/or walls.

1.31 EXCAVATING AND BACKFILLING

- .1 Provide all excavating and backfilling inside and outside the building for plumbing pipes, drains and equipment. All backfilling shall be new clean granular 'A' fill brought in specifically for the purpose of backfilling to the underside of floor slab. All backfilling shall be compacted at intervals not more than 150 mm (6") layer to the satisfaction of the Consultant.
- .2 Provide excavating and backfilling outside the building with granular A brought in specifically for backfilling to a minimum of 450 mm (18") over the pipe. Backfilling outside building over and above the 450 mm (18") backfill as previously specified herein shall be by the Plumbing Contractor as specified under Division 2. Where backfilling outside the building is not specified under Division 2 the plumbing contractor shall provide new clean granular 'A' fill to grade level.
- .3 Bottoms of trenches shall be excavated so that the pipe will be supported on a 150 mm (6") compacted bed of clean granular 'A' fill. Provide all necessary pumping to maintain excavation free of water.
- .4 Should water be encountered during excavation, the plumbing contractor shall provide all labour and material, including all equipment required for dewatering the excavation. After the water has been removed, this Contractor shall install a 300 mm (12") base of compacted 50 mm (2") clear stone covered with filter cloth before installing backfill as detailed and/or as specified.
- .5 Be responsible for all weather protection required to install piping and/or equipment to the satisfaction of the Consultant.
- .6 Be responsible for providing all clear stone or granular 'A' material suitable for application to replace existing soil not suitable for backfilling above the 450 mm (18") bedding material.

1.32 CONFINED SPACES

- .1 Certain areas of the building may be defined as a "Confined Space". Any personnel working in these areas must have confined space training, appropriate equipment and undertake all work in conformance with appropriate codes and standards.
- .2 Refer to building documentation for any spaces deemed "Confined Space".

1.33 EXISTING SYSTEM DRAINAGE

- .1 Drain all existing piping and drainage systems including all related equipment as required to facilitate system renovations.
- .2 Disposal of existing system shall be to the requirements of the local and/or provincial regulations.

1.34 DOMESTIC HW SYSTEM BALANCING

- .1 Meet all requirements as specified for balancing of hydronic systems.
- .2 Locations of equipment measurements: To include, but not be limited to, following as appropriate: Inlet and outlet of each heater, tank, pump, circulator, at each controller, controlled device.
- .3 At each circuit setter balancing valve.
- .4 Locations of systems measurements to include, but not be limited to, following as appropriate: main, main branch, branch, sub-branch.

1.35 BALANCING OTHER PLUMBING SYSTEM

- .1 Recirculating systems pump flows, pressures
- .2 Pumped sanitary water systems: test for proper operation at all possible flow rates.

1.36 COOPERATION WITH OTHER TRADES

- .1 Give full cooperation to other trades and furnish in writing to other trades, with copies to the engineer, any information necessary to permit the work of all trades to be installed satisfactorily and with the least possible interference or delay.
- .2 Where plumbing work will be installed in close proximity to, or will interfere with work of other trades, assist in working out space conditions to make a satisfactory adjustment. Prepare composite working drawings and sections at a suitable scale, not less than ¼ inches = 1-foot – 0-inches, clearly showing how the plumbing work is to be installed in relation to the work of other trades. If work is installed before coordinating with other trades, or if it causes any interference with work of other trades, make the necessary changes in the work to correct the conditions and bear all costs.
- .3 Furnish to other trades necessary templates, patterns, setting drawings, and shop details for the proper installation of work and for coordinating adjacent work.

1.37 WATERPROOFING SEAL MATERIALS

- .1 Modular, expanding mechanical seal assemblies consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and pipe sleeve or wall opening, assembled with stainless steel bolts and pressure plates and designed so when bolts are tightened the links expand to seal the opening watertight. Select seal assemblies to suit pipe size and sleeve size or wall opening size.
- .2 Standard of quality assurance manufacturers are:
 - .1 Thunderline Corp. (Power Plant Supply Co.) "Link Seal" Model S-316
 - .2 The Metraflex Co. "MetraSeal" type ES
 - .3 Or approved equivalent.

1.38 SLEEVE, CUT, AND FORMED OPENING LOCATION DRAWINGS

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

- .2 Such drawings are to be completely and accurately dimensioned and relate sleeve, recesses, and formed openings to suitable grid lines and elevation datum, and are to take into account structural items such as grade beams, column caps, and column drop slabs.
- .3 Begin to prepare such drawings immediately upon notification of acceptance of bid and award of Contract.

1.39 SUSTAINABLE CONSTRUCTION

- .1 Construction Waste Management:
 - .1 Recycle all waste materials to avoid land fill sites where possible.
 - .2 All metal contents shall be recycled.
 - .3 All cardboard and paper shall be recycled.
 - .4 All plastic packaging shall be recycled.
 - .5 All wood shall be directed to the appropriate recycled wood section at the landfill site.
- .2 This contractor is responsible for their own waste management system and cost associated with the disposal. This can be their own on site system, daily removal, back to shop, or a communal system shared with other contractors on site.
- .3 In all cases the cost to remove materials on site are the cost of this contractor.

1.40 FREEZE PROTECTION

- .1 Do not run lines in outside walls, or locations where freezing may occur. Piping next to outside walls shall be in furred spaces with insulation between the piping and the outside wall. Insulation of piping shall not be considered freeze protection.

1.41 SCAFFOLDING, RIGGING, AND HOISTING

- .1 Provide all scaffolding, rigging, hoisting, and services necessary for erection and delivery into the premises of any equipment and apparatus furnished; remove same from premises when no longer required. Conform to OSHA requirements and standards.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ANSI/ASME B40.100, Pressure Gauges and Gauge Attachments.
- .3 CAN/CGSB-14.4, Thermometers, Liquid-in-Glass, Self Indicating, Commercial/Industrial Type.
- .4 CAN/CGSB-14.5, Thermometers, Bimetallic, Self-Indicating, Commercial/Industrial Type.

1.2 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with general requirements.
- .2 Submit manufacturer's product data for following items:
 - .1 Thermometers.
 - .2 Pressure gauges.
 - .3 Stop cocks.
 - .4 Siphons.
 - .5 Wells.

Part 2 Products

2.1 GENERAL

- .1 Design point to be at mid point of scale or range.
- .2 Ranges: suitable for application.

2.2 DIRECT READING THERMOMETERS

- .1 Industrial, variable angle type, liquid filled, 225 mm (9") scale length: to CAN/CGSB 14.4.
 - .1 Acceptable Manufacturers:
 - .1 Terice
 - .2 Winters
 - .3 Wiess

2.3 REMOTE READING THERMOMETERS

- .1 100 mm (4") diameter liquid filled activated dial type: to CAN/CGSB-14.5, accuracy within one scale division, brass movement, stainless steel capillary, stainless steel spiral armour, stainless steel bulb and polished stainless steel case for wall mounting.
 - .1 Acceptable Manufacturers:
 - .1 Terice
 - .2 Winters

2.4 THERMOMETER WELLS

- .1 Copper pipe: copper or bronze.
- .2 Steel pipe: brass or stainless steel.

2.5 PRESSURE GAUGES

- .1 115 mm (4 1/2"), dial type: to ANSI/ASME B40.100, Grade 2A, stainless steel phosphor bronze bourdon tube having 0.5% accuracy full scale unless otherwise specified.
 - .1 Acceptable Manufacturers:
 - .1 Winters
 - .2 Terice
 - .3 Wiess
 - .2 Provide:
 - .1 Snubber for pulsating operation.
 - .2 Diaphragm assembly for corrosive service.
 - .3 Gasketed pressure relief back with solid front.
 - .4 Bronze stop cock.

Part 3 Execution

3.1 GENERAL

- .1 Install so they can be easily read from floor or platform. If this cannot be accomplished, install remote reading units.
- .2 Install between equipment and first fitting or valve.

3.2 THERMOMETERS

- .1 Install in wells on all piping. Provide heat conductive material inside well.
- .2 Install in locations as indicated and on inlet and outlet of:
 - .1 Water heaters/DHW boilers inlet and outlet.
 - .2 All ports of thermostatic mixing valve.
 - .3 In other locations indicated.
- .3 Install wells as indicated only for balancing purposes.
- .4 Use extensions where thermometers are installed through insulation.

3.3 PRESSURE GAUGES

- .1 Install in following locations:
 - .1 Suction and discharge of pumps.
 - .2 Upstream and downstream of PRV's.
 - .3 Upstream and downstream of control valves.
 - .4 Outlet of boilers.

- .5 Inlet and outlet of backflow preventors.
- .6 Upstream & downstream of water meters.
- .7 In other locations as indicated.
- .2 Install gauge cocks for balancing purposes, elsewhere as indicated.
- .3 Use extensions where pressure gauges are installed through insulation.

3.4 NAMEPLATES

- .1 Install engraved lamicoid nameplates as specified elsewhere identifying medium.

END OF SECTION

Part 1 General

1.1 GENERAL PROVISIONS

- .1 Conform to the General Provisions of General Requirements Section.
- .2 This project is one of a retrofit nature in part, and which will require some demolition.
- .3 Allow for all remedial work in areas indicated on the drawings and as generally defined in the relevant sections of the specifications.

1.2 RELATED WORK SPECIFIED ELSEWHERE

- .1 Electrical Division.

1.3 SCOPE OF WORK

- .1 The scope of work is essentially the selected disconnection and/or removal of services and/or equipment, piping, ductwork, etc. as indicated or required to complete the work.

Part 2 Products

2.1 GENERAL

- .1 This Division is to liaise with the Owners or Consultant for equipment being removed that may be suitable for reuse to that specified or handed over to the Owner.
- .2 This Division is to take full responsibility for any special tools or equipment required to disassemble or remove material from building.

Part 3 Execution

3.1 GENERAL

- .1 The general requirements are indicated on the drawings and on the outline specification in Division 1.
- .2 The general execution of the demolition is to be carried out in a clean and efficient manner.
- .3 Demolition of existing ceilings, walls, etc., to facilitate removal of existing services or equipment or installation of new to be kept to a minimum and then restored to match existing.
- .4 All openings or holes created by removal of existing plumbing systems which are not being reused are to be patched with the same material surrounding surfaces.
- .5 All new holes and openings to facilitate plumbing systems are to be patched to match surrounding surfaces.
- .6 Protect all existing furnishings, materials, and equipment. Any damage occurring as a result of the work of this Division shall be repaired or replaced at the expense of this Division.

- .7 Where work involves breaking into or connecting to existing services, carry out work at times directed by the Owners in an expedient manner with minimum disruption to the facility and systems downtime.
- .8 Where unknown services are encountered, immediately advise Consultant and confirm findings in writing.
- .9 Where the location of any services has been shown on the plans, such information is not guaranteed. It is this Division's responsibility to verify locations, invert elevations, etc., immediately after moving on site. Should for any reason the information obtained necessitate changes in procedure or design, advise the Consultant at once. If verification of existing conditions is not done at the outset and any problems arise, the responsibility for same is entirely this Division's.
- .10 Disconnect and/or remove equipment, piping, ductwork, etc. as indicated.
- .11 Cap and conceal all redundant and obsolete connections.
- .12 Provide a list of equipment to be removed to the Owner, for their acceptance of same. Remove all equipment from site which the Owner does not retain.
- .13 Maintain equipment to be retained by Owner on site where directed by Consultant.
- .14 Demolition of all parts of the work must be completed within the confines of the work area and in such a way as the dust produced and risk to injury of will not adversely affect the building users.
- .15 Demolished areas of the existing building will remain in their current use in some cases. Demolition in these areas must be kept to the minimum required to complete the work.
- .16 Demolition shall take place within areas isolated from all other areas with appropriate hoarding, scaffolding, netting, fencing or other means of security between building users and the work.
- .17 Co-ordinate making safe electrical devices, capping plumbing and removal of fixtures prior to commencement of demolition.
- .18 All piping and equipment to be removed and/or abandoned shall be drained prior to capping and/or abandoning. Disposal of all liquids shall be to the approval of authority of having jurisdiction and/or provincial regulations.

3.2 EXISTING SYSTEM DRAINAGE

- .1 Drain all existing piping systems including all related equipment as required to facilitate system renovations.
- .2 Disposal of existing system shall be to the requirements of the local and/or provincial regulations.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 American Society for Testing and Materials
 - .1 ASTM A53/A53M, Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
 - .2 ASTM A105/A105M, Specification for Carbon Steel Forgings for Piping Applications.
 - .3 MSS SP 58 (Manufacturers Standardization Society of the Valve and Fitting Industry – Pipe Hangers and Supports, Materials, Design and Manufacture).

1.2 DELEGATED ENGINEERING DESIGN AND PRODUCT SUBMITTAL

- .1 Provide a delegated engineering design for all hydronic and domestic water risers to good engineering practice.
 - .1 Design Limitation: No more than 1,800 lbs shall be point loaded per core slab plank per floor.
- .2 The design shall include analysis documentation signed and sealed by a licensed Professional Engineer with a minimum of five (5) years of experience in the design of piping risers and associated support systems.
- .3 Submittal Requirements:
 - .1 Submit detailed calculations addressing thermal expansion, and where applicable to project location, seismic restraint requirements for the piping systems.
 - .2 Submit schematic drawing of the installed Riser system indicating components used and locations.
 - .3 Submit maximum anchor reaction loads for review and approval by the Structural Engineer of Record.
 - .4 Provide detailed drawings for each anchor, including dimensions and attachment method to the building structure.
 - .5 Provide detailed drawings and specifications for field assembly and structural attachment of pipe alignment guides.
 - .6 Provide product submittals for each required guide, anchor and expansion device.
 - .1 Manufacturer, model number, line contents, pressure and temperature rating.
 - .2 Movement handled; axial, lateral, angular and the amounts of each.
 - .3 Nominal size and dimensions including details of construction and assembly.

1.3 CLOSEOUT SUBMITTALS

- .1 Submit maintenance data in accordance with general requirements.
- .2 Submit sign off letter from Professional Engineer who completed the expansion compensation design.
- .3 Data to include:
 - .1 Servicing requirements, including any special requirements, stuffing box packing, lubrication and recommended procedures.

Part 2 Products

2.1 ACCEPTABLE MATERIALS

- .1 All materials furnished under this section shall be from a single supplier, designed and engineered as a complete system:
 - .1 Mason Industries
 - .2 Kinetics Noise Control Inc.
 - .3 Flex Pression Ltd.

2.2 ANCHORS AND GUIDES

- .1 Anchors:
 - .1 Provide as indicated in expansion compensation design drawings.
- .2 Alignment guides:
 - .1 Provide as indicated in expansion compensation design drawings.
 - .2 To accommodate specified thickness of insulation.
 - .3 Vapour barriers, jackets to remain uninterrupted.

2.3 ALIGNMENT GUIDES

- .1 Wall Mounted:
 - .1 Spider type, designed to maintain axial alignment of piping.
 - .2 Guides shall not carry dead weight loads.
 - .3 Guides shall allow for movement of insulation with pipe.
- .2 Floor Mounted:
 - .1 Anchored to floor or ceiling and designed to maintain axial alignment of piping.
 - .2 Guides shall be provided with plastic inserts.
 - .3 Guides shall not carry dead weight loads.
 - .4 Guides shall allow for movement of insulation with pipe.

2.4 SLIP TYPE EXPANSION JOINTS

- .1 Application: For axial pipe movement, as indicated.
- .2 Repacking: Under full line pressure.

- .3 Body and packing housings: Class 150, 1Mpa carbon steel pipe to ASTM A53/A53M, Grade B. Wall thickness to match pipe and with raised face slip-on flanges to match pipe. One-piece body construction.
- .4 Slip or traverse sleeves: Carbon steel pipe to ASTM A53/A53M, Grade B, hard chrome plated.
- .5 Anchor base: Construction steel, welded to body.
- .6 Guides (internal and external): Embody into packing housing with concentric alignment of slip or traverse sleeve with packing housing.
- .7 Extension limit stop: Stainless steel, to prevent over-extension with accessible and removable pins.
- .8 Packing rings: 6 minimum, P7FE (teflon) or graphite impregnated non-asbestos fiber.
- .9 Thermal plastic packing: P7FE (teflon) or graphite impregnated non-asbestos fiber slug supplied loose.
- .10 Lubricating fittings: Pet cocks with grease nipple.
- .11 Plunger body and plunger:
 - .1 Plunger body: heavy wall carbon steel welded to body.
 - .2 Plunger: carbon steel with hex head for use with socket wrench.
- .12 Lubricant: To manufacturer's recommendations.
- .13 Lubricant gun: Complete with hose assembly.
- .14 Drip connection: 20 MPa (2900 psi) forged steel to ASTM A105. Include half coupling with drain plug.
- .15 Lubricant fittings, plunger, gun not required for low friction self lubricating packing.

2.5 BELLOWS TYPE EXPANSION JOINTS

- .1 For axial, lateral or angular movements, as indicated.
- .2 Maximum operating pressure: 1034 kPa (150 psi).
- .3 Maximum operating temperature: 200°C (392°F).
- .4 Type A: Free flexing, factory tested to 1½ times maximum working pressure. Furnish test certificates.
- .5 Type B: Externally pressurized, constant volume, pressure balanced, designed to eliminate pressure thrust, factory tested to 1.5 times maximum working pressure. Furnish test certificates.
- .6 Bellows:
 - .1 Multiple bellows, hydraulically formed, two ply, austenitic stainless steel for specified fluid, pressure and temperature, water treatment and pipeline cleaning procedures.
- .7 Reinforcing or control rings:
 - .1 2 piece nickel iron.

- .8 Ends:
 - .1 Slip-on flanges to match pipe.
- .9 Liner:
 - .1 Austenitic stainless steel in direction of flow.
- .10 Shroud:
 - .1 Carbon steel, painted.

2.6 EXPANSION LOOPS

- .1 Steel braided hoses, U-loop assembly.
- .2 Corrugated metal inner hoses, braided outer sheaths, braid retaining collar and 90 degree elbows.
- .3 321 or 316 stainless steel corrugated hose
- .4 304 or 316 stainless steel braid and braid collar
- .5 Operating conditions:
 - .1 Working pressure: 1034 kPa (150 psi).
 - .2 Working temperature: 250°C (482°F).
 - .3 To match system requirements.

2.7 FLEXIBLE CONNECTIONS

- .1 Application: To suit motion.
- .2 Minimum length in accordance with manufacturer's recommendations to suit offset.
- .3 Inner hose: Stainless steel corrugated.
- .4 Braided wire mesh stainless steel outer jacket.
- .5 Diameter and type of end connection: As indicated.
- .6 Operating conditions:
 - .1 Working pressure: 1034 kPa (150 psi).
 - .2 Working temperature: 250°C (482°F).
 - .3 To match system requirements.

2.8 EXPANSION COMPENSATORS (EXP)(2"-4")

- .1 All welded packless guided construction complete with multi ply stainless steel bellows.
- .2 Operating temperature (700°F).
- .3 Provide model HP3 for steel pipe and model HBFF3 for copper pipe.
- .4 Movement capability of 4" axial. Welded ends.
- .5 Material to match piping system.

.6 Acceptable Manufacturers:

- .1 Metraflex HP
- .2 Mark David Canada
- .3 Senior Flexonics
- .4 Flexi-craft

2.9 FLOATING RISER SYSTEM COMPONENTS

.1 Free Standing Spring Isolator

- .1 Vibration isolators shall be free standing, unhoused, laterally stable steel springs. Springs shall have a lateral stiffness greater than 1.0 times the rated vertical stiffness and shall be designed to provide a minimum 50% overload capacity.
- .2 Springs shall be assembled or welded between top and bottom load plates. The upper load plate shall be provided with steel leveling bolts, lock nut and washer for attachment to the supported equipment. The lower load plate shall incorporate a non-skid noise isolation pad and shall have provisions for bolting the isolator to the supporting structure, as required.
- .3 Springs shall be selected to provide operating static deflections shown on the Vibration Isolation Schedule or as otherwise indicated on the project documents. Springs shall be colour coded or otherwise identified to indicate load capacity.
- .4 Design Basis: Kinetics Noise Control, Model FDS.

.2 Coil Spring Isolator Incorporated with a Steel Housing

- .1 Spring isolators shall be seismic control restrained spring isolators, incorporating a single vibration isolator, having all the characteristics of the free-standing open spring isolators as previously specified. Springs shall be restrained using a housing engineered to limit both lateral and vertical movement of the supported equipment during an earthquake without degrading the vibration isolation of the spring during normal equipment operating conditions.
- .2 Vibration isolators shall incorporate a steel housing and snubbing grommet system designed to limit motion to approximately 0.2" (5 mm) in any direction and to prevent any direct metal-to-metal contact between the supported member and the fixed housing. The restraining system shall be designed to withstand a force equivalent to 1.0 g in any lateral or vertical direction without yield or failure. Where the capacity of the anchorage hardware in concrete is inadequate for the required seismic loadings, an adapter plate to allow the addition of more or larger anchors will be fitted to fulfill these requirements. In addition to the primary isolation spring, the load path will include a minimum 0.25" (6 mm) thick neoprene pad.
- .3 To facilitate servicing, the isolator will be designed in such a way that it can be removed without the requirement to lift or otherwise disturb the supported equipment.
- .4 Design Basis: Kinetics FHS and FHSL.

.3 Seismic Control Restrained Spring Isolator

- .1 Vibration isolators shall be seismically rated, restrained spring isolators for equipment which is subject to load variations and large external forces. Isolators shall consist of large diameter, laterally stable, steel springs assembled into welded steel housing assemblies designed to limit movement of the supported equipment in all directions.
- .2 Housing assembly shall be of fabricated steel members and shall consist of a top load plate complete with adjusting and leveling bolts, adjustable vertical restraints, isolation washers, and a bottom plate with internal non-skid noise isolation pads and holes for anchoring of housing to supporting structure. Housing shall be hot dip galvanized for corrosion resistance. Housing shall be designed to provide a constant free and operating height within 1/8" (3 mm).
- .3 The isolator housing shall provide a minimum of 1 g restraint in all directions.
- .4 Spring elements shall be selected to provide static deflections as shown on the vibration isolation schedule or as indicated or required in the project documents. Springs shall be colour coded or otherwise identified.
- .5 Spring elements shall have a lateral stiffness greater than 1.2 times the rated vertical stiffness and shall be designed to provide a minimum of 50% overload capacity. Non-welded spring elements shall be polyester powder coated and shall have a 1000 hr rating when tested in accordance with ASTM B-117.
- .6 Design Basis: Kinetics FLSS.

.4 All Direction 3 Axis Riser Anchor Assembly

- .1 Risers shall be restrained against excessive movement during service by the use of 3-axis resilient anchors designed to withstand the required installation and operating forces. Anchors are intended to be used in sets of two (2) and be oriented to effectively restrain the riser in all three directions, with particular emphasis on large and variable vertical loads that would be imparted by changes in the riser weight.
- .2 Anchors shall be of steel construction and shall be attached to the riser with either a heavy-duty riser clamp or a welded support bracket in a manner consistent with anticipated design loads. Snubbers shall limit lateral and vertical riser movement at each anchor location to a maximum of 1/4" (6 mm) in any direction.
- .3 Anchors shall include a minimum 1/2" (13 mm) thick resilient neoprene pad to cushion any impact and to avoid any potential for metal-to-metal contact. Maximum neoprene bearing pressure shall not exceed 1500 pounds / sq. inch (10.4 N / sq. mm). Anchors shall be capable of withstanding an externally applied force of up to their rated capacity in any direction.
- .4 Design Basis: Kinetics KPA.

- .5 Horizontal Motion Limiting Riser Guide Assembly
 - .1 Risers shall be restrained against excessive lateral movement during service by the use of 2-axis resilient guides designed to withstand the required installation and operating forces. Guides are intended to be used in sets of two (2) and be oriented to effectively restrain the riser in all horizontal directions, but to allow free motion within their operating range in the vertical axis.
 - .2 Guides shall be of steel construction and shall be attached to the riser with either a heavy-duty riser clamp or a welded support bracket in a manner consistent with anticipated design loads. Guides shall limit lateral riser movement at each Guide location to a maximum of ¼" (6 mm) in any direction.
 - .3 Anchors shall include a minimum 1/2" (13 mm) thick resilient neoprene pad to cushion any impact and to avoid any potential for metal-to-metal contact. Maximum neoprene bearing pressure shall not exceed 1500 pounds / sq. inch (10.4 N / sq. mm). Anchors shall be capable of withstanding an externally applied lateral force of up to their rated capacity in any direction.
 - .4 Design Basis: Kinetics KRG.
- .6 Spring Isolation Hanger
 - .1 Vibration isolators for suspended equipment, with minimum static deflection requirement exceeding 0.4" (10 mm), shall be hangers consisting of a free-standing, laterally stable steel spring and elastomeric washer in series, assembled in a stamped or welded steel bracket.
 - .2 The bracket shall be finished with a polyester powder coating.
 - .3 The hanger bracket shall be designed to carry a 500% overload without failure and to allow a support rod misalignment through a 30° arc without metal-to-metal contact or other short circuit.
 - .4 The 1" and 2" hanger brackets shall incorporate spring caps with indexed steps which correspond to the washer diameter of appropriately sized hanger rod to keep the rod centered in the spring cap and reduce rod misalignment.
 - .5 Springs shall have a minimum lateral stiffness of 1.0 times the rated vertical stiffness.
 - .6 Springs shall be selected to provide operating static deflections shown on the Vibration Isolation Schedule or as indicated on the project documents. Springs shall be colour coded or otherwise identified to indicate load capacity.

Part 3 Execution

3.1 INSTALLATION

- .1 Install expansion joints with cold setting, as indicated as instructed by Consultant. Make record of cold settings.
- .2 Install expansion joints and flexible connections in accordance with manufacturer's instructions.
- .3 Install pipe anchors and guides as indicated. Anchors to withstand 150% of axial thrust.

- .4 All isolators shall be adjusted to the preset dimensions provided as part of the engineered expansion system design prior to system filling.
- .5 Once the system is filled and loaded and operating at its normal temperature all restrained spring isolators shall be inspected and where/if they remain preloaded, the nuts shall be backed off the minimum amount to ensure contact with preloaded screws no longer exists.
- .6 No rigid connections shall be made between the system and structure where it will degrade either the seismic or expansion performance of the engineered system.

3.2 SITE REVIEW

- .1 The Professional Engineer who stamps the submitted expansion compensation shop drawings shall be responsible to conduct periodic site reviews of the installed systems.
- .2 The Professional Engineer shall provide written confirmation that the systems are installed to manufacturer recommendations and their design prior to project closeout.

3.3 APPLICATION

- .1 Provide on all vibration isolated equipment.
- .2 Provide where requested by equipment manufacturers installation manuals.
- .3 Install in accordance with manufacturer's recommendations.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 American National Standards Institute/ American Society of Mechanical Engineers (ANSI/ASME)
 - .1 ANSI/ASME B31.1, Power Piping, (SI Edition).
- .3 American Society for Testing and Materials (ASTM)
 - .1 ASTM A 125, Specification for Steel Springs, Helical, Heat-Treated.
 - .2 ASTM A 307, Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 - .3 ASTM A 563, Specification for Carbon and Alloy Steel Nuts.
- .4 Manufacturer's Standardization Society of the Valves and Fittings Industry (MSS)
 - .1 MSS SP-58, Pipe Hangers and Supports - Materials, Design, Manufacture Selection, Application, and Installation.

1.2 DESIGN REQUIREMENTS

- .1 Construct pipe hanger and support to manufacturer's recommendations utilizing manufacturer's regular production components, parts and assemblies.
- .2 Base maximum load ratings on allowable stresses prescribed by ASME B31.1 or MSS SP-58.
- .3 Ensure that supports, guides, anchors do not transmit excessive quantities of heat to building structure.
- .4 Design hangers and supports to support systems under all conditions of operation, allow free expansion and contraction, prevent excessive stresses from being introduced into pipework or connected equipment.
- .5 Provide for vertical adjustments after erection and during commissioning. Amount of adjustment to be in accordance with MSS SP-58.

1.3 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with general requirements.
- .2 Submit shop drawings and product data for following items:
 - .1 All bases, hangers and supports.
 - .2 Connections to equipment and structure.
 - .3 Structural assemblies.

1.4 MAINTENANCE DATA

- .1 Provide maintenance data for incorporation into manual specified in general requirements.

Part 2 Products

2.1 GENERAL

- .1 Fabricate hangers, supports and sway braces in accordance with ANSI B31.1 and MSS-SP-58.
- .2 Use components for intended design purpose only. Do not use for rigging or erection purposes.

2.2 PIPE HANGERS

- .1 Finishes:
 - .1 Pipe hangers and supports: to ANSI & ULC requirements
 - .2 Ensure steel hangers in contact with copper piping are copper plated.
- .2 Upper attachment structural: Suspension from upper flange of I-Beam or joist.
 - .1 Cold piping NPS 50 mm (2") maximum: Ductile iron C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip.
 - .1 Rod: 10 mm (3/8") UL listed
 - .2 Cold piping NPS 65 mm (2 1/2") or greater, all hot piping: Malleable iron beam clamp, eye rod, jaws and extension with carbon steel retaining clip, tie rod, nuts and washers, UL listed & FM approved.
- .3 Upper attachment structural: Suspension from upper flange of I-Beam.
 - .1 Cold piping NPS 50 mm (2") maximum: Ductile iron top-of-beam C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip, UL listed.
 - .2 Cold piping NPS 65 mm (2 1/2") or greater, all hot piping: Malleable iron top-of-beam jaw-clamp with hooked rod, spring washer, plain washer and nuts.
- .4 Upper attachment to concrete.
 - .1 Ceiling: Carbon steel welded eye rod, clevis plate, clevis pin and cotters with weldless forged steel eye nut. Ensure eye 6 mm (1/4") minimum greater than rod diameter.
 - .2 Concrete inserts: wedge shaped body with knockout protector plate ULC listed.
Note: Rapidex and Siporex are not considered concrete. Should one of these systems be encountered, piping/ductwork and/or equipment shall be supported from adjacent walls or from supplemental steel provided by this contractor attached to the adjacent walls/structure.
- .5 Shop and field-fabricated assemblies.
 - .1 Trapeze hanger assemblies: ASME B31.1.
 - .2 Steel brackets: ASME B31.1.
- .6 Hanger rods: threaded rod material to MSS SP-58.
 - .1 Ensure that hanger rods are subject to tensile loading only.
 - .2 Provide linkages where lateral or axial movement of pipework is anticipated.

- .7 Pipe attachments: material to MSS SP-58.
 - .1 Attachments for steel piping: carbon steel.
 - .2 Attachments for copper piping: copper plated black steel.
 - .3 Use insulation shields for all piping.
 - .4 Oversize pipe hangers and supports to accommodate thermal insulation. Provide 1.5 mm (16 gauge) saddles.
- .8 Adjustable clevis: material to MSS SP-58 UL listed, clevis bolt with nipple spacer and vertical adjustment nuts above and below clevis.
 - .1 Ensure "U" has hole in bottom for rivetting to insulation shields.

2.3 RISER CLAMPS

- .1 Steel or cast iron pipe: black carbon steel to MSS-SP-58, type 42, UL listed.
- .2 Copper pipe: carbon steel copper plated to MSS-SP-58, type 42.
- .3 Bolts: to ASTM A 307.
- .4 Nuts: to ASTM A 563.

2.4 INSULATION PROTECTION SHIELDS

- .1 Insulated cold piping:
 - .1 64 kg/m² (13.12 lbs/ft²) density insulation plus insulation protection shield to: MSS SP-69, galvanized sheet carbon steel. Length designed for maximum 3 m (10') span.
- .2 Insulated hot piping:
 - .1 Curved plate 300 mm (12") long, with edges turned up, welded-in centre plate for pipe sizes NPS 300 mm (12") and over, carbon steel to comply with MSS SP-58.

2.5 EQUIPMENT SUPPORTS

- .1 Fabricate equipment supports not provided by equipment manufacturer from structural grade steel meeting requirements of miscellaneous metals, specified herein. Submit calculations with shop drawings.

2.6 OTHER EQUIPMENT SUPPORTS

- .1 From structural grade steel meeting requirements of structural steel section specified herein.
- .2 Submit structural calculations with shop drawings.

2.7 MANUFACTURER

- .1 Acceptable Manufacturers:
 - .1 Grinnell
 - .2 Anvil
 - .3 Myatt
 - .4 Taylor

Part 3 Execution

3.1 INSTALLATION

- .1 Install in accordance with:
 - .1 Manufacturer's instructions and recommendations.
- .2 Clamps on riser piping:
 - .1 Support independent of connected horizontal pipework using riser clamps and riser clamp lugs welded to riser.
 - .2 Bolt-tightening torques to be to industry standards.
 - .3 Steel pipes: Install below coupling or shear lugs welded to pipe.
 - .4 Cast iron pipes: Install below joint.
- .3 Clevis plates:
 - .1 Attach to concrete with 4 minimum concrete inserts at each corner.
- .4 Provide supplementary structural steelwork where structural bearings do not exist or where concrete inserts are not in correct locations.

3.2 HANGER SPACING

- .1 Plumbing piping: most stringent requirements of Canadian Plumbing Code, Provincial Code, or authority having jurisdiction.
- .2 Copper piping: up to NPS 15 mm (1/2"): every 1.5 m (5').
- .3 Within 300 mm (12") of each elbow and:

Maximum Pipe Size: NPS	Spacing Steel	Maximum Spacing Copper
up to 32 mm (1 1/4")	2.1 m (7')	1.8 m (6')
40 mm (1 1/2")	2.7 m (9')	2.4 m (8')
50 mm (2")	3.0 m (10')	2.7 m (9')
65 mm (2 1/2")	3.6 m (12')	3.0 m (10')
80 mm (3")	3.6 m (12')	3.0 m (10')
90 mm (3 1/2")	3.9 m (13')	3.3 m (11')
100 mm (4")	4.2 m (14')	3.6 m (12')

3.3 HANGER INSTALLATION

- .1 Install hanger so that rod is vertical under operating conditions.
- .2 Adjust hangers to equalize load.
- .3 Support from structural members. Where structural bearing does not exist or inserts are not in suitable locations, provide supplementary structural steel members.
- .4 Do "NOT" support piping, ductwork and equipment from roof deck, on bottom chord of floor and/or roof joist and/or from OWSJ bridging. Provide structural member between joist.

3.4 HORIZONTAL MOVEMENT

- .1 Angularity of rod hanger resulting from horizontal movement of pipework from cold to hot position not to exceed 4mm (5/32") from vertical.
- .2 Where horizontal pipe movement is less than 15 mm (1/2"), offset pipe hanger and support so that rod hanger is vertical in the hot position.

3.5 FINAL ADJUSTMENT

- .1 Adjust hangers and supports:
 - .1 Ensure that rod is vertical under operating conditions.
 - .2 Equalize loads.
- .2 Adjustable clevis:
 - .1 Tighten hanger load nut securely to ensure proper hanger performance.
 - .2 Tighten upper nut after adjustment.
- .3 C-clamps:
 - .1 Follow manufacturer's recommended written instructions and torque values when tightening C-clamps to bottom flange of beam.
- .4 Beam clamps:
 - .1 Hammer jaw firmly against underside of beam.

END OF SECTION

Part 1 General

1.1 APPLICATION

- .1 Seismic restraint is becoming more prominent with improved soil testing equipment. Seismic requirement is not site specific by geographical area but determined by site soil conditions.
- .2 Where the structural engineer or architect documents have $I_e \cdot S_a(0.2) \cdot F_a < 3.5$ seismic is not required on the plumbing, mechanical, electrical, or fire protection systems.
- .3 Where the structural engineer or architect documents have $I_e \cdot S_a(0.2) \cdot F_a \geq 3.5$ seismic is required on the plumbing, mechanical, electrical, or fire protection systems.
- .4 Seismic will always be required on fire protection systems when required by NFPA codes.
- .5 Seismic will always be required on any "Disaster Relief Building." For example, hospitals, police stations, ambulance building, etc.
- .6 When it is unclear in the tender documents request information from the structural engineer or architect for clarification.

1.2 SECTION INCLUDES

- .1 Seismic Requirements for single rod hanger support for conduit, pipe and other similar systems.
- .2 Seismic Requirements for trapeze type supports for cable tray, conduit, pipe and other similar systems.
- .3 Seismic requirements for all plumbing equipment and piping.

1.3 RELATED WORK SPECIFIED ELSEWHERE

- .1 Vibration Isolation Measures.

1.4 REFERENCE STANDARDS

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 National Building Code of Canada (NBC).
- .3 Canadian Standards Association
 - .1 CSA S832, Seismic Risk Reduction of Operation and Functional Components (OFCs) of Buildings.
 - .2 CAN/CSA-S16.1 Limit States Design of Steel Structures
 - .3 CAN3-S136 Design of Cold Steel Structural Members
 - .4 CSA W47.1 Certification of Companies for Fusion Welding of Steel
 - .5 CSA W59 Welded Steel Construction

- .4 American Society of Testing and Materials
 - .1 ASTM A653/S653M, Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (galvannealed) by the Hot Dip Process.
 - .2 ASTM A879M Specification for Steel Sheet, Zinc Coated by the Electrolytic Process for Applications Requiring Designation of the Coating Mass on Each Surface.
 - .3 ASTM A307 Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 - .4 ASTM A325M Specification for Structural Bolts, Heat Treated 830MPa Minimum Tensile Strength.
- .5 All local codes.
- .6 FEMA: Seismic Restraint Installation Manuals 412. 413. & 414
 - .1 FEMA 412: Installing Seismic Restraints for Plumbing/Mechanical Equipment
 - .2 FEMA 413: Installing Seismic Restraints for Electrical Equipment
 - .3 FEMA 414: Installing Seismic Restraints for Duct and Pipe
- .7 ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.).
- .8 ASHRAE Applications Handbook; Seismic and Wind Restraint Design Chapter.

1.5 DEFINITIONS

- .1 A_v : Effective peak velocity related acceleration coefficient BOCA, SBC Code.
- .2 S_1 : Mapped Long Period Seismic Acceleration Coefficient IBC, TI-809-04, ASCE7.
- .3 S_s : Mapped Short Period Seismic Acceleration Coefficient IBC, TI-809-04, ASCE7.
- .4 v : Zonal Velocity Coefficient NBC-Canada.
- .5 VISCMA: The Vibration Isolation and Seismic Control Manufacturers Association has developed Testing and Rating Standards for Seismic Restraint Components that comply with Code and ASHRAE based requirements.
- .6 VISCMA 102-2007: Static Qualification Standards for Obtaining a VISCMA Compliant Seismic Component Rating.
- .7 Z : Seismic Zone defines Seismic Coefficient C_a used by UBC Code.

1.6 PERFORMANCE REQUIREMENTS

- .1 Design Ground Acceleration Coefficient (A_v , S_s , v , or Z depending on Code = X.XX).
- .2 (If IBC or TI-809-04) Design Long Period Ground Acceleration Coefficient (S_1 = X.XX).
- .3 Design Soil Type = (S_a , S_b , S_c , S_d) as appropriate. (If NBC Canada, the Foundation Factor).
- .4 Importance or Performance Factor appropriate to structure = I_p = X.XX.
- .5 If UBC Zone 4, Proximity to Fault and, if less than 10km, Fault Type.
- .6 Schedule or drawings indicating critical (I_p = 1.5) Duct/Piping systems, including systems whose importance factor may be increased by proximity to critical components.

1.7 DESCRIPTION OF SYSTEM

- .1 It shall be understood that the requirements of this seismic restraint section are in addition to other requirements as specified elsewhere for the support and attachment of equipment and plumbing services, and for the vibration isolation of same equipment. Nothing on the project drawings or specifications shall be interpreted as justification to waive the requirements of this seismic restraint section.
- .2 The work under this section shall include furnishing all labour, materials, tools, appliances, and equipment, and performing all operations necessary for the complete execution of the installation of seismic snubber restraint assemblies as shown, detailed, and/or scheduled on the drawing and/or specified in this section of the specifications.
- .3 All seismic snubber restraint assemblies shall meet the following minimum requirements:
 - .1 The snubber/restrained isolator for isolated equipment shall include a resilient element that will ensure that no un-cushioned shock can occur (this does not include cable restraints).
 - .2 It shall be possible to visually inspect the resilient material for damage and allow for replacement, if necessary.
 - .3 All snubbers are to include a maximum air gap of 0.25 in (6 mm).
 - .4 Seismic restraint systems shall be designed to offer seismic restraint in all directions, unless otherwise noted.
 - .5 Seismic restraint capacities to be verified by an independent test laboratory or certified by a registered Professional Engineer to ensure that the design intent of this specification is realized. Verification shall be by one of the following methods:
 - .1 An NRTL (National Recognized Testing Laboratory), or laboratory recommended by VISCMA.
 - .2 Certified by a Professional Engineer with at least 5 years of experience, using industry standard methods of analysis, which employ common engineering practices. Adherence to the ratings standard within ASHRAE SPC171 and VISCMA 102-2007 is required.
 - .3 By a nationally recognized agency, such as VISCMA, that has reviewed and approved the restraint.

1.8 SYSTEM DESIGN

- .1 Seismic restraint manufacturer shall be responsible for the structural design of attachment hardware as required to attach snubbers/restraints to both the equipment and supporting structure on vibration isolated equipment, or to directly attach equipment to the building structure for non-isolated equipment.
- .2 The contractor shall furnish, to the seismic restraint manufacturer, a complete set of approved shop drawings of all equipment that is to be restrained, from which the selection and design of seismic restraint devices and/or attachment hardware will be completed. The shop drawings furnished shall include, at a minimum, basic equipment layout, length, and width dimensions, and installed operating weights of the equipment to be restrained.

- .3 All piping, ductwork and equipment is to be restrained to meet code requirements. At a minimum, the seismic restraint manufacturer shall provide documentation on maximum restraint spacing for various restraint sizes and anchors, as well as “worst case” reaction loads for each restraint and/or anchor size.
- .4 The contractor shall ensure that all housekeeping pads used are adequately reinforced and are properly dowelled to the building structure, so as to withstand calculated seismic forces. In addition, the size of the housekeeping pad is to be coordinated with the seismic restraint manufacturer to ensure that adequate edge distances exist in order to obtain the desired equipment anchor capacities.

1.9 SEISMIC BRACING AND SUPPORT DESIGN REQUIREMENTS

- .1 Seismic restraint designer shall co-ordinate all attachments with the structural engineer of record.
- .2 Design analysis shall include calculated dead loads, static seismic loads, and capacity of materials utilized for the connection of the equipment or system to the structure.
- .3 Analysis shall detail anchoring methods, bolt diameter, and embedment depth.
- .4 All seismic restraint devices shall be designed to accept without failure the forces calculated per the applicable building code and as summarized in Section 3.01.
- .5 Friction from gravity loads shall not be considered resistance to seismic forces.
- .6 Fire protection systems shall meet the requirements of NFPA-13 and NFPA-14. Sway bracing used for seismic restraint purposes must be fitted with provisions to resist the vertical force component of the diagonal brace. Single diagonal brace for seismic restraint will not be approved.

1.10 QUALITY ASSURANCE

- .1 The contractor shall provide pre-engineered seismic restraint systems to meet total design lateral force requirements for support and restraint of piping, conduit, cable trays and other similar systems and equipment where required by the applicable building code.
- .2 System Supports/Restraints: Firms regularly engaged in the manufacture of products of the types specified in this section, whose products have been in satisfactory use in similar service for not less than 5 years.
- .3 Bolted framing channels and fittings shall have the manufacturers name, part number, and material heat code identification number stamped in the part itself for identification. Material certification sheets and test reports must be made available by the manufacturer upon request.
- .4 Only companies experienced in performing the work of this section shall do the installation.
- .5 All seismic restraint installations shall be independently reviewed by the Owners Representative for compliance with project specifications.

1.11 SUBMITTALS

- .1 Product Data: Include Seismic Rating Curve for each seismically rated isolator or restraint component.
- .2 Samples: The contractor shall submit samples of specified seismic snubber devices for approval.
- .3 Shop Drawings shall include the following:
 - .1 Design Calculations: Calculate requirements for selecting seismically rated vibration isolators and seismic restraints. Certification documents to be signed and sealed by a qualified Professional Engineer with at least 5 years of experience in the design of seismic restraints. Professional engineer shall have local jurisdiction and provide periodic field review and final certification upon completion of the project. All costs and fees associated with the engineering shall be the responsibility of this contractor.
 - .2 Vibration Isolation Bases: Dimensional drawings including anchorage and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads.
 - .3 Seismic-Restraint Details: Detailed submittal drawings of seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors. Include ratings for loads.
 - .4 Equipment Manufacturer Seismic Qualification Certification: The Equipment Manufacturer must submit certification that each piece of provided equipment will withstand seismic forces identified in "Performance Requirements" Article above. Include the following:
 - .1 Basis for Certification: Indicate whether the "withstand" certification is based on actual test assembled components or on calculations.
 - .2 Indicate the equipment is certified to be durable enough to:
 - .1 structurally resist the design forces and/or
 - .2 will remain functional after the seismic event.
 - .5 Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - .6 Detailed description of the assumed equipment anchorage devices on which the certification is based.

1.12 DELIVERY, STORAGE, AND HANDLING

- .1 Deliver strut systems, pipe hangers and components carefully to avoid breakage, denting, and scoring finishes. Do not install damaged equipment.
- .2 Store strut systems, pipe hangers and components in original cartons and in clean dry space; protect from weather and construction traffic.

1.13 WORK FURNISHED BUT NOT INSTALLED

- .1 The materials and systems specified in this section shall be purchased by the plumbing contractor from a single seismic snubber restraint materials manufacturer to assure sole source responsibility for the performance of the seismic restraints used.

- .2 The materials and systems specified in this section can, at the contractor's option, be installed by the subcontractor who installs the seismic restraint systems.

1.14 COORDINATION

- .1 Coordinate size, shape, reinforcement and attachment of all housekeeping pads supporting seismically rated equipment. Concrete shall have a minimum compressive strength of 3,000 psi or as specified by the consultant.
- .2 Coordinate with seismic restraint manufacturer to locate and size structural supports underneath seismically restrained equipment (e.g. roof curbs, cooling towers, and other similar equipment).

1.15 INSTALLATION

- .1 Installation of all seismic restraint materials specified herein shall be accomplished following the manufacturer's written instructions. Installation instructions shall be submitted to the engineer for approval prior to the beginning of the work.

Part 2 Products

2.1 MATERIALS

- .1 Unless otherwise specified materials used in the Work shall conform to the following:
 - .1 All steel rolled sections and steel plates shall conform to CAN/CSA G40.21M-300W
 - .2 All steel hollow structural steel sections shall conform to CAN/CSA G40.21-350W Class C
 - .3 Structural steel bolts, nuts and washers shall conform to ASTM A325M
 - .4 Weld electrodes shall be SMAW-E-E480XX and SAW-F480-EXXX.

2.2 ACCEPTABLE MANUFACTURERS

- .1 All seismic snubbers and combination restraint/vibration isolation materials specified herein shall be provided by a single manufacturer to assure sole source responsibility for the proper performance of the materials used. Manufacturer is to be a member of VISCMA.
- .2 Anchor types and sizes are to be per the design data as provided by the seismic restraint manufacturer.
- .3 Materials and systems specified herein and detailed or scheduled on the drawings are based upon materials manufactured by Kinetics Noise Control Inc. Materials and systems provided by other manufacturers are acceptable, provided that they meet all requirements as listed in this specification.
- .4 Kinetics Noise Control Inc.
- .5 Cooper 'B' Line.
- .6 Unistrut Building Systems.
- .7 Mason Industries.

2.3 SEISMIC SNUBBER TYPES

.1 GENERAL

(Isolator/Snubber Types contained herein are per ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.) Handbook, HVAC Applications, Seismic and Wind Restraint Design)

- .1 Type A, Coil Spring Isolator Incorporated Within a Ductile Iron or Cast Aluminum Housing.**
 - .1** Cast iron or aluminum housings are brittle when subjected to shock loading and are therefore not approved for seismic restraint applications.
- .2 Type B, Coil Spring Isolator Incorporated Within A Steel Housing**
 - .1** Spring isolators shall be seismic control restrained spring isolators, incorporating a single or multiple coil spring element, having all of the characteristics of free standing coil spring isolators as specified in the vibration isolation portion of this specification. Springs shall be restrained using a housing engineered to limit both lateral and vertical movement of the supported equipment during an earthquake without degrading the vibration isolation capabilities of the spring during normal equipment operating conditions.
 - .2** Vibration isolators shall incorporate a steel housing and neoprene snubbing grommet system designed to limit motion to no more than ¼" (6 mm) in any direction and to prevent any direct metal-to-metal contact between the supported member and the fixed restraint housing. The restraining system shall be designed to withstand the seismic design forces in any lateral or vertical direction without yield or failure. Where the capacity of the anchorage hardware in concrete is inadequate for the required seismic loadings, a steel adapter base plate to allow the addition of more or larger anchors will be fitted to fulfill these requirements. In addition to the primary isolation coil spring, the load path will include a minimum ¼" (6 mm) thick neoprene pad.
 - .3** Spring elements shall be colour coded or otherwise easily identified. Springs shall have a lateral stiffness greater than 1.2 times the rated vertical stiffness and shall be designed to provide a minimum of 50% overload capacity. Non-welded spring elements shall be epoxy powder coated and shall have a minimum of a 1000-hour rating when tested in accordance with ASTM B-117.
 - .4** . To facilitate servicing, the isolator will be designed in such a way that the coil spring element can be removed without the requirements to lift or otherwise disturb the supported equipment.
 - .5** Spring isolators shall be Model FHS as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (2).

- .3 Type C, Coil Spring Isolator Incorporated Within a Steel Housing
 - .1 Spring isolators shall be seismic control restrained spring isolators, incorporating one or more coil spring elements, having all the characteristics of free standing coil spring isolators per the vibration isolation section of this specification, for equipment which is subject to load variations and/or large external forces. Isolators shall consist of one or more laterally stable steel coil springs assembled into fabricated welded steel housings designed to limit movement of the supported equipment in all directions.
 - .2 Housing assembly shall be made of fabricated steel members and shall consist of a top load plate complete with adjusting and leveling bolts, adjustable vertical restraints, isolation washers, and a bottom load plate with internal non-skid isolation pads and holes for anchoring the housing to the supporting structure. Housing shall be hot dipped galvanized for outdoor corrosion resistance. Housing shall be designed to provide a constant free and operating height within $\frac{1}{8}$ " (3 mm).
 - .3 The isolator housing shall be designed to withstand the project design seismic forces in all directions.
 - .4 Coil spring elements shall be selected to provide static deflections as shown on the vibration isolation schedule or as indicated or required in the project documents. Spring elements shall be colour coded or otherwise easily identified. Springs shall have a lateral stiffness greater than 1.2 times the rated vertical stiffness and shall be designed to provide a minimum of 50% overload capacity. Non-welded spring elements shall be epoxy powder coated and shall have a minimum of a 1000-hour rating when tested in accordance with ASTM B-117.
 - .5 Spring isolators shall be Model FLS and FLSS as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (3).
- .4 Type D, Coil Spring Isolator Incorporated with Integral Seismic Restraint
 - .1 Spring isolators shall be single or multiple coil spring elements which have all of the characteristics of freestanding coil spring isolators as specified in the vibration isolation portion of this specification, incorporating lateral and vertically restrained seismic housing assemblies. Spring elements shall be readily replaceable without the need to list or remove the supported equipment.
 - .2 Restraint housing shall be sized to meet or exceed the force requirements of the application and shall have the capability of accepting coil springs of various sizes, capabilities, and deflections as required to meet the required isolation criteria. All spring forces shall be contained within the coil/housing assembly, and the restraint anchoring hardware shall not be exposed to spring generated forces under conditions of no seismic force. Spring element leveling adjustment shall be accessible from above and suitable for use with a conventional pneumatic or electric impact wrench.

- .3 Restraint element shall incorporate a steel housing with elastomeric elements at all dynamic contact points. Elastomeric elements shall be replaceable. Restraint shall allow $\frac{1}{4}$ " (6 mm) free motion in any direction from the neutral position. Restraint shall have an overturning factor (ratio of effective lateral snubber height to short axis anchor spacing) of 0.33 or less to ensure optimum anchorage capacity.
- .4 Spring isolators shall be Model FMS as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (4).
- .5 Type E, All Direction Neoprene Isolator
 - .1 Vibration Isolators shall be neoprene, molded from oil resistant compounds, designed to operate within the strain limits of the isolator so to provide the maximum isolation and longest life expectancy possible using neoprene compounds. Isolators shall include encapsulated cast-in-place top steel load transfer plate for bolting to equipment and a steel base plate with anchor holes for bolting to the supporting structure. Ductile iron or cast aluminum components are not acceptable alternatives and shall not be used due to brittleness when subjected to shock loading.
 - .2 Isolator shall be capable of withstanding the design seismic loads in all directions with no metal-to-metal contact.
 - .3 Isolator shall have minimum operating static deflections as shown on the project Vibration Isolation Schedule or as otherwise indicated in the project documents and shall not exceed published load capacities.
 - .4 Neoprene isolators shall be Model RQ as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections .2.01, 2.02 and 2.03 (5).
- .6 Type F, Light Capacity All Direction 3-Axis External Seismic Snubber Assembly
 - .1 Equipment shall be restrained against excessive movement during a seismic event by the use of 3-axis resilient snubbers, designed to withstand the project required seismic forces. A minimum of two (2) snubbers are to be used at each equipment installation, oriented to effectively restrain the isolated equipment in all three directions, and additional snubbers shall be used as required by seismic design conditions.
 - .2 Snubbers shall be of interlocking steel construction and shall be attached to the equipment structure and equipment in a manner consistent with anticipated design loads. Snubbers shall limit lateral and vertical equipment movement at each snubber location to a maximum of $\frac{1}{4}$ " (6 mm) in any direction.

- .3 Snubbers shall include a minimum ¼" (6 mm) thick resilient neoprene pads to cushion any impact and to avoid any potential for metal-to-metal contact. Maximum neoprene bearing pressure shall not exceed 1500 pounds / sq. inch (10.4 N / sq. mm). Snubber shall be capable of withstanding an externally applied seismic force of up to 3,000 pounds (1360 kg) in any direction. Snubber shall be installed only after the isolated equipment is mounted, piped, and operating so as to ensure that no contact occurs during normal equipment operation.
- .4 Three-axis seismic snubbers shall be Model HS-5 as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and 2.01, 2.02, and 2.03 (6).
- .7 Type G, Lateral 2-Axis External Seismic Snubber Assembly
 - .1 Equipment shall be restrained against excessive lateral movement during a seismic event by the use of 2-axis horizontal resilient snubbers, designed to withstand the project required seismic forces. A minimum of two (2) snubbers are to be used at each equipment installation, oriented to effectively restrain the isolated equipment in all horizontal directions, and additional snubbers shall be used as required by seismic design conditions.
 - .2 Snubbers shall be interlocking steel construction and shall be attached to the equipment structure and equipment in a manner consistent with anticipated design loads. Snubbers shall limit lateral equipment movement at each snubber location to a maximum of ¼" (6 mm).
 - .3 Snubbers shall include a minimum of ¼" (6 mm) thick resilient neoprene pads to cushion any impact and to avoid any potential for metal-to-metal contact. Snubber shall be installed only after the isolated equipment is mounted, piped, and operating so as to ensure that no contact occurs during normal equipment operation.
 - .4 Two-axis lateral seismic snubbers shall be Model HS-2 as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (7).
- .8 Type H, Heavy Capacity All Direction 3-Axis External Seismic Snubber Assembly
 - .1 Equipment shall be restrained against excessive vertical and horizontal movement during a seismic event by the use of 3-axis resilient snubbers, designed to withstand the project required seismic forces. A minimum of two (2) snubbers are to be used at each equipment installation, oriented to effectively restrain the isolated equipment in all three directions, and additional snubbers shall be used as required by seismic design conditions.
 - .2 Snubbers shall be of welded interlocking steel construction and shall be attached to the equipment structure and equipment in a manner consistent with anticipated design loads. Snubbers shall limit lateral and vertical equipment movement at each snubber location to a maximum of ¼" (6 mm) in any direction.

- .3 Snubbers shall include resilient neoprene pads with a minimum thickness of ¼" (6 mm) to cushion any impact and to avoid any potential for metal-to-metal contact. Snubber shall be capable of withstanding an externally applied seismic force up to 10,000 pounds (4,540 kg) in any direction. Snubber shall be installed only after the isolated equipment is mounted, piped, and operating so as to ensure that no contact occurs during normal equipment operation.
- .4 Three-axis seismic snubbers shall be Model HS-7 as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (8).
- .9 Type I, Horizontal 1-Axis External Seismic Snubber Assembly
 - .1 Equipment shall be restrained against excessive horizontal one-axis movement during a seismic event by the use of single-axis resilient snubbers, designed to withstand the project required seismic forces. A minimum of four (4) snubbers are to be used at each equipment installation, oriented to effectively restrain the isolated equipment in all lateral directions.
 - .2 Snubbers shall be of steel construction and shall be attached to the equipment structure and equipment in a manner consistent with anticipated design loads. Snubbers shall limit lateral equipment movement at each snubber location in the direction of impact to a maximum of ¼" (6 mm).
 - .3 Snubbers shall include resilient neoprene pads with a minimum thickness of ¼" (6 mm) to cushion any impact and to avoid any potential for metal-to-metal contact. Snubber shall be installed only after the isolated equipment is mounted, piped, and operating so as to eliminate any contact during normal equipment operation.
 - .4 Single-axis seismic snubbers shall be Model HS-1 as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (9).
- .10 Type J, Cable Restraints for Suspended Piping and Ductwork
 - .1 Seismic wire rope cable restraints shall consist of steel wire strand cables, sized to resist project seismic loads, arranged to offer seismic restraint capabilities for piping, ductwork, and suspended equipment in all lateral directions.
 - .2 Building and equipment attachment brackets at each end of the cable shall be designed to permit free cable movement in all directions up to a 45-degree misalignment. Protective thimbles shall be used at sharp connection points as required to eliminate potential for dynamic cable wear and strand breakage.
 - .3 Restraints shall be sized to the capacity of the cable or to the capacity of the anchorage, whichever is lesser.
 - .4 Seismic wire rope connections shall be made using overlap wire rope "U" clips or seismically rated tool-less wedge insert lock connectors.

- .5 Vertical suspension rods shall be braced as required to avoid potential for buckling due to vertical “up” forces. Braces shall be structural steel angle uniquely selected to be of sufficient strength to prevent support rod bending. Brace shall be attached to the vertical suspension rod by a series of adjustable straps. Clips shall be capable of securely locking brace to suspension rod without the need for hand tools.
- .6 Where clevis hanger brackets are used for seismic restraint attachment, they will be fitted with clevis internal braces to prevent buckling of the hanger brackets.
- .7 Seismic cable shall be as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.03 through 1.07 inclusive, and sections 2.01, 2.02, and 2.03 (10).
- .8 Seismic cable building and equipment attachment brackets shall be Model KSCA, KSCU, or KSCC as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (10).
- .9 Seismic cable concrete anchor bolts shall be Model KCAB Wedge, Model KCCAB Cracked Concrete, or Model KUAB Undercut, as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (10).
- .10 Seismic wire rope connectors shall be (Model KWRC - 'U' clamp) / (Model KWGC - Tool-less wedge lock) as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (10).
- .11 Seismic vertical suspension stiffener rod clips shall be Model KHRC as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (10).
- .12 Clevis Internal Braces shall be Model KCHB as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (10).

2.4 SEISMIC BRACING COMPONENTS

- .1 Steel strut shall be 1-5/8 wide in varying heights and mig-welded combinations as required to meet load capacities and designs. A material heat code, part number, and manufacturer's name shall be stamped on all strut and fittings to maintain traceability to material test reports.
- .2 Material for epoxy painted strut: ASTM A1011, SS, Grade 33.
- .3 Material for pre-galvanized strut: ASTM A653, SS, Grade 33.

- .4 Material for hot-dip galvanized strut: ASTM A1011, SS, Grade 33 and hot-dip galvanized after fabrication in accordance with ASTM A123.
- .5 Material for fittings and accessories: ASTM A907, Grade 33, Structural Quality or ASTM A1011, SS, Grade 33.
- .6 Fittings and accessories: Products shall be of the same manufacturer as strut and designed for use with that product.

2.5 UNIFORM BUILDING CODE REQUIREMENTS

- .1 Seismic Zone Factor to Table 16-I for area of jurisdiction.
- .2 Soil Profile Type to Table 16-J for area of jurisdiction.
- .3 Seismic Importance Factor to Table 16-K for area of jurisdiction.
- .4 Component Amplification Factor to Table 16-O for area of jurisdiction.
- .5 Component Response Mod. Factor to Table 16-O for area of jurisdiction.
- .6 Seismic Coefficient to Table 16-Q for area of jurisdiction.
- .7 The total height of the structure (h_t) and the height of the system to be restrained within the structure (h_x) shall be determined in co-ordination with architectural plans and the General Contractor.
- .8 Forces shall be calculated for individual supports using the above information. Exceptions to Table 16-O may be utilized. However, all use of exceptions shall be noted on submitted seismic bracing plan documents.

Part 3 Execution

3.1 GENERAL INSTALLATION

- .1 Installation of all seismic restraint materials specified in this section shall be accomplished as per the manufacturer's written instructions.
- .2 Refer to FEMA Manuals 412, 413, and 414 for typical industry standard installation guidelines.
- .3 Upon completion of installation of all seismic restraint materials and before start-up of restrained equipment, all debris shall be cleaned from beneath all protected equipment, leaving equipment free to contact snubbers/restraints.
- .4 Torque anchor bolts according to anchor manufacturer's written instructions to resist seismic forces.
- .5 All seismic restraint systems shall be installed in strict accordance with the manufacturer's seismic restraint guidelines manual and all certified submittal data.
- .6 Prior to installation, bring to the architect's/engineer's attention any discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection.
- .7 Brace support rods when necessary to accept compressive loads. Welding of compressive braces to the vertical support rods is not acceptable.

- .8 Seismic restraints shall be attached to the structural system. Looping restraints around the system is not acceptable.
- .9 Do not brace a system to two independent structures such as ceiling and wall.
- .10 Provide appropriately sized openings in walls, floors, and ceilings for anticipated seismic movement. Provide fire seal systems in fire-rated walls.
- .11 Seismic restraint cables shall be adjusted such that they are not visibly slack, or the flexibility is approximately 25mm under thumb pressure for a 1500mm cable length (equivalent ratio for other cable lengths).
- .12 All seismic restraint cables shall be at least 25mm clear of all other equipment and services.

3.2 EQUIPMENT INSTALLATION

- .1 All external utility connections to restrained equipment shall be designed to allow differential seismic motion without damage to the equipment or utility connections.
- .2 Adjust isolators and restraints after piping systems have been filled and equipment is at its operating weight, following the manufacturer's written instructions.
- .3 After equipment installation is completed, adjust limit stops following manufacturer's written instructions so that they are out of contact during normal operation.
- .4 Adjust snubbers according to manufacturer's written instructions.
- .5 Installation of seismic restraints shall not cause any change in position of equipment, resulting in stresses or misalignment.
- .6 No rigid connections between equipment and the building structure shall be made that degrade the noise and vibration isolation system specified.
- .7 Do not install any seismic restraint for equipment, cable trays or conduit that compromises isolation specified.

3.3 PIPING INSTALLATION

- .1 Hold down clamps must be used to attach pipe to all trapeze members before applying restraints.
- .2 Branch lines may not be used to restrain main lines.
- .3 Piping crossing building seismic or expansion joints, passing from building to building, or supported from different portions of the building shall be installed to allow differential support displacements without damaging the pipe, equipment connections, or support connections. Pipe offsets, loops, anchors, and guides shall be installed as required to provide specified motion capability and limit motion of adjacent piping.
- .4 Attach piping to the trapeze per seismic restraint manufacturer's design. Install cables so they do not bend across sharp edges of adjacent equipment or building structures.

3.4 FASTENING TO STRUCTURE

- .1 Bracing may occur from flanges of structural beams, upper truss cords of bar joists, cast in place inserts, or wedge-type concrete anchors. Consult structural engineer of record.
- .2 Overstressing of the building structure shall not occur from overhead support of equipment. Bracing attached to structural members may present additional stresses. The contractor shall submit loads to the structural engineer of record for approval in this event.
- .3 Coring is not permitted for the installation of concrete anchors. Use ground penetrating radar or equivalent method of embedment item detection to locate all embed items including reinforcing steel and electrical conduits. Concrete reinforcing steel and electrical conduits shall not be cut or damaged under any circumstances.
- .4 Install vertical braces to stiffen hanger rods and prevent buckling per seismic restraint manufacturer's design. Clamp vertical brace to hanger rods. Requirements apply equally to hanging equipment. Do not weld vertical braces to hanger rods.
- .5 If mounting hole diameter exceeds bolt diameter by more than 0.125" (3 mm), reduce clearance in hole with epoxy grout, flanged elastomeric bushings or welded washer.
- .6 Housekeeping Pads must be adequately reinforced and adequately sized for proper installation of equipment anchors. Refer to seismic restraint manufacturer's written instructions.

3.5 INSPECTION

- .1 The contractor shall notify the local representative of the seismic restraint materials manufacturer prior to installing any seismic restraint devices. The contractor shall seek the representative's guidance in any installation procedures with which he/she is unfamiliar.
- .2 Upon completion of the installation of all seismic restraint devices herein specified, the local representative of the seismic restraint manufacturer shall, at the contractor's request, inspect the completed system and report in writing any installation errors, improperly selected snubber devices, or other fault in the system which could affect the performance of the system.
- .3 The installing contractor shall submit a report upon request to the building architect and/or engineer, including the manufacturer's representative's final report, indicating that all seismic restraint material has been properly installed, or steps that are to be taken by the contractor to properly complete the seismic restraint work as per the specifications.
 - .1 Guidelines for Mechanical Systems", Second Edition (Remaining Codes).

END OF SECTION

Part 1 General

1.1 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with general requirements.
- .2 Provide separate shop drawings for each isolated system complete with performance and product data.

Part 2 Products

2.1 GENERAL

- .1 Size and shape of bases type and performance of vibration isolation to be as indicated.
- .2 To be of the same manufacturer for all isolation.
- .3 Acceptable Manufacturers:
 - .1 Korfund
 - .2 Vibro-Acoustics
 - .3 Vibron

2.2 ELASTOMERIC PADS

- .1 Type EP4 - rubber-steel-rubber; 10 mm (3/8") minimum thick rubber bonded to 1.5 mm (16 gauge) steel plate; 30 durometer natural rubber, waffle or ribbed; holes sleeved with isolation washers; maximum loading 415 kPa (60.2 psi).
- .2 Acceptable Manufacturers:
 - .1 Korfund
 - .2 IAC Acoustics
 - .3 Vibro-Acoustics
 - .4 Vibron

2.3 SPRINGS

- .1 Design stable springs so that ratio of lateral to axial stiffness is equal to or greater than 1.2 times the ratio of static deflection to working height. Select for 50% travel beyond rated load. Units to be complete with levelling devices.
- .2 Ratio of height when loaded to diameter of spring to be between 0.8 to 1.0.
- .3 Cadmium plate for all installations.
- .4 Colour code springs.

2.4 HORIZONTAL THRUST RESTRAINT

- .1 Spring and elastomeric element housed in box frame; assembly complete with rods and angle brackets for equipment and ductwork attachment; provision for adjustment to limit maximum start and stop movement to 10 mm (3/8").

- .2 Arrange restraints symmetrically on either side of unit and attach at centerline of thrust.
- .3 Acceptable Manufacturers:
 - .1 Korfund
 - .2 IAC Acoustics
 - .3 Vibron
 - .4 Vibro-Acoustics

Part 3 Execution

3.1 INSTALLATION

- .1 Install vibration isolation equipment in accordance with manufacturers instructions and adjust mountings to level equipment.
- .2 Ensure piping, ducting and electrical connections to isolated equipment do not reduce system flexibility and that piping, conduit and ducting passage through walls and floors do not transmit vibrations.
- .3 Unless indicated otherwise, support piping connected to isolated equipment with spring mounts or spring hangers with 25 mm (1") minimum static deflection as follows:
 - .1 Up to NPS 100 mm (4"): first 3 points of support. NPS 125 mm (5") to NPS 200 mm (8"): first 4 points of support. NPS 250 mm (10") and Over: first 6 points of support.
 - .2 First point of support shall have a static deflection of twice deflection of isolated equipment, but not more than 50 mm (2").
- .4 Where isolation is bolted to floor use vibration isolation rubber washers.
- .5 Block and shim level bases so that ductwork and piping connections can be made to a rigid system at the operating level, before isolator adjustment is made. Ensure that there is no physical contact between isolated equipment and building structure.

3.2 SITE VISIT

- .1 Manufacturer to visit site and provide written certification that installation is in accordance with manufacturer's instructions and submit report to Consultant.
- .2 Provide Consultant with notice 24 h in advance of visit.
- .3 Make adjustments and corrections in accordance with written report.

3.3 TESTING

- .1 Experienced and competent sound and vibration testing professional engineer to take vibration measurement for HVAC systems after start up and TAB of systems to Testing Adjusting and Balancing Section.
- .2 Vibration measurements shall be taken for equipment-listed below:
- .3 Provide Consultant with notice 48 h in advance of commencement of tests.

- .4 Establish adequacy of equipment isolation and acceptability of noise levels in occupied areas and where appropriate, remedial recommendations including sound curves.
- .5 Submit complete report of test results including sound curves.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 Canadian General Standards Board (CGSB).
 - .1 CAN/CGSB-1.60, Interior Alkyd Gloss Enamel.
 - .2 CAN/CGSB-24.3, Identification of Piping Systems.
- .3 Canadian Standards Association (CSA).
 - .1 Natural Gas and Propane Installation Code CSA B149.1.
- .4 National Fire Protection Association
 - .1 NFPA 13, Installation of Sprinkler Systems.

1.2 PRODUCT DATA

- .1 Submit product data in accordance with General Requirements.
- .2 Product data to include paint colour chips, all other products specified in this section.

1.3 PRODUCT LITERATURE

- .1 Submit product literature in accordance with General Requirements.
- .2 Product literature to include nameplates, labels, tags, lists of proposed legends.

Part 2 Products

2.1 MANUFACTURER'S EQUIPMENT NAMEPLATES

- .1 Metal or plastic lamicoid nameplate mechanically fastened to each piece of equipment by manufacturer.
- .2 Lettering and numbers to be raised or recessed.
- .3 Information to include, as appropriate:
 - .1 Equipment: Manufacturer's name, model, size, serial number, capacity.
 - .2 Motor: voltage, Hz, phase, power factor, duty, frame size.

2.2 SYSTEM NAMEPLATES

- .1 Colours:
 - .1 Black letters, white background (except where required otherwise by applicable codes).

.2 Construction:

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

.3 Sizes:

- .1 Conform to following table:

Size	No. of Sizes mm (")	Height of Line mm (")	Letters mm (")
1	10 x 50 (3/8" x 2")	1 (3/64")	3 (1/8")
2	15 x 75 (1/2" x 3")	1 (3/64")	6 (1/4")
3	15 x 75 (1/2" x 3")	2 (5/64")	3 (1/8")
4	20 x 100 (3/4" x 4")	1 (3/64")	10 (3/8")
5	20 x 100 (3/4" x 4")	2 (6/64")	6 (1/4")
6	20 x 200 (3/4" x 8")	1 (3/64")	10 (3/8")
7	25 x 125 (1" x 5")	1 (3/64")	15 (1/2")
8	25 x 125 (1" x 5")	2 (5/64")	10 (3/8")
9	32 x 200 (1 1/4" x 8")	1 (3/64")	20 (3/4")

- .2 Use maximum of 25 letters/numbers per line.

.4 Locations:

- .1 Equipment in Mechanical Rooms: Use size #9.
 .2 Equipment above ceiling: use size #1 riveted to ceiling suspension system.

2.3 EXISTING IDENTIFICATION SYSTEMS

- .1 Apply existing identification system to new work.
 .2 Where existing identification system does not cover for new work, use identification system specified this section.

2.4 IDENTIFICATION OF PIPING SYSTEMS

- .1 Identify contents by background colour marking, pictogram (as necessary), legend; direction of flow by arrows. To CAN/CGSB 24.3 except where specified otherwise.
 .2 Legend:
 .1 Block capitals to sizes and colours listed in CAN/CGSB-24.3.
 .3 Arrows showing direction of flow:
 .1 Outside diameter of pipe or insulation less than 75 mm (3"): 100 mm (4") long x 50 mm (2") high.
 .2 Outside diameter of pipe or insulation 75 mm (3") and greater: 150 mm (6") long x 50 mm (2") high.
 .3 Use double-headed arrows where flow is reversible.

- .4 Extent of background colour marking:
 - .1 To full circumference of pipe or insulation.
 - .2 Length to accommodate pictogram, full length of legend and arrows.
- .5 Materials for background colour marking, legend, arrows:
 - .1 Pipes and tubing 20 mm (3/4") and smaller: Waterproof and heat-resistant pressure sensitive plastic marker tags.
 - .2 All other pipes: Pressure sensitive vinyl with protective overcoating, waterproof contact adhesive undercoating, suitable for ambient of 100% RH and continuous operating temperature of 150°C (300°F) and intermittent temperature of 200°C (395°F).
- .6 Colours and Legends:
 - .1 Where not listed, obtain direction from Consultant.
 - .2 Colours for legends, arrows: To following table:

Background colour:	Legend:	Arrows:
Yellow	White	Black
Green	White	Black
Red	White	Black
- .7 **Pictograms:**
 - .1 **Where required, to Workplace Hazardous Materials Information System (WHMIS) regulations.**
- .8 Background colour marking and legends for piping systems:

CONTENTS	BACKGROUND COLOUR MARKING	
	MARKING	LEGEND
Domestic hot water supply	Green	DOM. HW SUPPLY
Dom. HW recirculation	Green	DOM. HW CIRC
Domestic cold water supply	Green	DOM. CWS
Domestic tempered supply	Green	DOM. TEMPERED
Trap Primer	Green	TRAP PRIMER
Storm water	Green	STORM
Sanitary	Green	SAN
Plumbing vent	Green	SAN. VENT

2.5 VALVES, CONTROLLERS

- .1 Brass tags with 15 mm (1/2") stamped identification data filled with black paint.
- .2 Include flow diagrams for each system, of approved size, showing charts and schedules with identification of each tagged item, valve type, service, function, normal position, location of tagged item.

- .3 Provide adhesive coloured tab (max. size 15 mm) indication on ceiling to locate valves/equipment above. Same applies to grid. Colour to be approved by consultant.

2.6 LANGUAGE

- .1 Identification to be in English.

Part 3 Execution

3.1 TIMING

- .1 Provide identification only after all painting specified has been completed.

3.2 INSTALLATION

- .1 Perform work in accordance with CAN/CGSB-24.3 except as specified otherwise.
- .2 Provide ULC and/or CSA registration plates as required by respective agency.

3.3 NAMEPLATES

- .1 Locations:
 - .1 In conspicuous location to facilitate easy reading and identification from operating floor.
- .2 Standoffs:
 - .1 Provide for nameplates on hot and/or insulated surfaces.
- .3 Protection
 - .1 Do not paint, insulate or cover in any way.

3.4 LOCATION OF IDENTIFICATION ON PIPING SYSTEMS

- .1 On long straight runs in open areas in boiler rooms, equipment rooms, galleries, tunnels not more than 1.7 m (5'-8") intervals and more frequently if required to ensure that at least one is visible from any one viewpoint in operating areas and walking aisles.
- .2 Adjacent to each change in direction.
- .3 At least once in each small room through which piping or ductwork passes.
- .4 On both sides of visual obstruction or where run is difficult to follow.
- .5 On both sides of separations such as walls, floors, partitions.
- .6 Where system is installed in pipe chases, ceiling spaces, galleries, other confined spaces, at entry and exit points, and at each access opening.
- .7 At beginning and end points of each run and at each piece of equipment in run.
- .8 Identification to be easily and accurately readable from usual operating areas and from access points.
 - .1 Position of identification to be approximately at right angles to most convenient line of sight, considering operating positions, lighting conditions, risk of physical damage or injury and reduced visibility over time due to dust and dirt.

3.5 VALVES, CONTROLLERS

- .1 Valves and operating controllers, except at plumbing fixtures, or where in plain sight of equipment they serve: Secure tags with non-ferrous chains or closed "S" hooks.
- .2 Install one copy of flow diagrams, valve schedules mounted in frame behind non-glare glass where directed by Consultant. Provide one copy (reduced in size if required) in each operating and maintenance manual.
- .3 Number valves in each system consecutively. Where existing numbering system is installed start new numbering system at 100.

END OF SECTION

Part 1 General

1.1 SHOP DRAWINGS AND AS-BUILT DRAWINGS

- .1 Conform to General Requirements Section for shop drawings and as-built drawings requirements.

1.2 INSTALLATION INSPECTION AND EQUIPMENT VERIFICATION

- .1 The Plumbing Contractor shall co-ordinate with the Consultant who will inspect the plumbing installation.
- .2 The Plumbing Contractor shall complete the equipment verification forms for each piece of equipment. The forms shall be included in the operating and maintenance manual. The equipment data shall include:
 - Manufacturers name, address and telephone number
 - Distributors name, address and telephone number
 - Make, model number and serial number
 - Pumps - RPM, impeller sizes, rated flow
 - Electrical - volts, amps, fuse size, overload size
 - Any other special characteristics.

1.3 PLUMBING AND DRAINAGE SYSTEM TESTING

- .1 The plumbing and drainage system shall be tested in accordance with the Plumbing Code under the Ontario Water Resources Act and the specification.
- .2 The Mechanical Contractor shall notify the Building Inspector when systems are available for testing. The Mechanical Contractor shall document all tests performed and shall arrange for the Building Inspector to sign for tests completed. The forms shall be forwarded to the Consultant.

1.4 THE CONTRACTOR'S TESTING OF PIPING SYSTEMS

- .1 Test all piping systems in accordance with all applicable plumbing codes and General Requirements section.
- .2 All tests for the systems shall be performed in the presence of the Consultant or Commissioning Consultant. Complete the testing forms and forward to the Consultant.

1.5 THE INDEPENDENT CONTRACTORS TESTING AND BALANCING OF WATER SYSTEMS

- .1 Conform with the specification section, Testing, Adjusting and Balancing.
- .2 The Independent Contractor shall be hired by the plumbing contractor and shall report to the Commissioning Consultant.

1.6 CLOSEOUT SCHEDULE

- .1 The Plumbing Contractor shall include the schedule for all tests and equipment start-up tests in the construction schedule.

- .2 All testing forms and reports associated with the plumbing systems shall be directed to the Consultant with copies to the Owner and Consultant.
- .3 The forms and reports to be issued shall include:
 - Shop drawings, issued and accepted
 - Equipment verification forms
 - Testing forms
 - Reports resulting from tests
 - Testing schedule
 - Equipment Start-up Forms

1.7 OPERATION AND MAINTENANCE MANUAL

- .1 Conform to General Requirements section for the Operating and Maintenance Manual requirements.

1.8 OPERATOR TRAINING

- .1 Conform to General Requirements section for requirements for Instruction to Operating Staff.
- .2 The training shall be conducted in a classroom and at the equipment or system.
- .3 Training will begin when the operating and maintenance manuals have been delivered to The Owner and approved by the Consultant.
- .4 Each training session shall be structured to cover:
 - The operating and maintenance manual
 - Operating procedures
 - Maintenance procedures
 - Trouble-shooting procedures
 - Spare parts required
 - Submit a course outline to the Consultant before training commences. Provide course documentation for up to eight people.
- .5 The training sessions shall be scheduled and co-ordinated by the Plumbing Contractor.
- .6 Training shall be provided for the following systems:

<u>System</u>	<u>Minimum Training Times</u>
Pumps	2 hours
Water Heaters	2 hours
Emergency Showers & Eye Wash	2 hours

1.9 COMMISSIONING CONSULTANT

- .1 A Commissioning Consultant (CC) reports to the Owner.
- .2 The CC responsibilities shall include:
 - Preparing the commissioning plan
 - Coordinating with the contractor to schedule tests
 - Preparing a test form manual
 - Witnessing selected tests

- Receiving all test forms
- Conducting performance test
- Coordinating the contractors training
- Chair commissioning meetings

- .3 The Plumbing Contractor shall co-operate with the CC.
- .4 The Plumbing Contractor shall provide assistance to the CC and have personnel available during the performance testing procedure. Each mechanical system shall be tested in the operational mode.
- .5 Performance testing shall begin when all systems have been completed, tested by the Mechanical Contractor and the Consultant has completed their final review.

1.10 PLUMBING SYSTEM DEMONSTRATION AND TURNOVER

- .1 Refer to General Requirements section, Mechanical Project Completion.
- .2 The system demonstration and turnover to The Owner shall occur when:
 - The installation is complete
 - The acceptance test conducted by the Mechanical Consultant has been completed successfully
 - The Commissioning Consultant system performance testing has been completed successfully
 - Training has been completed
 - Operating and Maintenance Manuals have been accepted
 - Shop-drawings have been updated
 - As-built drawings have been completed
- .3 The systems demonstration shall be conducted by the Mechanical Contractor and the manufacturers. The demonstration shall cover a demonstration of equipment installation and operation.

1.11 WARRANTIES

- .1 Equipment and system warranties shall not begin until the system demonstration and turnover has been conducted successfully and accepted by The Owner.
- .2 The Mechanical Contractor shall fill out the warranty form listing the equipment and systems and the start and finishing dates for warranty.
- .3 Refer to the general conditions specification section for the requirements during the warranty period.

1.12 CLOSEOUT PROCESS ALLOCATION

- .1 The mechanical contractor closeout process shall be as follows:
 - .1 3% for the first \$500,000 of contract value.
 - .2 1% of the contract value for value between \$500,000 to \$5,000,000.
 - .3 0.5% of contract value for the value in excess of \$5,000,000.
 - .4 Minimum Allocation for Close Out Documents is \$5,000.

- .2 The Mechanical Contractor shall submit all test and verification forms. The Consultant will use these forms to calculate percentage complete.
- .3 The monies shall not be paid out until the performance testing, O & M manuals, systems demonstration, and training including all required paperwork have been completed to the satisfaction of the consultant. Refer to General Requirements section for contract breakdown.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 Canadian General Standards Board (CGSB)
 - .1 ASTM C553, Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
 - .2 CGSB 51-GP-52Ma, Vapour Barrier Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
 - .3 CAN/CGSB-51.53, Poly (Vinyl Chloride) Jacketing Sheet, for Insulating Pipes, Vessels and Round Ducts.
- .3 Underwriters Laboratories of Canada (ULC)
 - .1 CAN/ULC-S102, Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.
- .4 American Society for Testing and Materials (ASTM)
 - .1 ASTM C547, Type I and IV, Standard Specifications for Mineral Fibre Pipe Insulation.
 - .2 ASTM C 335, Test Method for Steady State Heat Transfer Properties of Pipe Insulation.
 - .3 ASTM C177, Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot-Plate Apparatus.
 - .4 ASTM C518, Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
 - .5 ASTM C 921, Practice for Determining the Properties Jacketing Materials for Thermal Insulation.
 - .6 ASTM C1695, Standard Specification for Fabrication of Flexible, Removable, and Reusable Blanket Insulation for Hot Service.
 - .7 ASTM C1729 Standard Specification for Aluminium Jacketing for Insulation.
- .5 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).
 - .1 ASHRAE Standard 90.1.
- .6 Manufacturer's Trade Associations
 - .1 Thermal Insulation Association of Canada (TIAC), North American Commercial and Industrial Insulation Standards.

1.2 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with general requirements.
- .2 Submit for approval manufacturer's catalogue literature related to installation, fabrication for pipe, fittings, valves, and jointing recommendations.

- .3 Submit properly completed detail plates from the North American Commercial and Industrial Insulation Standards manual, applicable to installation types required by this specific section.

1.3 INSTALLATION INSTRUCTIONS

- .1 Submit manufacturer's installation instructions in accordance with general requirements.
- .2 Installation instructions to include procedures to be used, installation standards to be achieved.

1.4 QUALIFICATIONS

- .1 Installer to have successfully completed apprenticeship program.
- .2 Installer to be specialist in performing work of this section and have at least three (3) years successful experience in this size and type of project, qualified to standards of TIAC.

1.5 DELIVERY, STORAGE AND HANDLING

- .1 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .2 Protect from weather, construction traffic.
- .3 Protect against damage from any source.
- .4 Store at temperatures and conditions required by manufacturer.

1.6 DEFINITIONS

- .1 For purposes of this section:
 - .1 "CONCEALED" - insulated mechanical services in suspended ceilings and non-accessible chases and furred-in spaces.
 - .2 "EXPOSED" - will mean "not concealed" as defined herein.
 - .3 "ASJ+" – All Service Jacket – vapor retarder laminate of aluminium foil inner layer, reinforced with fiberglass scrim, bonded to a bleached kraft paper, with outer poly film leaving no paper exposed.
 - .4 "ASJ" – All Service Jacket (no outer film) – vapor retarder laminate of aluminium foil inner layer, reinforced with fiberglass scrim, bonded to a bleached kraft paper outer layer.

Part 2 Products

2.1 MATERIAL LIMITATIONS

- .1 Products shall not contain formaldehyde, asbestos, lead, mercury or mercury compounds or PBDE fire retardants.

2.2 FIRE AND SMOKE RATING

- .1 In accordance with CAN/ULC-S102:
 - .1 Maximum flame spread rating: 25.
 - .2 Maximum smoke developed rating: 50.

2.3 INSULATION

- .1 Mineral fibre as specified herein includes glass fibre, rock wool, slag wool.
- .2 Thermal conductivity ("k" factor) not to exceed specified values at 24°C (75°F) mean temperature when tested in accordance with ASTM C335, ASTM C177 or ASTM C518.
- .3 Type A-1: Rigid moulded or wound mineral fibre with factory applied vapour retarder jacket.
 - .1 Mineral fibre: to ASTM C547 Type I and IV.
 - .2 Jacket: to ASTM C1136, Type I, II, III, IV, X.
 - .3 Maximum "k" factor: to ASTM C547.
- .4 Type A-2: Mineral fibre faced with factory applied vapour retarder jacket.
 - .1 Mineral fibre: to ASTM C553.
 - .2 Jacket: to CGSB 51-GP-52 Ma.
 - .3 Maximum "k" factor: to ASTM C553.
- .5 Materials:
 - .1 All materials must be supplied by the same manufacturer.
 - .2 Acceptable Manufacturers:
 - .1 Johns Manville
 - .2 Knauf
 - .3 Manson
 - .4 Owens Corning

2.4 INSULATION SECUREMENT

- .1 Tape: Self-adhesive, aluminum, reinforced, 50 mm (2") wide minimum.
- .2 Contact adhesive: Quick setting.
- .3 Canvas adhesive: Washable.

2.5 CEMENT

- .1 Thermal insulating and finishing cement:
 - .1 Hydraulic setting or Air drying on mineral wool, to ASTM C 449M.

2.6 VAPOUR RETARDER LAP ADHESIVE

- .1 Water based, fire retardant type, compatible with insulation.

2.7 INDOOR VAPOUR RETARDER FINISH

- .1 Compatible with insulation.

2.8 JACKETS

- .1 Polyvinyl Chloride (PVC):
 - .1 Minimum thickness: 20 mm (0.020")
 - .2 One-piece moulded type [and sheet] to CAN/CGSB-51.53 with pre-formed shapes as required.
 - .3 Colours: white.
 - .4 Minimum service temperatures: -29°C (-20°F).
 - .5 Maximum service temperature: 65°C (150°F).
 - .6 Moisture vapour transmission: 0.05 perm.
 - .7 Fastenings:
 - .1 Use solvent weld adhesive compatible with insulation to seal laps and joints.
 - .2 Tacks are not to be used below ambient temperature (cold) operating systems.
 - .3 Pressure sensitive vinyl tape of matching colour.

2.9 CAULKING FOR JACKETS

- .1 Caulking: Silicone clear caulking.

Part 3 Execution

3.1 PRE-INSTALLATION REQUIREMENT

- .1 Pressure testing of piping systems and adjacent equipment to be complete, witnessed, and certified.
- .2 Surfaces to be clean, dry, free from foreign material.

3.2 INSTALLATION

- .1 Install in accordance with TIAC, North American Commercial and Industrial Insulation Standards.
- .2 Apply materials in accordance with manufacturers' instructions and this specification.
- .3 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
 - .1 Hangers, supports to be outside vapour retarder jacket.
- .4 Supports, Hangers:
 - .1 Apply high compressive strength insulation, suitable for service, at oversized saddles and shoes where insulation saddles have not been provided.
- .5 Below ambient/chilled water installation:
 - .1 All pipes, valves, strainers, flanges, unions, and other pipe system components and spec must be properly insulated with correctly completed vapor retarder applied.

- .2 All insulation material must have properly installed and sealed vapor retarding jacket, including circumferential and longitudinal seams.
- .3 All penetrations, tears, and punctures must be repaired and sealed with a vapor retarding material with a 0.02 or lower perm rating.
- .4 Vapor stops must be installed at 18' intervals at all pipe insulation termination points including fittings, flanges, and other changes in direction or other types of piping specialties.
- .5 All fitting insulation must be of the same type, thickness, and density of the pipe insulation, be premoulded insulation covers or fabricate from the same material as the pipe insulation. Full thickness must be maintained over all fitting surfaces. Blanket insulation with a factory applied vapor retarder facing is unacceptable.
- .6 A complete vapor retarder must be installed on insulation over fittings before applying final finish. Vapor retarder must extend onto and be sealed to the vapor retarder of the pipe insulation.
- .7 Additional fitting covers, PVC, or metal must have a vapor retarder seal applied to all longitudinal and circumferential seams in addition to the vapor retarder applied to the fitting insulation.
- .8 Additional field applied to jackets must not use staples, screws, tacks, or rivets for attachment to avoid puncturing vapor retarder underneath.
- .9 Insulating support inserts are to be high compressive strength insulation with a rigid shield. No calcium silicate is to be used for insulation on below-ambient operation piping.

3.3 REMOVABLE, PRE-FABRICATED, INSULATION AND ENCLOSURES

- .1 Application: At expansion joints, valves, primary flow measuring elements, flanges, and unions at equipment.
- .2 Flexible removable blanket insulation covers are not acceptable for below-ambient (cold) operation piping systems. Rigid removable insulation jackets that are vapor retarder exterior material, that can be vapor sealed at the seams, are acceptable on below-ambient (cold) operation piping systems.
- .3 Design: To permit movement of expansion joint and to permit periodic removal and replacement without damage to adjacent insulation.
- .4 Insulation:
 - .1 Insulation, fastenings and finishes: same as system.
 - .2 Jacket: As per adjacent insulation.

3.4 INSTALLATION OF ELASTOMERIC INSULATION

- .1 Insulation to remain dry at all times. Overlaps to manufacturers instructions. Ensure tight joints.
- .2 Provide vapour retarder as recommended by manufacturer.

3.5 PIPING INSULATION SCHEDULES

- .1 Includes valves, valve bonnets, strainers, flanges, and fittings unless otherwise specified.
- .2 Install insulator and jackets to applicable TIAC codes.
- .3 Insulate ends of capped piping with type and thickness indicated for capped service.
- .4 Thickness of insulation to be as listed in following table:
 - .1 Do not insulate exposed runouts to plumbing fixtures, chrome plated piping, valves, fittings.
 - .2 All storm piping including all vertical and horizontal piping shall be insulated.

Application	Type	Pipe sizes through (NPS) and insulation thickness mm (")				
		to	32 (1¼")	50 (2")	105 (4")	200 (8")
		25 (1")	40 (1½")	80 (3")	150 (6")	& over
Domestic Water Piping	A-1	25 (1")	25 (1")	40 (1½")	40 (1½")	40 (1½")
Storm Piping	A-1/A-5	25 (1")	25 (1")	25 (1")	25 (1")	25 (1")
Cooling Coil cond. Drain	A-1	25 (1")	25 (1")	25 (1")	25 (1")	25 (1")
Roof Drain sumps	A-2/A-5	25 (1")	25 (1")	25 (1")	25 (1")	25 (1")
Horizontal Cast Iron	A-1/A-5	N/A	N/A	25 (1")	25 (1")	25 (1")
Sanitary Piping						
Trap Primer Piping	A-1	15 (½")	15 (½")	25 (1")		

- .5 Finishes: Conform to the following table:

Application	Piping	Valves & Fittings
Exposed indoors	PVC	PVC
Exposed in mech. rooms	PVC	PVC
Concealed indoors	N/A	PVC

- .6 Connection: To appropriate TIAC code.
- .7 Finish attachments: SS bands, @ 150 mm (6") oc. seals: closed.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ANSI/AWWA B301, Liquid Chlorine.
- .3 ANSI/AWWA C104/A21.4, Cement-Mortar Lining for Ductile Iron Pipe and Fittings for Water.
- .4 ANSI/AWWA C205, Cement Mortar Protective Lining and Coating for Steel Water Pipe - 4 inch and larger - Shop Applied.
- .5 ANSI/AWWA C207, Steel Pipe Flanges for Waterworks Service, 4 inch through 144 inch.
- .6 ANSI/AWWA C500, Metal-seated Gate Valves for Water Supply Service.
- .7 ANSI/AWWA C600, Installation of Ductile Iron Water Mains, and their Appurtenances.
- .8 ANSI/AWWA C800, Underground Service Line Valves and Fittings.

1.2 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with general division.

1.3 AS-BUILT DRAWINGS

- .1 Provide Data to produce as-built drawings, including directions for operating valves, list of equipment required to operate valves, details of pipe material, location of air and vacuum release valves, hydrant details, maintenance and operating instructions in accordance with Submittals Section.

1.4 SCHEDULING OF WORK

- .1 Schedule work to minimize interruptions to existing services. Interruptions during school hours will not be allowed.
- .2 Submit schedule of expected interruptions to Consultant for approval and adhere to interruption schedule as approved by Consultant.
- .3 Notify building occupants' minimum of 24 h in advance of any interruption in service.
- .4 Do not interrupt water service for more than 3 h and confine this period between 16:00 and 6:00 h local time or weekends unless otherwise authorized.
- .5 Notify fire department of any planned or accidental interruption of water supply to hydrants.
- .6 Advise local police department of anticipated interference with movement of traffic.
- .7 Notify owner's security company with any interruptions.

Part 2 Products

2.1 PIPES, JOINTS AND FITTINGS

- .1 Ductile iron pipe: to ANSI/AWWA C151/A21.51, class 52 cement mortar lined to ANSI/AWWA C104/A21.4.
 - .1 Acceptable material: HYPROTEC
- .2 P.V.C. pipe: to AWWA C900, CSA B137.2, ASTM, class 150 P.V.C. (DR18).
 - .1 Acceptable material: Blue Brute or Equal.
- .3 Joints and fittings for ductile iron pipe:
 - .1 Joints:
 - .1 Rubber gasket for mechanical pipe joints: to ANSI/AWWA C111/A21.11.
 - .2 Rubber gasket for flange pipe joints 1.6 mm thick: to ANSI/AWWA C111/A21.11.
 - .3 Bolts, nuts, hex head with washers: to ASTM A307, heavy series.
 - .4 Ensure electrical conductivity across joints.
 - .2 Fittings:
 - .1 Mechanical joint cast iron and ductile iron fittings NPS 3 and larger: to ANSI/AWWA C110/A21.10.
 - .2 Flanged cast iron fittings NPS 3 and larger: to ANSI/AWWA C110/A21.10.

2.2 FITTINGS AND SPECIALTIES

- .1 All fittings and specials shall be installed where shown or where ordered by the Engineer. Fittings subject to lateral thrust or “blow-out” shall be properly supported by cast-in-place thrust blocks of 25 Mpa concrete placed against undisturbed earth in accordance with the contract drawings. Where necessary, when working in unstable ground conditions or when installing vertical bends, the contractor shall use anchor blocks with anchor rods, or tie rods connected to the closest solid joint, to assure proper support against “blow-out”.

2.3 PIPE BEDDING AND SURROUND MATERIAL

- .1 Granular material to Aggregates: General and following requirements:
 - .1 Crushed or screened stone, gravel or sand.
 - .2 Gradations to be within limits specified when tested to ASTM C136 and ASTM C117 Sieve sizes to CAN/CGSB-8.1.
- .2 Concrete mixes and materials required for bedding cradles, encasement, supports, thrust blocks: to Cast-in-Place Concrete Section.

2.4 BACKFILL MATERIAL

- .1 As indicated.
- .2 Type 3, in accordance with Excavating, Trenching and Backfilling.

2.5 PIPE DISINFECTION

- .1 Liquid chlorine to ANSI/AWWA B301 to disinfect water mains.

Part 3 Execution

3.1 PREPARATION

- .1 Clean pipes, fittings, valves, hydrants, and appurtenances of accumulated debris and water before installation. Carefully inspect materials for defects. Remove defective materials from site.

3.2 TRENCHING

- .1 Do trenching work in accordance with Excavating Trenching and Backfilling Section.
- .2 Trench depth to provide cover over pipe of not less than 1.85 m from finished grade.

3.3 GRANULAR BEDDING

- .1 Place granular bedding material in uniform layers not exceeding 150 mm compacted thickness to depth of 150 mm below bottom of pipe to depth as indicated.
- .2 Do not place material in frozen condition.
- .3 Shape bed true to grade to provide continuous uniform bearing surface for pipe.
- .4 Shape transverse depressions in bedding as required to suit joints.
- .5 Compact each layer full width of bed to at least 95% of corrected maximum dry density and 95% maximum density to ASTM D698.
- .6 Fill authorized or unauthorized excavation below design elevation of bottom of specified bedding in accordance with Excavating Trenching and Backfilling Section.

3.4 PIPE INSTALLATION

- .1 Connect to domestic water and fire main piping installed by site services contractor. Terminate building water service inside building and 450 mm above finish floor. Install coupling necessary for connection to building plumbing. If plumbing is already installed, make connection; otherwise cap or seal end of pipe.
- .2 Lay pipes to ANSI/AWWA C600 and ANSI/AWWA Manual of Practice and manufacturer's standard instructions and specifications. Do not use blocks.
- .3 Join pipes in accordance with ANSI/AWWA C600 ANSI/AWWA C602 ANSI/AWWA C206 AWWA Manual of Practice and manufacturer's recommendations.
- .4 Handle pipe by methods recommended by pipe manufacturer. Do not use chains or cables passed through pipe bore so that weight of pipe bears on pipe ends.
- .5 Lay pipes on prepared bed, true to line and grade. Ensure barrel of each pipe is in contact with shaped bed throughout its full length. Take up and replace defective pipe. Correct pipe, which is not in true alignment or grade or pipe, which shows differential settlement after installation greater than 10 mm.

- .6 Face socket ends of pipe in direction of laying. For mains on a grade of 2% or greater, face socket ends up-grade.
- .7 Do not exceed permissible deflection at joints as recommended by pipe manufacturer.
- .8 Keep jointing materials and installed pipe free of dirt and water and other foreign materials. Whenever work is stopped, install a removable watertight bulkhead at open end of last pipe laid to prevent entry of foreign materials.
- .9 Position and join pipes with equipment and methods approved by Consultant.
- .10 Cut pipes in an approved manner as recommended by pipe manufacturer, without damaging pipe or its coating and to leave smooth end at right angles to axis of pipe.
- .11 Align pipes carefully before jointing.
- .12 Install gaskets to manufacturer's recommendations. Support pipes with hand slings or crane as required to minimize lateral pressure on gasket and maintain concentricity until gasket is properly positioned.
- .13 Avoid displacing gasket or contaminating with dirt or other foreign material. Gaskets so disturbed or contaminated shall be removed, cleaned, lubricated and replaced before jointing is attempted again.
- .14 Complete each joint before laying next length of pipe.
- .15 Minimize deflection after joint has been made.
- .16 Apply sufficient pressure in making joints to ensure that joint is completed to manufacturer's recommendations.
- .17 Ensure completed joints are restrained by compacting bedding material alongside and over installed pipes or as otherwise approved by Engineer.
- .18 When stoppage of work occurs, block pipes in an approved manner to prevent creep during down time.
- .19 Recheck plastic pipe joints assembled above ground after placing in trench to ensure that no movement of joint has taken place.
- .20 Do not lay pipe on frozen bedding.
- .21 Do hydrostatic and leakage test and have results approved by Consultant before surrounding and covering joints and fittings with granular material.
- .22 Backfill remainder of trench.

3.5 THRUST BLOCKS

- .1 Install thrust blocks to OPS standards for roads and municipal services.
- .2 Concrete shall be placed to within 50 mm of the face of the bell.
- .3 Bond breaker shall be used between the fittings and concrete.

3.6 HYDROSTATIC AND LEAKAGE TESTING

- .1 Provide labour, equipment and materials required to perform hydrostatic and leakage tests hereinafter described.
- .2 Notify Consultant at least 24 h in advance of all proposed tests. Perform tests in presence of Consultant.
- .3 Where any section of system is provided with concrete thrust blocks, conduct tests at least 5 days after placing concrete or 2 days if high early strength concrete is used.
- .4 Upon completion of pipe laying and after Consultant has inspected work in place, surround and cover pipes between joints with approved granular material placed to dimensions indicated or directed by Consultant.
- .5 Leave hydrants, valves, joints and fittings exposed.
- .6 Strut and brace caps, bends, tees, and valves, to prevent movement when test pressure is applied.
- .7 Open valves.
- .8 Expel air from main by slowly filling main with potable water. Install corporation stops at high points in main where no air-vacuum release valves are installed. Remove stops after satisfactory completion of test and seal holes with plugs.
- .9 Thoroughly examine exposed parts and correct for leakage as necessary.
- .10 Examine exposed pipe, joints, fittings and appurtenances while system is under pressure.
- .11 Remove joints, fittings and appurtenances found defective and replace with new sound material and make watertight.
- .12 Do not exceed allowable leakage of 0.03 L/mm diameter per 300 m of pipe, including lateral connections, per hour.
- .13 Locate and repair defects if leakage is greater than amount specified.
- .14 Repeat test until leakage is within specified allowance for full length of watermain.

3.7 PIPE SURROUND

- .1 Upon completion of pipe laying and after Consultant has inspected work in place, surround and cover pipes as indicated.
- .2 Hand place surround material in uniform layers not exceeding 150 mm compacted thickness as indicated.
- .3 Place layers uniformly and simultaneously on each side of pipe.
- .4 Do not place material in frozen condition.
- .5 Compact each layer from pipe invert to mid height of pipe to at least 95% of corrected maximum dry density.
- .6 Compact each layer from mid height of pipe to underside of backfill to at least 90% of corrected maximum dry density.

3.8 BACKFILL

- .1 Place backfill material, above pipe surround, in uniform layers not exceeding 150 mm compacted thickness up to grades as indicated.
- .2 Do not place backfill in frozen condition.
- .3 Under paving and walks, compact backfill to at least 95% corrected maximum dry density. In other areas, compact to at least 90% corrected maximum dry density.

3.9 FLUSHING AND DISINFECTING

- .1 Flush water mains through available outlets with a sufficient flow of potable water to produce a velocity of 1.5 m/s, within pipe for 10 min, or until foreign materials have been removed and flushed water is clear with backflow protection.
- .2 Flushing flows shall be as follows:

<u>Pipe Size NPS</u>	<u>Flow (L/s) Minimum</u>
6 and below	38
8	75
10	115
<u>12</u>	<u>150</u>
- .3 Provide connections and pumps for flushing as required.
- .4 Open and close valves, hydrants and service connections to ensure thorough flushing.
- .5 When flushing has been completed to satisfaction of Consultant, introduce a strong solution of chlorine as approved by authority having jurisdiction into watermain and ensure that it is distributed throughout entire system.
- .6 Rate of chlorine application to be proportional to rate of water entering pipe.
- .7 Chlorine application to be close to point of filling water main and to occur at same time.
- .8 Operate valves, hydrants and appurtenances while main contains chlorine solution.
- .9 Flush line to remove chlorine solution after 24 h.
- .10 Measure chlorine residuals at extreme end of pipe-line being tested.
- .11 Perform bacteriological tests on water main, after chlorine solution has been flushed out. Take samples daily for minimum of two days. Should contamination remain or recur during this period, repeat disinfecting procedure. Specialist contractor shall submit certified copy of test results.
- .12 Take water samples at hydrants and service connections, in suitable sequence, to test for chlorine residual.
- .13 After adequate chlorine residual not less than 50 ppm has been obtained leave system charged with chlorine solution for 24 h. After 24 h, further samples shall be taken to ensure that there is still not less than 10 ppm of chlorine residual remaining throughout system.

3.10 SURFACE RESTORATION

- .1 After installing and backfilling over water mains, restore surface including all roads, curbs, sidewalks, landscaped areas etc. to original condition and to standards of local authority having jurisdiction.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ANSI/ASME B16.15, Cast Copper Alloy Threaded Fittings, Classes 125 and 250.
- .3 ANSI B16.18, Cast Copper Alloy Solder Joint Pressure Fittings.
- .4 ANSI/ASME B16.22, Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
- .5 ANSI B16.24, Cast Copper Alloy, Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500.
- .6 ASTM B88M, Specification for Seamless Copper Water Tube (Metric).
- .7 MSS-SP-70, Cast Iron Gate Valves, Flanged and Threaded Ends.
- .8 MSS-SP-71, Cast Iron Swing Check Valves, Flanged and Threaded Ends.
- .9 MSS-SP-80, Bronze Gate, Globe, Angle and Check Valves.

1.2 SHOP DRAWINGS

- .1 Submit shop drawing data in accordance with general requirements.

1.3 MAINTENANCE DATA

- .1 Provide maintenance data for incorporation into manual specified in general requirements.

Part 2 Products

2.1 PIPING

- .1 Domestic hot, cold and recirculation systems, within building.
 - .1 Above ground: copper tube, hard drawn, type L: to ASTM B88M.

2.2 FITTINGS

- .1 Bronze pipe flanges and flanged fittings, Class 150 and 300: to ANSI B16.24.
- .2 Cast bronze threaded fittings, Class 125 and 250: to ANSI/ASME B16.15.
- .3 Cast copper, solder type: to ANSI B16.18.
- .4 Wrought copper and copper alloy, solder type: to ANSI/ASME B16.22.
- .5 Tee drill NPS 25 mm (1") and larger.
- .6 NPS 80 mm (3") and larger: roll grooved to CSA B242.

2.3 JOINTS

- .1 Solder: 95/5.
- .2 Teflon tape: for threaded joints.
- .3 Dielectric connections between dissimilar metals: dielectric fitting to ASTM F1545, complete with thermoplastic liner.
- .4 Tee drill fittings shall be brazed with silver solder, 45% Ag - 15% Cu or copper phosphorous, 95% Cu, 5% P and non-corrosive flux.

2.4 VALVES

- .1 All valves shall be of commercial grade and of same manufacturer, Lead-Free.
- .2 Acceptable Manufacturers:
 - .1 Milwaukee
 - .2 Crane
 - .3 Kitz
 - .4 Apollo

2.5 BALL VALVES

- .1 All valves shall be of commercial grade and of same manufacturer.
- .2 NPS 80 mm (3") and under, soldered:
 - .1 To ANSI B16.18, Class 150.
 - .2 Bronze body, full port stainless steel ball, PTFE Teflon adjustable packing, brass gland and PTFE Teflon seat, steel lever handle, with NPT to copper adaptors.

2.6 GATE VALVES

- .1 NPS 50 mm (2") and under, soldered:
 - .1 Rising stem: to MSS SP-80, Class 125, 860 kPa (125 psi), bronze body, screw-in bonnet, solid wedge disc.
- .2 NPS 50 mm (2") and under, screwed:
 - .1 Rising stem: to MSS SP-80, Class 125, 860 kPa (125 psi), bronze body, screw-in bonnet, solid wedge disc.
- .3 NPS 65 mm (2-1/2") and over, other than mechanical rooms, flanged:
 - .1 Non-rising stem: to MSS SP-70, Class 125, 860 kPa (125 psi), flat flange faces, cast-iron body, bronze trim, bolted bonnet.

2.7 GLOBE VALVES

- .1 NPS 50 mm (2") and under, soldered:
 - .1 To MSS SP-80, Class 125, 860 kPa (125 psi), bronze body, renewable composition disc, screwed over bonnet.
 - .2 Lockshield handles: as indicated.

- .2 NPS 50 mm (2") and under, screwed:
 - .1 To MSS SP-80, Class 150, 1.03 MPa (150 psi), bronze body, screwed over bonnet, renewable composition disc.
 - .2 Lockshield handles: as indicated.

2.8 SWING CHECK VALVES

- .1 NPS 50 mm (2") and under, soldered:
 - .1 To MSS SP-80, Class 125, 860 kPa (125 psi), bronze body, bronze swing disc, screw in cap, regrindable seat.
- .2 NPS 50 mm (2") and under, screwed:
 - .1 To MSS SP-80, Class 125, 860 kPa (125 psi), bronze body, bronze swing disc, screw in cap, regrindable seat.
- .3 NPS 65 mm (2 1/2") and over, flanged:
 - .1 To MSS SP-71, Class 125, 860 kPa (125 psi), cast iron body, flat flange faces, [regrind] [renewable] seat, bronze disc, bolted cap.

2.9 BALANCING VALVES

- .1 Provide brass balancing valves suitable for potable water.
- .2 Brass body, EDPM O-Ring, Polytetrafluoroethylene slip washer and stainless steel spring.
- .3 Connect with dielectric connections.

2.10 CIRCUIT SETTER DOMESTIC WATER RECIRCULATING VALVE

- .1 Acceptable Manufacturers:
 - .1 ThermOmegaTech Inc.
 - .2 CircuitSolver® Models CS, CSU, CSUA, CSUAS, CSUTD-D as well as associated accessories such as Model CSA and CSUATD-D and models with optional thermometer PEX ends or ProPress ends.
- .2 Components
 - .1 Thermostatic Balance Valve
 - .1 The valve shall be certified lead free according to NSF/ANSI 61 standards.
 - .2 The valve body shall be constructed out of stainless steel.
 - .3 The valve shall be rated for 200 PSIG working pressure and 250°F max. temperature.
 - .4 The valve shall have a fixed, non-adjustable (tamper proof) temperature setpoint; temperature setpoints range from 80°F (27°C) to 170°F (27°C) in 5°F (2.8°C) increments.
 - .5 The valve shall have a temperature accuracy of ±3.0°F (±1.7°C).
 - .6 The valve shall have a wax thermostatic element.
 - .7 The valve shall come in six (6) sizes: 1/2"; 3/4"; 1"; 1 1/4"; 1 1/2"; 2".

- .3 Accessories
 - .1 PEX or ProPress ends as required.

Part 3 Execution

3.1 INSTALLATION

- .1 Install in accordance with Provincial Plumbing Code and local authority having jurisdiction.
- .2 Cut square, ream and clean tubing and tube ends, clean recesses of fittings and assemble without binding.
- .3 Assemble all piping using fittings manufactured to ANSI standards.
- .4 Install tubing close to building structure to minimize furring, conserve headroom and space. Group exposed piping and run parallel to walls.
- .5 Install CWS piping below and away from HWS and HWR and all other hot piping so as to maintain temperature of cold water as low as possible.
- .6 Connect to fixtures and equipment in accordance with manufacturers instructions unless otherwise indicated.
- .7 Bent tubing is not acceptable.

3.2 VALVES

- .1 Isolate equipment, fixtures and branches with ball valves.
- .2 Balance recirculation system using lockshield globe valves. Mark settings and record on as-built drawings on completion.

3.3 PRESSURE TESTS

- .1 Conform to requirements of general requirements.
- .2 Test pressure: greater of 1½ times maximum system operating pressure or 860 kPa (125 psi).

3.4 FLUSHING AND DISINFECTING

- .1 Maintain testable RP backflow preventor between municipal water and new plumbing system.
- .2 Ensure a minimum of 90% of plumbing fixtures are installed.
- .3 Flush water mains through available outlets with a sufficient flow of potable water to produce a velocity of 1.5 m/s, within pipe for 10 min, or until foreign materials have been removed and flushed water is clear with backflow protection.
- .4 Provide connections and pumps for flushing as required.
- .5 Open and close valves, and operate fixtures to ensure thorough flushing.

- .6 When flushing has been complete to satisfaction of Consultant introduce a strong solution of Chlorine into water system and ensure that it is distributed throughout entire system.
- .7 Rate of chlorine application to be proportional to rate of water entering pipe.
- .8 Chlorine injection to be close to point of filling water main or at building water service and to occur simultaneously.
- .9 Confirm adequate chlorine residual not less than 50 ppm has been obtained, leave system charged with chlorine solution for 24 h. After 24 h, further samples shall be taken to ensure that there is still not less than 10 ppm of chlorine residual remaining throughout system.
- .10 Upon 10 ppm confirmation and 24 hr elapsed time flush line to remove chlorine solution.
- .11 Measure chlorine residuals at extreme end of pipe-line being tested.
- .12 Perform bacteriological tests on water main, after chlorine solution has been flushed out. Take samples daily for minimum of two days. Should contamination remain or reoccur during this period, repeat disinfecting procedure. Specialist contractor shall submit certified copy of test results.
- .13 Take water samples at remote fixtures and service connections.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 CAN/CSA – B64.10/B64.10.1 – Selection and Installation of Backflow Preventers/Maintenance and Field Testing of Backflow Preventers.

1.2 SUBMITTALS

- .1 Complete the required cross connection survey form and submit to authority having jurisdiction. Provide a copy to the consultant.
- .2 Incorporate data into maintenance manual.

Part 2 Products

2.1 GENERAL

- .1 Provide backflow prevention devices in all new and existing fixtures and equipment as indicated and as required by the authority having jurisdiction.
- .2 Acceptable Manufacturers:
Watts
Wilkins

Part 3 Execution

3.1 INSTALLATION

- .1 Install devices in accordance with acceptable engineering practices, the requirements of the Ontario Building Code and the requirements of the authority having jurisdiction.

3.2 TESTING

- .1 Provide testing to requirements of authority having jurisdiction.
- .2 Provide copy of test report for each device in the maintenance manual.
- .3 Provide tag on each device.
- .4 Provide a list of devices complete with tag number on a framed chart. Locate chart in Water Entrance Room.
- .5 Provide additional testing on all devices at one year warranty period. Provide documentation to owner and consultant.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ASTM A126, Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
- .3 ASTM B62, Specification for Composition Bronze or Ounce Metal Castings.
- .4 PDI-WH201, Water Hammer Arresters.
- .5 CAN/CSA-B64 Series, Backflow Preventers and Vacuum Breakers.
- .6 ANSI/AWWA C700, Cold Water Meters-Displacement Type, Bronze Main Case.
- .7 ANSI/AWWA C701, Cold Water Meters-Turbine Type, for Customer Service.
- .8 ANSI/AWWA C702, Cold Water Meters-Compound Type.

1.2 SUBMITTALS

- .1 Submit shop drawings and product data in accordance with general requirements.
- .2 For shop drawings, indicate dimensions, construction details and materials.
- .3 For product data, indicate dimensions, construction details and materials for all items specified herein.

1.3 MAINTENANCE DATA

- .1 Provide maintenance data for incorporation into manual specified in general requirements.
- .2 Data to include:
 - .1 Description of plumbing specialties and accessories, giving manufacturers name, type, model, year and capacity.
 - .2 Details of operation, servicing and maintenance.
 - .3 Recommended spare parts list.

Part 2 Products

2.1 NON FREEZE WALL HYDRANTS (RECESSED, ENCASED)

- .1 Recessed, encased, all bronze construction, anti-syphon, non freeze wall hydrant with non-turning operating rod, free floating compression valve, integral vacuum breaker, self draining, replaceable seat and seat washer. Nickel bronze box and hinged cover with operating key lock. NPS 20 mm ($\frac{3}{4}$ ") hose outlet.
- .2 Acceptable Manufacturers:
 - .1 Zurn Z-1300
 - .2 Mifab MHY-20
 - .3 Ancon HY-725
 - .4 Contour C7100

2.2 INTERIOR HOSE BIBB

- .1 20 mm (3/4") diameter brass construction, 200 psi, 180°F pressure and temperature limits, complete with hose connection, and wheel handle straight/angle pattern to suit.
- .2 Provide vacuum breaker complete with hose connection.
- .3 Acceptable Manufacturers:
 - .1 Exposed on wall; Watts BD series
 - .2 Surface mounted (piping in wall); Watts SC-3 series
 - .3 Delta
 - .4 Waltec
 - .5 Wilkins
 - .6 Emco

2.3 BACKFLOW PREVENTORS

- .1 General Requirements:
 - .1 The backflow preventor shall prevent backflow by either backpressure or backsiphonage from a cross-connection between potable water lines and substances that are objectionable.
 - .2 To CAN/CSA-B64.
 - .3 Application: as indicated.
- .2 Reduced Pressure Principle:
 - .1 Up to 50 mm (2"):
 - .1 Rated to 180°F and supplied with full port ball valves. The main body and access covers shall be bronze (ASTM B584), the seat ring and all internal polymers shall be NSF® Listed Noryl™, and the seat disc elastomers shall be SILICONE. The first and second check shall be orientated at a 45° angle up-wards and accessible for maintenance without removing the relief valve. Supplied with an air gap adapter.
 - .2 Acceptable Manufacturers:
 - .1 Watts 009 ½" - 2"
 - .2 Wilkins 975 XL ½" - 2"
 - .3 Conbraco 40-200 Series
 - .2 65 mm (2½") to 250 mm (10"):
 - .1 The reduced pressure principle backflow preventer shall be ASSE 1013 approved and supplied with full port gate valves. The main body and access covers shall be epoxy coated cast iron (ASTM A126 Class B), the seat ring and check valve shall be cast bronze (ASTM B584), the stem shall be stainless steel (ASTM A276) and the seat disc elastomers shall be EPDM. The first and second checks shall be accessible for maintenance without removing the relief valve or the entire device from the line.
 - .2 If installed indoors, the installation shall be supplied with an air gap adapter, strainer, and integral monitor switch.

- .3 Acceptable Manufacturers:
 - .1 Watts 909 2½" - 10"
 - .2 Wilkins 975 2½" - 10" or 375 4" - 6"
 - .3 Conbraco 40-200 Series
- .3 Double Check Valve Assembly (DCVA):
 - .1 Up to 50mm (2"):
 - .1 The double check type backflow preventer shall be ASSE 1015 approved and supplied with full port ball valves. The main body and access covers shall be bronze (ASTM B584), the seat rings and all internal polymers shall be NSF® Listed Noryl™, and the seat disc elastomers shall be silicone. The first and second checks shall be accessible for maintenance without removing the device from the line.
 - .2 Acceptable Manufacturers:
 - .1 Watts 007 ½"-2"
 - .2 Wilkins 950XL ¾ "-2"
 - .3 Conbraco 40-100 Series
 - .2 65 mm (2½") to 250 mm (10"):
 - .1 The double check backflow preventer shall be ASSE 1015 approved and supplied with full port gate valves. The main body and access covers shall be epoxy coated cast iron (ASTM A126 Class B), the seat ring and check valve shall be cast bronze (ASTM B584), the stem shall be stainless steel (ASTM A276), and the seat disc elastomers shall be EPDM. The checks shall be accessible for maintenance without removing the device from the line.
 - .2 Acceptable Manufacturers:
 - .1 Watts 709 2½" - 10"
 - .2 Wilkins 950 2" - 10", 350 4" - 6"
 - .3 Conbraco 40-100 Series
- .4 Dual Check Valve with Intermediate Atmospheric Vent:
 - .1 Application: Laboratory equipment, processing tanks, sterilizers, dairy equipment.
 - .2 Suitable for continuous pressure applications and both hot and cold water systems.
 - .3 Primary check valve features check valve with rubber disc seating against a mating rubber part to ensure tight closing.
 - .4 Secondary check valve utilizes rubber disc to metal contact closing.
 - .5 In the event of backflow, leaks through the atmospheric vent.
 - .6 Bronze body, stainless steel working parts with integral strainer.
 - .7 Sizing: Match line size.

- .8 Installation: As per manufacturer instructions, ensure serviceable location. Pipe atmospheric vent to drain. Unit shall be installed surface mounted on wall, not hidden in wall or ceiling.
- .9 Acceptable Manufacturers:
 - .1 Watts Series 9D
 - .2 Wilkins 750
 - .3 Conbraco 40-4A Series
- .5 Dual Check Valve without Atmospheric Vent:
 - .1 Application: Non-carbonated beverage filling stations, cooking equipment with domestic water connections.
 - .2 Suitable for continuous pressure applications and both hot and cold water systems.
 - .3 Body and adapters are all 316 stainless steel construction.
 - .4 Rubber components comply with FDA food additive regulations and Safe Drinking Water Act. Bronze body, stainless steel working parts with integral strainer.
 - .5 Sizing: Match line size.
 - .6 Installation: As per manufacturer instructions, ensure serviceable location. Install prior to any filters provided with beverage dispenser. Unit shall be installed surface mounted on wall, not hidden in wall or ceiling.
 - .7 Acceptable Manufacturers:
 - .1 Watts Series 2D
 - .2 Wilkins
 - .3 Conbraco
- .6 Recessed Enclosures – DCVA and RP Backflow:
 - .1 Application: Provide for all DCVA and RP Backflow devices installed outside of service spaces and where indicated on plans.
 - .2 Size: Suitable for installed devices with appropriate service space for regular testing of device. Provide unit large enough for two devices where two devices are present.
 - .3 Construction:
 - .1 304 stainless steel.
 - .2 Concealed hinge access door complete with viewing window.
 - .3 Access door to have hasped/locking closure mechanism.
 - .4 Side or top/bottom openings to suit domestic water connections.
 - .5 Bottom opening for 50 mm (2") drain port.
 - .4 Acceptable Manufacturer:
 - .1 Emerson ValvCheQ.
 - .2 Others as approved by Consultant prior to tender close.

2.4 PRESSURE REGULATORS

- .1 Capacity: as indicated.
 - .1 Inlet pressure: 1034 kPa (150 psi).
 - .2 Outlet pressure: 41 kPa (5.9 psi).
- .2 Up to NPS 40 mm (1 1/2") bronze bodies, screwed: to ASTM B62.
 - .1 Acceptable Manufacturers:
 - .1 Watts Series 25AUB (1/2" - 2")
- .3 NPS 50 mm (2") and over, semi-steel bodies, Class 125, flanged: to ASTM A126, Class [B].
 - .1 Acceptable Manufacturers:
 - .1 Watts PV-10
 - .2 Conbraco 36 Series
- .4 Semi-steel spring chambers with bronze trim.
 - .1 Acceptable Manufacturers:
 - .1 Watts PV-10
 - .2 Conbraco 36 Series

2.5 HOSE BIBBS AND SEDIMENT FAUCETS

- .1 Bronze construction complete with integral back flow preventer, hose thread spout, replaceable composition disc, and chrome plated in finished areas.
 - .1 Acceptable Manufacturers:
 - .1 Watts BD series
 - .2 Emco
 - .3 Chicago
 - .4 Zurn

2.6 STRAINERS

- .1 860 kPa (125 psi), Y type with 20 mm (3/4") mesh, bronze or stainless steel removable screen.
- .2 NPS 50 mm (2") and under, bronze body, screwed ends, with brass cap.
 - .1 Acceptable Manufacturers:
 - .1 Watts Series 777SI
 - .2 Crane/Powers
 - .3 Colton 125 YTB
 - .4 Wilkins S Series

.3 NPS 65 mm (2½") and over, cast iron body, flanged ends, with bolted cap.

.1 Acceptable Manufacturers:

- .1 Watts 77F-D (77F-D-FDA for water service)
- .2 Crane/Powers
- .3 Colton 125 YTB
- .4 Wilkins FS Series

2.7 SOLENOID VALVES

.1 Two (2) way normally closed all bronze construction.

.2 Voltage shall be suitable for controlling function.

.3 Acceptable Manufacturers:

- .1 Asco

2.8 OWNER SUPPLIED EQUIPMENT

.1 The mechanical contractor shall supply and install all water, gas, condensate and sanitary piping to the owner supplied equipment. Connection to equipment shall be by this contractor.

.2 Provide flexible riser stops to all sinks and ball valves to all other equipment.

.3 Provide backflow preventors on equipment required by the local plumbing inspector.

.4 Provide flexible gas piping to all gas equipment.

.5 All equipment in store equipment schedule will be supplied and set in place by Mechanical Contractor unless otherwise noted.

.6 Coordinate all rough-ins and connection with the supplier on site.

.7 Owner supplied equipment includes existing relocated equipment.

Part 3 Execution

3.1 INSTALLATION

.1 Install in accordance with provincial codes, and local authority having jurisdiction.

.2 Install in accordance with manufacturer's instructions and as specified.

3.2 NON FREEZE WALL HYDRANTS

.1 Install 600 mm (24") above finished grade unless otherwise indicated.

3.3 BACK FLOW PREVENTORS

.1 Install in accordance with CAN/CSA-B64 Series, where indicated and elsewhere as required by code.

.2 Pipe discharge to terminate over nearest drain and or service sink.

.3 Provide test results in manual and leave tag with test results on device.

3.4 HOSE BIBBS AND SEDIMENT FAUCETS

- .1 Install at bottom of all risers, at low points to drain systems, and as indicated.

3.5 STRAINERS

- .1 Install with sufficient room to remove basket.
- .2 Strainer size to match pipe size.

3.6 WATER METERS

- .1 Install water meter provided by local water authority.
- .2 Install water meter as indicated.
- .3 Install remote readout to acceptance of local water authority and as indicated.

3.7 COMMISSIONING

- .1 In context of this paragraph, "verify" to include "demonstrate" to Consultant.
- .2 Timing: commission only after start-up deficiencies rectified.
- .3 Access doors: verify size and location relative to items to be services.
- .4 Adjust to suit site conditions, including, but not necessarily limited to, following:
 - .1 Non-freeze wall hydrants:
 - .1 Verify complete drainage.
 - .2 Verify operation of vacuum breaker.
 - .2 Backflow preventors, vacuum breakers:
 - .1 Verify installation of correct type to suit application.
 - .2 Adjust as necessary to ensure proper operation.
 - .3 Verify visibility of discharge.
 - .3 Pressure regulators:
 - .1 Adjust settings to suit installed locations, required flow rates.
 - .4 Hose bibbs, sediment faucets:
 - .1 Verify operation.
 - .5 Water meters:
 - .1 Verify operation.
 - .6 Pipeline strainers:
 - .1 Verify accessibility of basket.
 - .2 Clean out during commissioning until system clean.
- .5 Commissioning reports:
 - .1 Record all results on approved report forms.
 - .2 Include signature of tester and supervisor.
 - .3 To be countersigned by Consultant.

- .6 Verification:
 - .1 Notify Consultant 48 h before commencing tests.
 - .2 All tests and procedures to be witnessed by Consultant.
 - .3 All reported results subject to verification by consultant.
- .7 Training:
 - .1 Train O&M personnel in start-up, operation, monitoring, servicing, maintenance and shut-down procedures.
- .8 Demonstrations:
 - .1 Demonstrate full compliance with Design Criteria.
 - .2 Demonstrations also to show completeness of O&M personnel training.

3.8 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.
- .3 Warranty Coverage:
 - .1 Applies to parts and labour.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ASTM C117, Test Method for Material Finer Than 0.075 mm (3 mil) Sieve in Mineral Aggregates by Washing.
- .3 ASTM C136, Method for Sieve Analysis of Fine and Coarse Aggregates.
- .4 ASTM D698, Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (600 kN-m/m³).
- .5 ASTM D2680, Specification for Acrylonitrile-Butadiene-Styrene (ABS) and Poly (Vinyl Chloride) (PVC) Composite Sewer Piping.
- .6 ASTM D3034, Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
- .7 CAN/CSA-B182.1, Plastic Drain and Sewer Pipe and Pipe Fittings.
- .8 CAN/CSA-B182.2, PVC Sewer Pipe and Fittings (PSM Type).
- .9 CSA B182.11, Standard Practice for the Installation of Thermoplastic Drain and Sewer, Storm Pipe and Pipe Fittings.

1.2 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with Submittals Section.

1.3 MATERIAL CERTIFICATION

- .1 Submit manufacturers test data and certification at least 2 weeks prior to commencing work.

1.4 SCHEDULING OF WORK

- .1 Schedule work to minimize interruptions to existing services and to maintain existing sewage flows during construction.
- .2 Submit schedule of expected interruptions for approval and adhere to approved schedule.
- .3 Notify the building manager a minimum of 24 hrs in advance of any interruption in service.

Part 2 Products

2.1 PLASTIC PIPE

- .1 Type PSM Polyvinyl Chloride (PVC): to ASTM D3034 or CAN/CSA-B182.2.
 - .1 Standard Dimensional Ratio SDR 28 35 41.
 - .2 Locked in gasket and integral bell system.
 - .3 Nominal lengths: 6 m (20').

2.2 CEMENT MORTAR

- .1 Portland cement: to CAN/CSA-A300 Series, normal type 10.
- .2 Mix mortar one part by volume of cement to two parts of clean, sharp sand mixed dry. Add only sufficient water after mixing to give optimum consistency for placement. Do not use additives.

2.3 PIPE BEDDING AND SURROUND MATERIALS

- .1 Granular material to Excavating, Trenching, and Backfilling Section: and following requirements:
 - .1 Crushed or screened stone, gravel or sand.
 - .2 Gradations to be within limits specified when tested to ASTM C136 and ASTM C117]. Sieve sizes to CAN/CGSB-8.1.

	<u>Stone/Gravel</u>	<u>Gravel/Sand</u>
200 mm (8")	-	-
75 mm (3")	-	-
50 mm (2")	-	-
40 mm (1 1/2")	-	-
25 mm (1")	100	-
20 mm (3/4")	-	-
15 mm (1/2")	65-90	100
10 mm (3/8")	-	-
5 mm (3/16")	35-55	50-100
2.00 mm (80 mil)	-	30-90
0.425 mm (16 mil)	10-25	10-50
0.180 mm (7 mil)	-	-
<u>0.075 mm (3 mil)</u>	<u>0-8</u>	<u>0-10</u>

- .2 Concrete mixes and materials for cradles, encasement, and supports: to Cast-in-Place Concrete Section.

2.4 BACKFILL MATERIAL

- .1 As indicated.
- .2 Type 3, in accordance with Excavating, Trenching and Backfilling Section.
- .3 Unshrinkable fill: to Excavating, Trenching and Backfilling Section.

Part 3 Execution

3.1 PREPARATION

- .1 Clean and dry pipes and fittings before installation.

3.2 TRENCHING

- .1 Do trenching work in accordance with Excavating, Trenching and Backfilling Section.
- .2 Do not allow contents of any sewer or sewer connection to flow into trench.
- .3 Trench alignment and depth require approval of Consultant prior to placing bedding material and pipe.

3.3 GRANULAR BEDDING

- .1 Place bedding in unfrozen condition.
- .2 Place granular bedding materials in uniform layer(s) not exceeding 150 mm (6") compacted thickness to depth of 300 mm (12").
- .3 Shape bed true to grade and to provide continuous, uniform bearing surface for pipe. Do not use blocks when bedding pipe.
- .4 Shape transverse depressions as required to suit joints.
- .5 Compact each layer full width of bed to at least 95% maximum density to ASTM D698.
- .6 Fill excavation below bottom of specified bedding adjacent to manholes or structures with compacted bedding material.

3.4 INSTALLATION

- .1 Lay and join pipes in accordance with manufacturer's recommendations.
- .2 Handle pipe using methods approved. Do not use chains or cables passed through rigid pipe bore so that weight of pipe bears upon pipe ends.
- .3 Lay pipes on prepared bed, true to line and grade, with pipe invert smooth and free of sags or high points. Ensure barrel of each pipe is in contact with shaped bed throughout its full length.
- .4 Commence laying at outlet and proceed in upstream direction with socket ends of pipe facing upgrade.
- .5 Do not exceed maximum joint deflection recommended by pipe manufacturer.
- .6 Do not allow water to flow through pipe during construction.
- .7 Whenever work is suspended, install removable watertight bulkhead at open end of last pipe laid to prevent entry of foreign materials.
- .8 Install plastic pipe and fittings in accordance with CSA B182.11.
- .9 Pipe jointing:
 - .1 Install gaskets in accordance with manufacturer's recommendations.
 - .2 Support pipes with hand slings or crane as required to minimize lateral pressure on gasket and maintain concentricity until gasket is properly positioned.

- .3 Align pipes before joining.
- .4 Maintain pipe joints free from mud, silt, gravel and other foreign material.
- .5 Avoid displacing gasket or contaminating with dirt or other foreign material. Gaskets so disturbed shall be removed, cleaned and lubricated and replaced before joining is attempted.
- .6 Complete each joint before laying next length of pipe.
- .7 Minimize joint deflection after joint has been made to avoid joint damage.
- .8 At rigid structures, install pipe joints not more than 1.5 m (5') from side of structure.
- .9 Apply sufficient pressure in making joints to ensure that joint is complete as outlined in manufacturer's recommendations.
- .10 Cut pipes as required for special inserts, fittings or closure pieces as recommended by pipe manufacturer, without damaging pipe or its coating and to leave smooth end at right angles to axis of pipe.
- .11 Make watertight connections to manholes. Use shrinkage compensating grout when suitable gaskets are not available.
- .12 Use prefabricated saddles or field connections approved by Consultant, for connecting pipes to existing sewer pipes. Joints to be structurally sound and watertight.

3.5 PIPE SURROUND

- .1 Place surround material in unfrozen condition.
- .2 Upon completion of pipe laying, and after Consultant has inspected pipe joints, surround and cover pipes as indicated. Leave joints and fittings exposed until field testing is completed.
- .3 Hand place surround material in uniform layers not exceeding 150 mm (6") compacted thickness as indicated. Do not dump material within 1.0 m (40") of pipe.
- .4 Place layers uniformly and simultaneously on each side of pipe.
- .5 Compact each layer from pipe invert to mid height of pipe to at least 95% maximum density to ASTM D698.
- .6 Compact each layer from mid height of pipe to underside of backfill to at least 90% corrected maximum dry density and maximum density to ASTM D698.
- .7 When field test results are acceptable to Consultant, place surround material at pipe joints.

3.6 BACKFILL

- .1 Place backfill material in unfrozen condition.
- .2 Place backfill material, above pipe surround in uniform layers not exceeding 150 mm (6") compacted thickness up to grades as indicated.
- .3 Under paving and walks, compact backfill to at least 95% maximum density to ASTM D698. In other areas, compact to at least 90% maximum density to ASTM D698.

3.7 FIELD TESTING GRAVITY DRAINS

- .1 Repair or replace pipe, pipe joint or bedding found defective.
- .2 When directed by Consultant, draw tapered wooden plug with diameter of 50 mm (2") less than nominal pipe diameter through sewer to ensure that pipe is free of obstruction.
- .3 Remove foreign material from sewers and related appurtenances by flushing with water.
- .4 Perform infiltration and exfiltration testing as soon as practicable after jointing and bedding are complete, and service connections have been installed.
- .5 Carry out tests on each section of sewer between successive manholes including service connections.
- .6 Install watertight bulkheads in suitable manner to isolate test section from rest of pipeline.
- .7 Exfiltration test:
 - .1 Fill test section with water in such a manner as to allow displacement of air in line. Maintain under nominal head for 24 h to ensure absorption in pipe wall is complete before test measurements are commenced.
 - .2 Immediately prior to test period add water to pipeline until there is a head of 1.0 m (40") over interior crown of pipe measured at highest point of test section or water in manhole is 1.0 m (40") above static ground water level, whichever is greater.
 - .3 Duration of exfiltration test: 2 h.
 - .4 Water loss at end of test period: not to exceed maximum allowable exfiltration over any section of pipe between manholes.
- .8 Repair and retest sewer line as required, until test results are within limits specified.
- .9 Repair visible leaks regardless of test results.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ASTM A126, Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
- .3 ASTM B62, Specification for Composition Bronze or Ounce Metal Castings.
- .4 CAN/CSA-B79, Commercial and Residential Drains and Cleanouts.

1.2 SUBMITTALS

- .1 Submit shop drawings and product data in accordance with general requirements.
- .2 For shop drawings, indicate dimensions, construction details and materials.
- .3 For product data, indicate dimensions, construction details and materials for all items specified herein.

1.3 MAINTENANCE DATA

- .1 Provide maintenance data for incorporation into manual specified in general requirements.
- .2 Data to include:
 - .1 Description of plumbing specialties and accessories, giving manufacturers name, type, model, year, and capacity.
 - .2 Details of operation, servicing, and maintenance.
 - .3 Recommended spare parts list.

Part 2 Products

2.1 FLOOR DRAINS

- .1 Floor drains and trench drains: to CAN/CSA-B79.
- .2 Refer to schedule for types and acceptable manufacturer.

2.2 CLEANOUTS

- .1 Cleanout plugs: heavy cast iron male ferrule with brass screws and threaded brass or bronze plug. Sealing-caulked lead seat or neoprene gasket.
- .2 Wall access: face or wall type, stainless steel round cover with flush head securing screws, bevelled edge frame complete with anchoring lugs.
 - .1 Acceptable Manufacturers:
 - .1 Zurn ZSS-1469
 - .2 Mifab C1400-RD
 - .3 Watts CO-480-RD-3
 - .4 Jay R. Smith 4710

- .3 Floor access: rectangular, round, as indicated, cast iron body and frame with adjustable secured 15 mm (½") thick flush mounted heavy duty nickel bronze top and:
Plugs: bolted bronze with neoprene gasket.
 - .1 Cover for unfinished concrete floors: nickel bronze round, gasket, vandal-proof screws.
 - .1 Acceptable Manufacturers:
 - .1 Zurn ZN-1400 – HD or Zurn ZZN-1612
 - .2 Mifab C1100-XR-6
 - .3 Watts CO-200-RX-1-6
 - .4 Jay R. Smith SQ-4-1753-XNBCO-SP-U
 - .2 Cover for VCT tile and linoleum floors: square polished nickel bronze with 15 mm (1/2") thick flush mounted heavy duty nickel bronze cover, complete with vandal-proof locking screws.
 - .1 Acceptable Manufacturers:
 - .1 Zurn ZN-1400-T – HD
 - .2 Mifab C1100-TS-6
 - .3 Watts CO-200-TS-1-6
 - .4 Jay R. Smith 4200-U
 - .3 Cover for ceramic tile floors: 15 mm (½") thick heavy duty nickel bronze square, cover complete with gasket, vandal-proof screws, for flush finish.
 - .1 Acceptable Manufacturers:
 - .1 Zurn ZN-1400 – T-HD or Zurn ZZN-1612
 - .2 Mifab C1100-S-6
 - .3 Watts CO-200-S-1-6
 - .4 Jay R. Smith SQ-4-1753-NBCO-SP-U-Y
 - .4 Cover for carpeted floors: round polished nickel bronze with flush cover, complete with stainless steel carpet marker, vandal-proof locking screws.
 - .1 Acceptable Manufacturers:
 - .1 Zurn ZN-1400-HD-CM or ZN-1612-CM
 - .2 Mifab C1100C-S-1-6
 - .3 Ancon CO-200-RC-1-6
 - .4 Smith
 - .5 Contour C3000RMNB

2.3 TRAP SEAL PRIMER STATIONS

- .1 Provide trap primer stations where indicated complete with solenoid valve, backflow preventor, vacuum breaker, NPS 15 mm (1/2") solder ends, NPS 15 mm (1/2") drip line connections.
- .2 Solenoid valve electric characteristics shall be suitable for controlling function.
- .3 Coordinate location and number of trap primer stations with Building Automation System (BAS) contractor.

.4 Acceptable Manufacturers:

- .1 Mifab
- .2 Watts
- .3 Zurn

2.4 SOLENOID VALVES (HEADER TRAP SEAL PRIMER)

- .1 Two (2) way normal closed all bronze construction.
- .2 With integral adjustable cycle time clock control. Timer control to have two dial functions, time between cycles and time held in "open position".
- .3 Suitable for 120V.
- .4 Acceptable Manufacturers:
 - .1 Asco

Part 3 Execution

3.1 INSTALLATION

- .1 Install in accordance with provincial codes, and local authority having jurisdiction.
- .2 Install in accordance with manufacturer's instructions and as specified.

3.2 CLEANOUTS

- .1 In addition to those required by code, and as indicated, install at base of all soil and waste stacks.
- .2 Bring cleanouts to wall or finished floor unless serviceable from below floor.
- .3 Building drain cleanout and stack base cleanouts: line size to maximum NPS 100 mm (4").

3.3 TRAP SEAL PRIMERS

- .1 Install for all floor, hub and trench drains and elsewhere, as indicated.
- .2 Install on cold water supply to nearest frequently used plumbing fixture, in concealed space, to approval of Consultant.
- .3 Install soft copper tubing to floor drains above grade and polyethylene piping to floor drains below grade.

3.4 TRAP SEAL PRIMER STATIONS

- .1 Provide primer stations where indicated.
- .2 Install for all floor drains and elsewhere, as indicated.
- .3 Install copper piping to floor drains above grade. Install polypropylene piping to floor drains on grade.

3.5 COMMISSIONING

- .1 In context of this paragraph, "verify" to include "demonstrate" to Consultant.
- .2 Timing: Commission only after start-up deficiencies rectified.
- .3 Access doors: Verify size and location relative to items to be services.
- .4 Adjust to suit site conditions, including, but not necessarily limited to, following:
 - .1 Floor, hub and trench drains:
 - .1 Verify proper operation of trap primer, flushing features.
 - .2 Verify security and removability of strainers.
 - .2 Cleanouts:
 - .1 Verify covers are gastight, secure and easily removable.
 - .2 Verify that cleanout rods can probe as far as next cleanout.
 - .3 Trap seal primers:
 - .1 Verify operation.
 - .2 Adjust flow rate to suit site conditions.
- .5 Commissioning reports:
 - .1 Record all results on approved report forms.
 - .2 Include signature of tester and supervisor.
 - .3 To be countersigned by Consultant.
- .6 Verification:
 - .1 Notify Consultant 48 h before commencing tests.
 - .2 All tests and procedures to be witnessed by Consultant.
 - .3 All reported results subject to verification by consultant.
- .7 Training:
 - .1 Train O&M personnel in start-up, operation, monitoring, servicing, maintenance and shut-down procedures.
- .8 Demonstrations:
 - .1 Demonstrate full compliance with Design Criteria.
 - .2 Demonstrations also to show completeness of O&M personnel training.

3.6 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.

.3 Warranty Coverage:

.1 Applies to parts and labour.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ASTM B32, Specification for Solder Metal.
- .3 ASTM B306, Specification for Copper Drainage Tube (DWV).
- .4 ASTM C564, Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
- .5 CAN/CSA-B70, Cast Iron Soil Pipe, Fittings and Means of Joining.
- .6 CAN/CSA-B125.3, Plumbing Fittings.

Part 2 Products

2.1 COPPER TUBE AND FITTINGS

- .1 Above ground sanitary, and vent, maximum 65 mm (2½") Type DWV copper to: ASTM B306.
 - .1 Fittings.
 - .1 Cast brass: to CAN/CSA B125.3.
 - .2 Wrought copper: to CAN/CSA B125.3.
 - .2 Solder: tin-lead, 50:50, to ASTM B32, type 50A.

2.2 CAST IRON PIPING AND FITTINGS

- .1 Above and below ground sanitary, and vent, minimum NPS 80 mm (3"), cast iron to: CAN/CSA-B70.
 - .1 Mechanical joints (vents)
 - .1 Neoprene or butyl rubber compression gaskets: to ASTM C564 or CAN/CSA-B70.
 - .2 Stainless steel clamps (2 band).
 - .2 Mechanical joints (sanitary)
 - .1 Heavy duty neoprene or butyl rubber compression gaskets to: ASTM C1540.
 - .2 Stainless steel clamps (4 band min).

2.3 VENT FLASHINGS

- .1 Thaler or equal spun aluminum complete with insulation, cap, and rubber gasket.

Part 3 Execution

3.1 APPLICATION

- .1 Install copper or cast iron drainage on first 10'-0" (3.0m) of all fixtures discharging waste above 110°F.

3.2 INSTALLATION

- .1 Install in accordance with Provincial Plumbing Code and local authority having jurisdiction.
- .2 Install above ground piping parallel and close to walls and ceilings to conserve headroom and space, and to grade as indicated.
- .3 Place Cleanouts
 - .1 Where shown on Drawings and near bottom of each stack and riser.
 - .2 At every 90 degree change of direction for horizontal lines.
 - .3 Every 15 m (50') of horizontal run.
 - .4 Extend clean out to accessible surface. Do not place cleanouts in carpeted floors. In such locations, use wall type cleanouts.
- .4 Each fixture and appliance discharging water into sanitary sewer or building sewer lines shall have a seal trap in connection with a complete venting system so gases pass freely to atmosphere with no pressure or syphon condition on water seal.
- .5 Vent entire waste system to atmosphere.
 - .1 Discharge 500 mm (20") above roof. Join lines together in fewest practicable number before projecting above roof.
 - .2 Set back vent lines so they will not pierce roof near an edge or valley.
 - .3 Venting shall be 7.5 m (25'-0") from any outdoor air intakes.
 - .4 Provide copper vent piping through roof as per detail.
- .6 Use torque wrench to obtain proper tension in cinch bands when using hubless cast iron pipe. Butt ends of pipe against centering flange of coupling.
- .7 Flash pipes passing through roof with 453 g (16 oz) sheet copper flashing fitted snugly around pipes and caulk between flashing and pipe with flexible waterproof compound.
 - .1 Flashing base shall be at least 600 mm (24") square.
 - .2 Flashing may be a 24 kg/m² (5 lb/ft²) lead flashing fitted around pipes and turned down into pipe 15 mm (½") with turned edge hammered against pipe wall.
- .8 Before piping is covered, conduct tests in presence of Consultant and correct leaks or defective work. Conduct test prior to placing floor slab but after backfill is placed.
 - .1 Do not caulk threaded work.
 - .2 Fill waste and vent system to roof level [a minimum of 3,100 mm - (10')] with water and show no leaks for 2 hours.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ASTM D2235, Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings.
- .3 ASTM D2564, Specification for Solvent Cements for Poly(Vinyl-Chloride) (PVC) Plastic Piping Systems.
- .4 CAN/CSA-B181.1, ABS Drain, Waste and Vent Pipe and Pipe Fittings.
- .5 CAN/CSA-B181.2, PVC and CPVC Drain, Waste and Vent Pipe and Pipe Fittings.
- .6 CAN/CSA-B182.1, Plastic Drain and Sewer Pipe and Pipe Fittings.

Part 2 Products

2.1 PIPING AND FITTINGS

- .1 Buried sanitary, and vent piping to:
 - .1 80 mm (3") and smaller: ABS drain waste and vent pipe to CAN/CSA-B181.1.
 - .2 100 mm (4") and larger: SDR-35 PVC drain waste and vent pipe to CAN/CSA-B181.2.
 - .3 Vent piping: any size, PVC-DWV plastic drain and sewer pipe and fittings CAN/CSA-B181.2.
- .2 Above grade sanitary and vent piping:
 - .1 80 mm (3") and smaller: IPEX: PVC-XFR drain waste and vent pipe to CAN/CSA-B181.2.
 - .2 100 mm (4") and larger: IPEX: PVC-XFR drain waste and vent pipe to CAN/CSA-B181.2.
 - .3 Vent piping: any size, IPEX: PVC-XFR plastic drain and sewer pipe and fittings CAN/CSA-B181.2.
- .3 Use plastic XFR – DWV in pipe chase for urinal piping to 1.5 M (5' –0") above finished floor.
- .4 Where piping pierces a fire separation an approved fire stop system to the approval of authority having jurisdiction shall be used.

2.2 JOINTS

- .1 Solvent weld for PVC: to ASTM D2564.
- .2 Solvent weld for ABS: to ASTM D2235.

2.3 EXPANSION

- .1 Provide solvent welded expansion joints as required by manufacturer's recommendations.

2.4 VENT FLASHINGS

- .1 Thaler Stack Jack spun aluminum complete with insulation, cap, and rubber gasket.

Part 3 Execution

3.1 INSTALLATION

- .1 Install in accordance with Provincial Plumbing Code and local authority having jurisdiction. Install in accordance with manufacturer's instructions.
- .2 Installation of underground pipe
 - .1 Provide all excavation, bedding, backfill, and compaction.
 - .2 Install materials in accordance with Manufacturer's instructions.
 - .3 Use jacks to make-up gasketed joints.
 - .4 Stabilize unstable trench bottoms.
 - .5 Bed pipe true to line and grade with continuous support from firm base.
 - .1 Bedding depth - 100 mm to 150 mm (4" to 6").
 - .2 Material and compaction to meet ASTM standard noted above.
 - .6 Excavate bell holes into bedding material so pipe is uniformly supported along its entire length. Blocking to grade pipe is forbidden.
 - .7 Trench width at top of pipe -
 - .1 Minimum 450 mm (18") or diameter of pipe plus 300 mm (12"), whichever is greater.
 - .2 Maximum - Outside diameter of pipe plus 600 mm (24").
 - .8 Piping and joints shall be clean and installed according to manufacturer's recommendations. Break down contaminated joints, clean seats and gaskets and reinstall.
 - .9 Do not use back hoe or power equipment to assemble pipe.
 - .10 Initial backfill shall be 300 mm (12") above top of pipe with material specified in referenced ASTM standard.
- .3 Place Cleanouts
 - .1 Where shown on Drawings and near bottom of each stack and riser.
 - .2 At every 90 degree change of direction for horizontal lines.
 - .3 Every 15 m (50') of horizontal run.
 - .4 Extend clean out to accessible surface. Do not place cleanouts in carpeted floors. In such locations, use wall type cleanouts
- .4 Each fixture and appliance discharging water into sanitary sewer or building sewer lines shall have a seal trap in connection with a complete venting system so gases pass freely to atmosphere with no pressure or syphon condition on water seal.

- .5 Before piping is covered, conduct tests in presence of Consultant and correct leaks or defective work. Conduct test prior to placing floor slab but after backfill is placed.
 - .1 Fill waste and vent system a minimum of 1.8 m (6') above finished floor with water and show no leaks for 2 hours.
 - .2 Conduct ball test in presence of consultant to ensure proper grade and clear of obstructions.
- .6 Install solvent welded expansion joints as per manufacturer's recommendation. Care is to be taken to accommodate ambient temperatures at time of install.
- .7 Vent entire waste system to atmosphere.
 - .1 Discharge 350 mm (14") above roof. Join lines together in fewest practicable number before projecting above roof.
 - .2 Set back vent lines so they will not pierce roof near an edge or valley.
 - .3 Venting shall be 7.5 m (25'-0") from any outdoor air intakes.
- .8 Flash pipes passing through roof with Thaler insulated Stack Jack flashing.
 - .1 Flashing base shall be at least 600 mm (24") square.
- .9 Install above ground piping parallel and close to walls and ceilings to conserve headroom and space, and to grade as indicated.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ASTM A126, Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
- .3 ASTM B62, Specification for Composition Bronze or Ounce Metal Castings.
- .4 CAN/CSA-B79, Commercial and Residential Drains and Cleanouts.
- .5 PDI-WH201, Water Hammer Arresters.
- .6 CAN/CSA-B64 Series, Backflow Preventers and Vacuum Breakers.
- .7 PDI-G101, Testing and Rating Procedure for Grease Interceptors.
- .8 CAN/CSA-B481 Senes12, Grease Interceptors.

1.2 SUBMITTALS

- .1 Submit shop drawings and product data in accordance with general requirements.
- .2 For shop drawings, indicate dimensions, construction details and materials.
- .3 For product data, indicate dimensions, construction details and materials for all items specified herein.

1.3 MAINTENANCE DATA

- .1 Provide maintenance data for incorporation into manual specified in general requirements.
- .2 Data to include:
 - .1 Description of plumbing specialties and accessories, giving manufacturers name, type, model, year and capacity.
 - .2 Details of operation, servicing and maintenance.
 - .3 Recommended spare parts list.

Part 2 Products

2.1 HYDROMECHANICAL GREASE INTERCEPTORS (PLASTIC)

- .1 Hydromechanical type interceptor, tested and rated in accordance with the Environmental Protection Act (EPA), complete with fire resistant polypropylene construction for mounting flush with floor with aluminum non-skid covers on floor complete with flow control fitting suitably vented, and extension.
- .2 Capacity:
 - .1 Refer to Schedules.
- .3 The unit shall be able to treat effluent to less than 100 mg/litre of oil and grease.

- .4 Provide extensions as required to suit finished floor elevation and installed depth.
- .5 Provide secondary flow control devices for all interceptors that serve fixtures installed more than one storey above unit.
- .6 Acceptable Manufacturers:
 - .1 Canplas Endura
 - .2 MIFAB (with confirmation of CSA Compliance)
 - .3 JRC Plastic Interrupters and Pit Boxes (Tel: 1-416-453-2364) (with confirmation of CSA compliance)
 - .4 Jonespec (with confirmation of CSA compliance)
 - .5 Contour (with confirmation of CSA compliance)

Part 3 Execution

3.1 INSTALLATION

- .1 Install in accordance with provincial codes, and local authority having jurisdiction.
- .2 Install in accordance with manufacturer's instructions and as specified.

3.2 INTERCEPTORS

- .1 Install with sufficient space, as indicated, for ease of maintenance.

3.3 COMMISSIONING

- .1 In context of this paragraph, "verify" to include "demonstrate" to Consultant.
- .2 Timing: commission only after start-up deficiencies rectified.
- .3 Access doors: verify size and location relative to items to be services.
- .4 Adjust to suit site conditions, including, but not necessarily limited to, following:
 - .1 Grease interceptors:
 - .1 Activate, using manufacturer's recommended activation procedures and materials.
- .5 Commissioning reports:
 - .1 Record all results on approved report forms.
 - .2 Include signature of tester and supervisor.
 - .3 To be countersigned by Consultant.
- .6 Verification:
 - .1 Notify Consultant 48 h before commencing tests.
 - .2 All tests and procedures to be witnessed by Consultant.
 - .3 All reported results subject to verification by consultant.

- .7 Training:
 - .1 Train O&M personnel in start-up, operation, monitoring, servicing, maintenance and shut-down procedures.
- .8 Demonstrations:
 - .1 Demonstrate full compliance with Design Criteria.
 - .2 Demonstrations also to show completeness of O&M personnel training.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ASTM C14M, Specification for Non-reinforced Concrete Sewer, Storm Drain and Culvert Pipe.
- .3 ASTM C76M, Specification for Reinforced Concrete Culvert, Storm Drain and Sewer Pipe.
- .4 ASTM C117, Test Method for Material Finer Than 0.075 mm (3 mil) Sieve in Mineral Aggregates by Washing.
- .5 ASTM C136, Method for Sieve Analysis of fine and Coarse Aggregates.
- .6 ASTM C443M, Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
- .7 ASTM D2680, Specification for Acrylonitrile-Butadiene-Styrene (ABS) and Poly (Vinyl Chloride) (PVC) Composite Sewer Piping.
- .8 ASTM D3034, Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
- .9 CAN/CSA-A3001, Cementitious Materials for Use in Concrete.
- .10 ASTM C700, Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated.
- .11 CAN/CSA-A257, Standards for Concrete Pipe and Manhole Sections.
- .12 CAN/CSA-B182.1, Plastic Drain and Sewer Pipe and Pipe Fittings.
- .13 CAN/CSA-B182.2, PVC Sewer Pipe and Fittings (PSM Type).
- .14 CSA B182.11, Standard Practice for the Installation of Thermoplastic Drain, Storm, and Sewer Pipe and Pipe Fittings.
- .15 CAN/CGSB-8.1, Sieves Testing, Woven Wire.
- .16 CAN/CGSB-8.2, Sieves Testing, Woven Wire, Metric.

1.2 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with Submittals Section.

1.3 MATERIAL CERTIFICATION

- .1 Submit manufacturers test data and certification at least 2 weeks prior to commencing work.

1.4 SCHEDULING OF WORK

- .1 Schedule work to minimize interruptions to existing services and to maintain existing flow during construction.

- .2 Submit schedule of expected interruptions for approval and adhere to approved schedule.

1.5 STANDARDS

- .1 To local Municipal Standards.
- .2 To Ontario Provincial Standards (OPS) for Roads and Municipal Services.

Part 2 Products

2.1 CONCRETE PIPE

- .1 Non-reinforced circular concrete pipe and fittings: to CAN/CSA-A257, ASTM C14M 300 mm (12") and smaller diameter, Class 100D, designed for flexible rubber gasket joints to ASTM C443M CSA A257.
- .2 Reinforced circular concrete pipe and fittings: to CAN/CSA-A257, ASTM C76M 450 mm (18") and larger diameter, strength classification 100 D, designed for flexible rubber gasket joints to ASTM C443M CAN/CSA A257.

2.2 PLASTIC PIPE

- .1 Large diameter, ribbed PVC sewer pipe and fittings: to CAN/CSA B182.4 ASTM F794.
 - .1 Standard dimension ratio SDR 35
 - .2 Gasket and integral bell system
 - .3 Nominal length 6 m (20').

2.3 PIPE BEDDING AND SURROUND MATERIAL

- .1 Granular material to Excavating, Trenching, and Backfilling Section and following requirements:
 - .1 Crushed or screened stone, gravel or sand.
 - .2 Gradations to be within limits specified when tested to ASTM C136 and ASTM C117. Sieve sizes to CAN/CGSB-8.1.

	<u>Stone/Gravel</u>	<u>Gravel/Sand</u>
200 mm (8")	-	-
75 mm (3")	-	-
50 mm (2")	-	-
40 mm (1 1/2")	-	-
25 mm (1")	[100]	-
20 mm (3/4")	-	-
15 mm (1/2")	[65-90]	[100]
10 mm (3/8")	-	-
5 mm (3/16")	[35-55]	[50-100]
2.00 mm (80 mil)	-	[30-90]
0.425 mm (16 mil)	[10-25]	[10-50]
0.180 mm (7 mil)	-	-
0.075 mm (3 mil)	[0-8]	[0-10]

- .2 Concrete mixes and materials for bedding, cradles, encasement, and supports: to Cast-in-Place Concrete Section.

2.4 BACKFILL MATERIAL

- .1 As indicated.
- .2 Type 3 to Excavating Trenching and Backfilling Section.

Part 3 Execution

3.1 PREPARATION

- .1 Clean pipes and fittings of debris and water before installation and remove defective materials from site to approval of Consultant.

3.2 TRENCHING

- .1 Do trenching work in accordance with Excavating, Trenching and Backfilling Section.
- .2 Do not allow contents of any sewer or sewer connection to flow into trench.
- .3 Trench alignment and depth to approval of Consultant prior to placing bedding material and pipe.

3.3 GRANULAR BEDDING AND PIPE SURROUND

- .1 Place bedding in unfrozen condition.
- .2 Place granular bedding material in uniform layers not exceeding 150 mm (6") compacted thickness to depth of as indicated.
- .3 Shape bed true to grade and to provide continuous, uniform bearing surface for pipe. Do not use blocks when bedding pipes.
- .4 Shape transverse depressions as required to suit joints.
- .5 Compact each layer full width of bed to at least 95% maximum density to ASTM D698.
- .6 Fill excavation below bottom of specified bedding adjacent to manholes or catch basins with compacted bedding material.
- .7 Hand place surround material in uniform layers not exceeding 150 mm compacted thickness as indicated. Do not dump material within 1.0 m of pipe.
- .8 Compact each layer from native material to 300 mm (12") above pipe to at least 95% corrected maximum dry density.

3.4 INSTALLATION

- .1 Lay and join pipe in accordance with manufacturer's recommendations and to approval of Consultant.
- .2 Handle pipe using methods approved by Consultant. Do not use chains or cables passed through rigid pipe bore so that weight of pipe bears upon pipe ends.

- .3 Lay pipes on prepared bed, true to line and grade with pipe inverts smooth and free of sags or high points. Ensure barrel of each pipe is in contact with shaped bed throughout its full length.
- .4 Commence laying at outlet and proceed in upstream direction with socket ends of pipe facing upgrade.
- .5 Do not exceed maximum joint deflection recommended by pipe manufacturer.
- .6 Do not allow water to flow through pipes during construction.
- .7 Install plastic pipe and fittings in accordance with CSA B182.11.
- .8 Cut pipes as required for special inserts, fittings or closure pieces, as recommended by pipe manufacturer, without damaging pipe or its coating and to leave smooth end at right angles to axis of pipe.
- .9 Make watertight connections to manholes and catch basins. Use shrinkage compensating grout when suitable gaskets are not available.
- .10 Use prefabricated saddles or approved field connections for connecting pipes to existing sewer pipes. Joint to be structurally sound and watertight.
- .11 Temporarily plug open upstream ends of pipes with removable watertight concrete, steel or plastic bulkheads.

3.5 PIPE SURROUND

- .1 Place surround material in unfrozen condition.
- .2 Upon completion of pipe laying, and after Consultant has inspected pipe joints, surround and cover pipes as indicated. Leave joints and fittings exposed until field testing is completed.
- .3 Hand place surround material in uniform layers not exceeding 150 mm (6") compacted thickness as indicated. Do not dump material within 1.0 m (40") of pipe.
- .4 Place layers uniformly and simultaneously on each side of pipe.
- .5 Compact each layer from pipe invert to mid height of pipe to at least 95% corrected maximum dry density.
- .6 Compact each layer from mid height of pipe to underside of backfill to at least 90% corrected maximum dry density.
- .7 When field test results are acceptable to Consultant, place surround material at pipe joints.

3.6 BACKFILL

- .1 Place backfill material in unfrozen condition.
- .2 Place backfill material, above pipe surround, in uniform layers not exceeding 150 mm (6") compacted thickness up to grades as indicated.
- .3 Under paving and walks, compact backfill to at least 95% corrected maximum dry density maximum density to ASTM D698. In other areas, compact backfill to at least 90% maximum density to ASTM D698.

3.7 FIELD TESTING

- .1 Repair or replace pipe, pipe joint or bedding found defective.
- .2 When directed by Consultant, draw tapered wooden plug with diameter of 50 mm (2") less than nominal pipe diameter through sewer to ensure that pipe is free of obstruction.
- .3 Remove foreign material from sewers and related appurtenances by flushing with water.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ASTM B32, Specification for Solder Metal.
- .3 ASTM B306, Specification for Copper Drainage Tube (DWV).
- .4 ASTM C564, Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
- .5 CAN/CSA-B70, Cast Iron Soil Pipe, Fittings and Means of Joining.
- .6 CAN/CSA-B125.3, Plumbing Fittings.

Part 2 Products

2.1 COPPER TUBE AND FITTINGS

- .1 Above ground storm maximum 65 mm (2½") Type DWV copper to: ASTM B306.
 - .1 Fittings.
 - .1 Cast brass: to CAN/CSA B125.3.
 - .2 Wrought copper: to CAN/CSA B125.3.
 - .2 Solder: tin-lead, 50:50, to ASTM B32, type 50A.

2.2 CAST IRON PIPING AND FITTINGS

- .1 Above ground storm minimum NPS 80 mm (3"), cast iron to: CAN/CSA-B70.
 - .1 Mechanical joints (storm)
 - .1 Heavy duty neoprene or butyl rubber compression gaskets to: ASTM C1540.
 - .2 Stainless steel clamps (4 band min).

Part 3 Execution

3.1 INSTALLATION

- .1 Install in accordance with Provincial Plumbing Code and local authority having jurisdiction.
- .2 Install above ground piping parallel and close to walls and ceilings to conserve headroom and space, and to grade as indicated.

- .3 Place Cleanouts
 - .1 Where shown on Drawings and near bottom of each stack and riser.
 - .2 At every 90 degree change of direction for horizontal lines.
 - .3 Every 15 m (50') of horizontal run.
 - .4 Extend clean out to accessible surface. Do not place cleanouts in carpeted floors. In such locations, use wall type cleanouts.
- .4 Use torque wrench to obtain proper tension in cinch bands when using hubless cast iron pipe. Butt ends of pipe against centering flange of coupling.
- .5 Before piping is covered, conduct tests in presence of Consultant and correct leaks or defective work. Conduct test prior to placing floor slab but after backfill is placed.
 - .1 Do not caulk threaded work.
 - .2 Fill waste and vent system to roof level [a minimum of 3,100 mm (10')] with water and show no leaks for 2 hours.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ASTM D2235, Specification for Solvent Cement for Acrylonitrille-Butadiene-Styrene (ABS) Plastic Pipe and Fittings.
- .3 ASTM D2564, Specification for Solvent Cements for Poly(Vinyl-Chloride) (PVC) Plastic Piping Systems.
- .4 CAN/CSA-B181.1, ABS Drain, Waste and Vent Pipe and Pipe Fittings.
- .5 CAN/CSA-B181.2, PVC and CPVC Drain, Waste and Vent Pipe and Pipe Fittings.
- .6 CAN/CSA-B182.1, Plastic Drain and Sewer Pipe and Pipe Fittings.

Part 2 Products

2.1 PIPING AND FITTINGS

- .1 Buried storm piping to:
 - .1 80 mm (3") and smaller: ABS drain pipe to CAN/CSA-B181.1.
 - .2 100 mm (4") and larger: SDR-35 PVC drain pipe to CAN/CSA-B181.2.
- .2 Above grade storm piping:
 - .1 80 mm (3") and smaller: IPEX: PVC-XFR fire rated drain storm pipe to CAN/CSA-B181.1.
 - .2 100 mm (4") and larger: IPEX: PVC-XFR storm pipe to CAN/CSA-B181.2.
- .3 Where piping pierces a fire separation an approved fire stop system to the approval of authority having jurisdiction shall be used.

2.2 JOINTS

- .1 Solvent weld for PVC: to ASTM D2564.
- .2 Solvent weld for ABS: to ASTM D2235.

Part 3 Execution

3.1 INSTALLATION

- .1 Install in accordance with Provincial Plumbing Code and local authority having jurisdiction.
- .2 Installation of underground pipe
 - .1 Provide all excavation, bedding, backfill, and compaction.
 - .2 Install materials in accordance with Manufacturer's instructions.

- .3 Use jacks to make-up gasketed joints.
- .4 Stabilize unstable trench bottoms.
- .5 Bed pipe true to line and grade with continuous support from firm base.
 - .1 Bedding depth - 100 mm to 150 mm (4" to 6").
 - .2 Material and compaction to meet ASTM standard noted above.
- .6 Excavate bell holes into bedding material so pipe is uniformly supported along its entire length. Blocking to grade pipe is forbidden.
- .7 Trench width at top of pipe -
 - .1 Minimum 450 mm (18") or diameter of pipe plus 300 mm (12"), whichever is greater.
 - .2 Maximum - Outside diameter of pipe plus 600 mm (24").
- .8 Piping and joints shall be clean and installed according to manufacturer's recommendations. Break down contaminated joints, clean seats and gaskets and reinstall.
- .9 Do not use back hoe or power equipment to assemble pipe.
- .10 Initial backfill shall be 300 mm (12") above top of pipe with material specified in referenced ASTM standard.
- .3 Place Cleanouts
 - .1 Where shown on Drawings and near bottom of each stack and riser.
 - .2 At every 90 degree change of direction for horizontal lines.
 - .3 Every 15 m (50 ft) of horizontal run.
 - .4 Extend clean out to accessible surface. Do not place cleanouts in carpeted floors. In such locations, use wall type cleanouts
- .4 Before piping is covered, conduct tests in presence of Consultant and correct leaks or defective work. Conduct test prior to placing floor slab but after backfill is placed.
 - .1 Fill waste and vent system a minimum of 1.8 m (6 ft) above finished floor with water and show no leaks for 2 hours.
 - .2 Conduct ball test in presence of consultant to ensure proper grade and clear of obstructions.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ASTM A126, Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
- .3 ASTM B62, Specification for Composition Bronze or Ounce Metal Castings.
- .4 CAN/CSA-B79, Commercial and Residential Drains and Cleanouts.

1.2 SUBMITTALS

- .1 Submit shop drawings and product data in accordance with general requirements.
- .2 For shop drawings, indicate dimensions, construction details and materials.
- .3 For product data, indicate dimensions, construction details and materials for all items specified herein.

1.3 MAINTENANCE DATA

- .1 Provide maintenance data for incorporation into manual specified in general requirements.
- .2 Data to include:
 - .1 Description of plumbing specialties and accessories, giving manufacturers name, type, model, year and capacity.
 - .2 Details of operation, servicing and maintenance.
 - .3 Recommended spare parts list.

Part 2 Products

2.1 ROOF DRAINS

- .1 As indicated on schedules.

2.2 CLEANOUTS

- .1 Cleanout plugs: heavy cast iron male ferrule with brass screws and threaded brass or bronze plug. Sealing-caulked lead seat or neoprene gasket.
- .2 Wall access: face or wall type, stainless steel round cover with flush head securing screws, bevelled edge frame complete with anchoring lugs.
 - .1 Acceptable Manufacturers:
 - .1 Zurn ZSS-1469
 - .2 Mifab C1400-RD
 - .3 WATTS CO-480-RD-3
 - .4 Jay R. Smith SQ-A-1753-XNBCO-SP-U

- .3 Floor access: rectangular, round, as indicated, cast iron body and frame with adjustable secured 15 mm (½") thick flush mounted heavy duty nickel bronze top and:
Plugs: bolted bronze with neoprene gasket.
 - .1 Cover for unfinished concrete floors: nickel bronze round, gasket, vandal-proof screws.
 - .1 Acceptable Manufacturers:
 - .1 Zurn ZN-1400 – HD or Zurn ZZN-1612
 - .2 Mifab C1100-XR-6
 - .3 WATTS CO-200-RX-1-6
 - .4 Jay R. Smith SQ-4-1753-XNBCO-SP-U
 - .2 Cover for VCT tile and linoleum floors: square polished nickel bronze with 15 mm (1/2") thick flush mounted heavy duty nickel bronze cover, complete with vandal-proof locking screws.
 - .1 Acceptable Manufacturers:
 - .1 Zurn ZN-1400-T – HD
 - .2 Mifab C1100-TS-6
 - .3 WATTS CO-200-S-1-6
 - .4 Jay R. Smith 4200-U
 - .3 Cover for ceramic tile floors: 15 (½") thick heavy duty nickel bronze square, cover complete with gasket, vandal-proof screws, for flush finish.
 - .1 Acceptable Manufacturers:
 - .1 Zurn ZN-1400 – T-HD or Zurn ZZN-1612
 - .2 Mifab C1100-S-6
 - .3 WATTS CO-200-RC-1-6
 - .4 Jay R. Smith SQ-4-1753-NBCO-SP-U-Y
 - .4 Cover for carpeted floors: round polished nickel bronze with flush cover, complete with stainless steel carpet marker, vandal-proof locking screws.
 - .1 Acceptable Manufacturers:
 - .1 Zurn ZN-1400-HD-CM or ZN-1612-CM
 - .2 Mifab C1100C-S-1-6
 - .3 Ancon CO-200-RC-1-6
 - .4 Smith
 - .5 Contour C3000RMNB

Part 3 Execution

3.1 INSTALLATION

- .1 Install in accordance with provincial codes, and local authority having jurisdiction.
- .2 Install in accordance with manufacturer's instructions and as specified.
- .3 Install roof drains in lowest point of roof. Co-ordinate location with architectural, structural, and mechanical drawings.

3.2 CLEANOUTS

- .1 In addition to those required by code, and as indicated, install at base of all soil and waste stacks, and rainwater leaders.
- .2 Bring cleanouts to wall or finished floor unless serviceable from below floor.
- .3 Building drain cleanout and stack base cleanouts: line size to maximum NPS 100 mm (4").

3.3 COMMISSIONING

- .1 In context of this paragraph, "verify" to include "demonstrate" to Consultant.
- .2 Timing: commission only after start-up deficiencies rectified.
- .3 Access doors: verify size and location relative to items to be services.
- .4 Adjust to suit site conditions, including, but not necessarily limited to, following:
 - .1 Roof drains:
 - .1 Verify installation at low points in roof.
 - .2 Verify security and removability of dome.
 - .3 Adjust weirs to suit actual roof slope and meet requirements of design.
 - .4 Verify provision for movement of roof and integrity of roof drain piping system.
 - .2 Cleanouts:
 - .1 Verify covers are gastight, secure and easily removable.
 - .2 Verify that cleanout rods can probe as far as next cleanout.
- .5 Commissioning reports:
 - .1 Record all results on approved report forms.
 - .2 Include signature of tester and supervisor.
 - .3 To be countersigned by Consultant.
- .6 Verification:
 - .1 Notify Consultant 48 h before commencing tests.
 - .2 All tests and procedures to be witnessed by Consultant.
 - .3 All reported results subject to verification by consultant.
- .7 Training:
 - .1 Train O&M personnel in start-up, operation, monitoring, servicing, maintenance and shut-down procedures.
- .8 Demonstrations:
 - .1 Demonstrate full compliance with Design Criteria.
 - .2 Demonstrations also to show completeness of O&M personnel training.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code.
- .3 CAN/CSA C22.2 No. 110, Construction and Test of Electric Storage Tank Water Heaters.
- .4 CAN/CSA-C191, CSA Standards on Performance of Electric Storage Tank Water Heaters for Domestic Hot Water.
- .5 CAN/CSA-C309, Performance Requirements for Glass-Lined Storage Tanks for Household Hot Water Service.

1.2 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with general requirements.
- .2 Indicate:
 - .1 Equipment, including connections, fittings, control assemblies and ancillaries, identifying factory and field assembled.
 - .2 Wiring and schematic diagrams.
 - .3 Dimensions and recommended installation.
 - .4 Pump performance and efficiency curves.

1.3 CLOSEOUT SUBMITTALS

- .1 Provide maintenance and engineering data for incorporation into manual specified in general requirements
- .2 Data to include:
 - .1 Manufacturer's name, type, model year, capacity, and serial number.
 - .2 Details of operation, servicing, and maintenance.
 - .3 Recommended spare parts list with names and addresses.

Part 2 Products

2.1 ELECTRIC WATER HEATER

- .1 To CAN/CSA C22.2 No. 110, CAN/CSA-C191 [and CAN/CSA-C309 for glass-lined storage tanks], with immersion type elements, 6000 W (20.5 MBH) each, and immersion type adjustable thermostats, power requirements: 575/3/60.
- .2 Tank: size as per mechanical schedule, 50 mm (2") thick mineral wool or fibreglass insulation, enamelled steel jacket, integral hi-limit safety shut-off switch and top connections.
- .3 Tank to be ASME certified if over 600mm (24") in diameter.

2.2 WATER HEATER TRIM AND INSTRUMENTATION

- .1 Drain valve: NPS 25 mm (1") with hose end.
- .2 Thermometer: 100 mm (4") dial type with red pointer and thermowell filled with conductive paste.
- .3 Thermowell filled with conductive paste for control valve temperature sensor.
- .4 ASME rated temperature and pressure relief valve sized for full capacity of heater, having discharge terminating over floor drain and visible to operators.
- .5 Magnesium anodes adequate for 20 years of operation and located for easy replacement.

Part 3 Execution

3.1 WATER HEATER

- .1 Install in accordance with manufacturer's recommendations and authority having jurisdiction.
- .2 Provide structural steel for horizontal (vertical) mounted tanks.
- .3 Provide insulation between tank and supports.
- .4 Provide neutralizing cartridge on each vent drain.

3.2 FIELD QUALITY CONTROL

- .1 Manufacturer's factory trained, certified Engineer to start up and commission DHW heaters.
- .2 Check power supply.
- .3 Check starter protective devices.
- .4 Start up, check for proper and safe operation.
- .5 Check settings and operation of all hand-off-auto selector switch, operating, safety and limit controls, audible and visual alarms, over-temperature and other protective devices.
- .6 Demonstrate equipment operation as directed by consultant.

3.3 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 Electric water heater: tank, three (3) year warranty
- .3 Warranty Coverage:
 - .1 Applies to parts and labour.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code.

1.2 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with general requirements.
- .2 Indicate:
 - .1 Equipment, including connections, fittings, control assemblies and ancillaries, identifying factory and field assembled.
 - .2 Wiring and schematic diagrams.
 - .3 Dimensions and recommended installation.
 - .4 Pump performance and efficiency curves.

1.3 CLOSEOUT SUBMITTALS

- .1 Provide maintenance and engineering data for incorporation into manual specified in general requirements
- .2 Data to include:
 - .1 Manufacturer's name, type, model year, capacity, and serial number.
 - .2 Details of operation, servicing, and maintenance.
- .3 Recommended spare parts list with names and addresses.

Part 2 Products

2.1 DOMESTIC HOT WATER EXPANSION TANK

- .1 Pre-charged 6.4 gal (3.2 gal accept volume) hydropneumatic steel expansion tank complete with internal butyl diaphragm.
- .2 Tank construction shall be in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code, with all welds conforming to ASME Section IX. The tank must be stamped with a maximum working pressure of 150 psi and a maximum working temperature of 250°F.
- .3 Tank shall be one of two styles:
 - .1 Complete with anti legionella liner (silver antimicrobial) and designed with water agitator to deter any legionella growth.
 - .2 Flow through style to ensure continuous water movement.
 - .1 This Contractor shall pipe flow through expansion tanks as per manufacturer's recommendations. Provide isolation valve on both sides of horizontal tank. Provide bypass valve around tank.

- .4 Tank volume: 24 l (4.5 gallons) with 0.73 acceptance factor.
- .5 Acceptable Manufacturers:
 - .1 Amtrol ST-12C
 - .2 Calefactio FTTE-12

2.2 DOMESTIC HOT WATER CIRCULATING PUMPS

- .1 Capacity: as per mechanical schedule.
- .2 Construction: closed-coupled, in-line centrifugal, all bronze construction, stainless steel shaft, stainless steel or bronze shaft sleeve, two oil lubricated bronze sleeves or ball bearings. Design for 105°C (220°F) continuous service.
- .3 Motor: FHP, drip-proof, with thermal overload protection.
- .4 Supports: provide as recommended by manufacturer.
- .5 Acceptable Manufacturers:
 - .1 Bell & Gossett
 - .2 Armstrong
 - .3 Taco

2.3 THERMOSTATIC WATER CONTROLLER (3 Port)

- .1 3/4" inlets 3/4" outlets thermostatic controller with swivel action check stops, removable cartridge with strainer, stainless steel piston and liquid fill thermal motor with bellows mounted out of water. Volume control shut off valve, bimetal dial thermometer (3" face, range 20° – 240°F), brass pipe, fittings and unions. Standard valve and piping finish is rough bronze.
- .2 Acceptable Manufacturers:
 - .1 Symmons 7-200A-ASB-W
 - .2 Powers

2.4 ANCHOR BOLTS AND TEMPLATES

- .1 Supply for installation by other Divisions.

Part 3 Execution

3.1 RECIRCULATING PUMP

- .1 Make piping and electrical connections to pump and motor assembly and controls as indicated.
- .2 Ensure pump and motor assembly do not support piping.

3.2 DOMESTIC HOT WATER EXPANSION TANK

- .1 Adjust expansion tank pressure to suit system pressure.
- .2 Provide an expansion tank on the cold water feed to each water heater complete with lockshield type shutoff valve at inlet to tank.
- .3 Provide an expansion tank at the water entrance.

3.3 FIELD QUALITY CONTROL

- .1 Manufacturer's factory trained, certified Engineer to start up and commission DHW heaters.
- .2 Check power supply.
- .3 Check starter protective devices.
- .4 Start up, check for proper and safe operation.
- .5 Check settings and operation of all hand-off-auto selector switch, operating, safety and limit controls, audible and visual alarms, over-temperature and other protective devices.
- .6 Adjust flow from water-cooled bearings.
- .7 Adjust impeller shaft stuffing boxes, packing glands.
- .8 Demonstrate equipment operation as directed by consultant.
- .9 Demonstrate water softener regeneration controls.

3.4 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.
- .3 Warranty Coverage:
 - .1 Applies to parts and labour.

END OF SECTION

Part 1 General

1.1 GENERAL REQUIREMENTS

- .1 Conform to Sections of Division 1 and to General Mechanical Requirements Section.

1.2 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 Perform work in accordance with the recommendations of and the requirements of:
 - .1 Local and district bylaws and regulations.
 - .2 N.F.P.A.14 "Installation of Standpipe and Hose Systems".
 - .3 The Ontario Building Code.
 - .4 U.L.C. or Factory Mutual approval for hose, valve and extinguisher requirements.
 - .5 N.F.P.A.10 "Standard for Portable Fire Extinguishers".
 - .6 The Ontario Fire Code.

1.3 SUBMITTALS

- .1 Submit shop drawings and maintenance data in accordance with general requirements.

1.4 COORDINATION

- .1 Confirm fire extinguisher cabinet locations and quantities from both architectural and mechanical drawings and report any discrepancies to consultant prior to bid close.
- .2 Coordinate location of cabinet with other trades and provide protection against damage during construction.

Part 2 Products

2.1 MULTI-PURPOSE DRY CHEMICAL EXTINGUISHERS (CLASS ABC)

- .1 Stored pressure rechargeable type with hose and shut off nozzle, ULC labelled for A, B and C class protection as indicated. Size of extinguishers shall be as follows:

.1	Kitchen	Type 'K'	10 lb	20BC rating
.2	Mechanical Rooms		10 lb	ABC rating
.3	Storage Rooms		10 lb	ABC rating
.4	Corridor/Gym/Finished Areas		5 lb	ABC rating complete with cabinet
- .2 Acceptable Manufacturers:
 - .1 Wilson & Cousins
 - .2 National

2.2 CABINETS

- .1 Recessed mounted type of a size sufficient to contain all necessary components. Tub to be constructed of 1.5 mm (16 gauge) steel and finished with Wilco "Pro-Tech" Premier white painted finish. Adjustable frame comprising of 180° opening door and trim to be separate assembly adaptable to any type of finished wall. Trim to have 6 mm (1/4") return on outer edges with full length semi-concealed piano hinge, and Corbin style latching device.
- .2 Doors and trim to be 1.5 mm (16 gauge) white painted finish. Door glass to be 6 mm (1/4") Duo Lite Safety Glass.
- .3 Cabinet to maintain fire resistive rating of construction in which they occur.
- .4 Do not provide cabinets for mechanical room and service area fire extinguishers unless indicated.
- .5 Acceptable Manufacturers:
 - .1 Wilson & Cousins Model IE - 105R (5 and 10 lb. Class)
 - .2 National

2.3 IDENTIFICATION

- .1 Identify extinguishers in accordance with recommendations of NFPA 10.
- .2 Attach tag or label to extinguishers indicating month and year of installation and provide space for the addition of recording service dates.

2.4 FIRE BLANKET

- .1 100% non-combustible fire retardant glass fibre, non-toxic, non-conductor, cleanable complete with straps.
- .2 Size: 1 m x 1 m (40" x 40").
- .3 Cabinet to be surface mounted, 400 mm x 300 mm (16" x 12").
- .4 Mount on wall in kitchen area where indicated or directed on site by consultant.
- .5 Acceptable Manufacturers:
 - .1 National FB 4040 blanket, FB 6078 MC cabinet
 - .2 Wilson & Cousins

Part 3 Execution

3.1 INSTALLATION

- .1 Provide portable fire extinguisher cabinets and mount in wall during construction. Cabinet to be surface or recessed mounted as indicated on the drawings. Install cabinets so that the door will not obstruct normal traffic when open.
- .2 Hang extinguishers in cabinets with wall mounting bracket.

- .3 Prior to installing the extinguisher cabinets, confirm the mounting height and exact location with the Consultant. Mount extinguisher so top of unit is not more than 1.5 m (5').
- .4 Install wall mounted fire extinguishers complete with wall mounting bracket where indicated and/or directed on site by consultant.
- .5 Caulk perimeter of fire extinguisher cabinets after acceptance.

3.2 TESTS

- .1 Fire protection equipment shall be tested to the requirements of NFPA10, NFPA13, NFPA14 and comply with the requirements of the authorities having jurisdiction.

3.3 FIRE BLANKET

- .1 Hang blanket on wall in cabinet as indicated, to manufacturers' recommendations.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 CAN/CSA B45S1, Supplement #1 to CAN/CSA B-45 Series Plumbing Fixtures.
- .3 CAN/CSA-B45 Series, CSA Standards on Plumbing Fixtures.
- .4 CAN/CSA-B125.3, Plumbing Fittings.
- .5 CAN/CSA-B651, Accessible Design for the Built Environment.

1.2 SHOP DRAWINGS

- .1 Submit shop drawings and product data in accordance with general requirements.
- .2 Indicate, for all fixtures and trim:
 - .1 Dimensions, construction details, roughing-in dimensions.
 - .2 Factory-set water consumption per flush at recommended pressure.
 - .3 For water closets, urinals: minimum pressure required for flushing.

1.3 CLOSEOUT SUBMITTALS

- .1 Provide maintenance data including monitoring requirements for incorporation into manual specified in general requirements.
- .2 Include:
 - .1 Description of fixtures and trim, giving manufacturer's name, type, model, year, capacity.
 - .2 Details of operation, servicing, maintenance.
 - .3 List of recommended spare parts.

Part 2 Products

2.1 MANUFACTURED UNITS

- .1 Fixtures: manufacture in accordance with CAN/CSA-B45 series.
- .2 Trim, fittings: manufacture in accordance with CAN/CSA-B125.3.
- .3 Exposed plumbing brass to be chrome plated.
- .4 Number, locations: Architectural drawings to govern.
- .5 Fixtures in any one location to be product of one manufacturer and of same type.
- .6 Trim in any one location to be product of one manufacturer and of same type.

2.2 FIXTURE CARRIERS

- .1 Provide factory manufactured floor-mounted carrier systems for all wall-mounted fixtures.
- .2 Acceptable Manufacturers:
 - .1 Zurn
 - .2 Smith
 - .3 Ancon

2.3 PLUMBING FIXTURES

- .1 Refer to plumbing fixture schedule on the drawings for fixture type, manufacturer, trim, drainage supply, and accessories.

2.4 FIXTURE PIPING

- .1 Hot and cold water supplies to each fixture/faucet:
 - .1 Chrome plated flexible supply pipes each with screwdriver stop, reducers, escutcheon and chrome plated nipple.
 - .2 Acceptable Manufacturers:
 - .1 Delta 47T900 Series
 - .2 McGuire
- .2 Waste:
 - .1 Open grid strainer, or pop up as indicated, offset open grid strainer on Barrier-Free fixtures, cast brass fittings with tubular piping, chrome plated, rubber gasket compression fitting, and overflow flange.
 - .2 Acceptable Manufacturers:
 - .1 Delta 33T200 Series
 - .2 McGuire
- .3 'P' Traps:
 - .1 Cast brass P trap with cleanout on each fixture not having integral trap.
 - .2 Chrome plated in all exposed places.
 - .3 Acceptable Manufacturers:
 - .1 Delta 33T300 Series
 - .2 McGuire

Part 3 Execution

3.1 INSTALLATION

- .1 Mounting heights:
 - .1 Standard: to comply with manufacturer's recommendations unless otherwise indicated or specified. Confirm mounting height(s) with consultant prior to rough-in.
 - .2 Wall-hung fixtures: measured from finished floor.
 - .3 Physically Barrier-Free: to comply with most stringent of either NBCC or CAN/CSA B651.
- .2 Drinking fountains:
 - .1 In accordance with CAN/CSA B45S1.

3.2 ADJUSTING

- .1 Conform to water conservation requirements specified this section.
- .2 Adjustments.
 - .1 Adjust water flow rate to design flow rates.
 - .2 Adjust pressure to fixtures to ensure no splashing at maximum pressures.
 - .3 Adjust flush valves to suit actual site conditions.
 - .4 Adjust drinking fountain flow stream to ensure no spillage.
 - .5 Automatic flush valves for water closets: set controls to prevent unnecessary flush cycles during silent hours.
- .3 Checks.
 - .1 Water closets: flushing action.
 - .2 Aerators: operation, cleanliness.
 - .3 Backflow preventors: operation under all conditions.
 - .4 Wash fountains: operation of flow-actuating devices.
- .4 Thermostatic controls.
 - .1 Verify temperature settings, operation of control, limit and safety controls.
- .5 Floor and wall mounted fixtures: caulk to floor or wall using silicone caulking to make water tight, colour to match fixture.
- .6 Counter mounted fixtures: lay fixtures into bead of caulking to ensure excess moisture does not reach the cut edge of the countertop. Clean excess caulking off outside the sink.

3.3 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.

END OF SECTION

Part 1 General

1.1 INSTRUCTIONS TO BIDDERS

- .1 The HVAC Supplemental Tender Form must be submitted to the architect and consultant (admin@deiassociates.ca) within 2 hours after tender closing. HVAC contractors shall identify all sub-contractors he/she intends to use and must complete all information requested. The requisite information shall be given at the office of the Consultant. Contractor shall sign and date this page and initial and date each page thereafter.

- .2 Should the HVAC Supplemental Form not be submitted then the contractor shall use Base Bid manufacturers as listed.

.3 CONTRACTOR

I/We certify that I/We have the authority to bind the company.

COMPANY NAME

AUTHORIZED SIGNATURE

ADDRESS

PRINTED SIGNATURE

CITY

TITLE

TELEPHONE NUMBER

DATE

.4 SUB-CONTRACTORS

The Contractor shall state below the name of the Sub-contractors he intends to use, which shall not be changed without the consent of the Consultant.

Insulation _____

Sheet Metal _____

TAB _____

BAS Controls _____

- .5 The Stipulated Bid Sum shall be for the base bid manufacturer or supplier equipment only, unless otherwise indicated. Where a choice of this equipment is given, this Contractor shall indicate the supplier or manufacturer he intends to use. Where no choice is indicated, the base bid supplier or equipment shall be used.

CONTRACTOR'S NAME: _____

DATE: _____

- .6 Equipment or materials manufactured by firms named in the following listing only shall be deemed equal to the equipment or material specified, provided the equipment or material will have capacity, performance, rating, construction, physical dimensions, accessories and features which, in the opinion of the Consultant, are equal to those of the specified equipment or material. The HVAC Contractor shall not indicate equipment, materials or suppliers which are not listed. If this is done, the base bid supplier shall be used.
- .7 Where modifications to the work of other trades are required as a result or part of the alternative offered, include the cost of said modifications in the work.
- .8 Submit the following list of Base Bid and alternative suppliers in accordance with the bid requirements:

Spec. Reference Section	Equipment	Base Bid	Acceptable Alternate Manufacturer Or Supplier	Indicate Manufacturer Or Supplier
23 05 11	Access Doors	Le Hage	Zurn Acudor Nailor Industries Inc.	
23 05 19	Thermometers	Trerice	Winters Wiess	
23 05 19	Pressure Gauges	Trerice	Winters Wiess	
23 05 34	Bases, Hangers, & Supports (Indoor)	Grinnell	Anvil Myatt Taylor	
23 05 35	Bases, Hangers & Supports (Outdoor)	Thaler MERS-800 series	Acceptable equals if submitted and approved during tender period	
23 05 35	Non-Penetrating Roof Equipment Support (Small Units)	Portable pipe hanger	Bigfoot systems Miro rooftop systems Trikon Systems Walravin BIS Yet Ecofoot	

CONTRACTOR'S NAME: _____

DATE: _____

23 05 35	Manufactured Roof Supports	Quick Block	Erico	
23 05 49	Elastomeric Mounts	Vibro-Acoustics	Korfund IAC Acoustics Vibron	
23 05 49	Hangers	Vibron	IAC Acoustics Korfund Vibro-Acoustics	
23 10 13	Duct Insulation	Johns Manville	Knauf Manson	
23 10 19	HVAC Piping Insulation	Knauf	Manson Owens Corning	
23 11 23	Regulators	Singer	Schlumberger	
23 21 13	Valves	Newman Hattersley Canada Ltd.	Jenkins/Crane Milwaukee Toyo Kitz	
23 21 13	Balancing Valves	Bell & Gossett Circuit Setters	Armstrong Taco Tour & Anderson Oventrop	
23 21 13	Triple Duty Valve	Bell & Gossett	Armstrong	
23 21 13	Automatic Air Vent	Maid-O-Mist	Spirax Sarco	
23 23 13	Prefabricated Pipe Entry Doghouse	Sigrist Alta Pipe Chase Housing	Vault Roof Penetration Housing Other Acceptable Manufacturers if approved by Consultant prior to tender close	
23 23 13	Pipe Support Assembly	Unistrut	Or equal	
23 32 13	Prefabricated Plenums	Vibron	BVA Systems VAW Systems IAC Acoustics	

CONTRACTOR'S NAME: _____

DATE: _____

23 33 13	Access Doors in Ducts	Nailor	E.H. Price Titus	
23 37 23	Louvres/Brick Vents	Greenheck	Construction Specialties Aiolite Co. Krueger Ventex Ruskin Ventmaster Nailor Carnes GLAB Penn Barry Pottorff E.H. Price	
23 38 13	Fire Blanket	National		
23 05 11	Fire Stopping	Minnesota Mining & Manufacturing	Fryesleeve Industries Inc. General Electric Pensil Firestop Systems International Protective Coatings Corp. Rectorseal Corporation (Metacaulk) Proset Systems 3M AS Systems Hilti	
23 21 11	Combination Coalescing Air Separator/Strainer	Spirotherm	Armstron Bell & Gossett Taco	
23 26 11	Hydraulic Pumping Systems	Lincoln (Flo Components)		

CONTRACTOR'S NAME: _____

DATE: _____

23 33 16	Fire Dampers	Ruskin	Nailor E.H. Price Ventox/Alumavent United Enertech Safeair-Dowco T.A. Morrison Greenheck Pottorff Tamco	
23 33 17	Smoke Control Dampers	E.H. Price	NCA Ltd. Nailor Industries Ruskin Alumavent United Enertech Safeair-Dawco (stainless steel) Pottorff	
23 33 18	Motorized Dampers	Honeywell	Johnson T.A. Morrison E.H. Price Tamco Ruskin Nailor Henderson Industrial Ventex/Alumavent Pottorff	
23 34 23	Packaged Exhausters	Greenheck	Penn-Barry Cook Jenn/Jenco (S&P) Carnes Acme Zonex Nutone (Range hood) Broan (Range hood) Twin-City Reversomatic Fantech Aerovent	
23 34 23	Dryer Booster Fan	Reversomatic		

CONTRACTOR'S NAME: _____

DATE: _____

23 36 16	VAV/VVT Boxes	Krueger	Nailor Titus Carnes Metalaire Barber Colman E.H. Price	
23 37 13	Grilles and Diffusers	E.H. Price	Nailor Krueger Titus Carnes Seiho Metalaire Tuttle and Bailey	
23 81 26	Condensing Unit	LG	Lennox Trane Carrier	
23 81 26	Indoor DX Cooling Coil	Mitsubishi	LG Daikin Carrier Lennox	
23 81 46	Water Source Heat Pumps	Daikin	WaterFurnace Trane Johnson Controls	
23 21 23	Circulators	Bell & Gossett	Armstrong Grundfos	
23 52 13	Stainless Steel Condensing Boilers	Lochinvar	Patterson-Kelly Wiel-McLain	
23 74 43	Packaged HVAC Rooftop	Carrier	Trane Johnson Controls	
23 75 12	Semi-Custom Outdoor Heating & Cooling Air Handling Units	Daikin	Engineered Air	

1.2 LABOUR RATES

- .1 The following labour rates shall apply for calculating the cost of credit or extras on Change Notices. The rates shall include any employee benefits. The labour rates do not include overhead and profit.

CONTRACTOR'S NAME: _____

DATE: _____

Superintendent	\$_____/hr
Journeymen	\$_____/hr
Labourers	\$_____/hr
Sheet Metal	\$_____/hr
Insulation	\$_____/hr
Other	\$_____/hr

1.3 HVAC TENDER PRICE (EXCLUDING HST)

- .1 Having carefully examined all Drawings and Specifications and the Addenda to the Drawings and Specifications, and having carefully examined the sites and all conditions affecting the work, we, the undersigned thereby offer to provide all plant, labour, materials and incidentals required to complete the work of all trades for: All the work specified for herein for

the Total Stipulated Price of: \$_____

(in writing)

in lawful money of Canada; included in which are all applicable excise taxes, custom duties, freight, exchange, and all other charges. HST is not included.

Part 2 Products

2.1 NOT USED

- .1 Not used.

CONTRACTOR'S NAME:_____

DATE:_____

Part 3 Products

3.1 NOT USED

.1 Not used.

END OF SECTION

CONTRACTOR'S NAME: _____

DATE: _____

Part 1 General

1.1 GENERAL PROVISIONS

- .1 This section covers items common to all sections of Heating, Ventilation, and Air Conditioning (HVAC) Division.
- .2 Conform to Division 1 General Conditions.
- .3 Furnish labour, materials, and equipment necessary for completion of work as described in contract documents.
- .4 Unless specifically indicated, all materials and equipment provided under this contract shall be new and shall be manufactured in the project year.
- .5 The term "Mechanical Contractor" shall remain active and shall mean a "single contractor" performing plumbing, drainage, heating, cooling, ventilation, and control services.
- .6 When quoting as a subcontractor this building contractor shall explicitly state the services they are providing i.e. Mechanical (all services), Plumbing (water and drainage systems) or HVAC (including hydronic and air systems).
- .7 Contractors shall be explicit to identify whether Fire Protection is included or omitted from the mechanical scope.

1.2 INTENT

- .1 Mention herein or indication on Drawings of articles, materials, operations or methods requires: supply of each item mentioned or indicated, of quality, or subject to qualifications noted; installation according to conditions stated: and performance of each operation prescribed with furnishing of necessary labour, equipment, and incidentals for HVAC work.
- .2 Where used, words "Section" and "Division" shall also include other Subcontractors engaged on site to perform work to make building and site complete in all respects.
- .3 Where used, word "supply" shall mean furnishing to site in location required or directed complete with accessory parts.
- .4 Where used, word "install" shall mean secured in place and connected up for operation as noted or directed.
- .5 Where used, word "provide" shall mean supply and install as each is described above.

1.3 TENDERS AND BONDING

- .1 Complete Supplemental Tender Form including list of equipment and materials to be used on this project and forming part of tender documents.
- .2 Submit Supplemental Tender Form as noted.
- .3 Submit tender based on specified described equipment or Alternates listed.
- .4 State in Tender, names of all Subcontractors proposed for work under this Division.

1.4 REGULATIONS, PERMITS, AND FEES

- .1 All materials and quality of work shall meet all current and latest Provincial, Municipal and Fire Marshall requirements, regulations, codes, and by-laws in force in the area of the project.
- .2 Each contractor shall give all necessary notices, obtain all necessary permits, and pay all fees in order that the work shown or specified may be carried out. Each contractor shall furnish any certificates necessary as evidence that the work installed conforms with the laws and regulations of all authorities having jurisdiction.
- .3 In the event that changes, or alterations are required on completed work by authorized inspectors, these changes shall be made at the contractor's expense.
- .4 Special equipment which does not have a standard CSA label shall be inspected by the local electrical authority having jurisdiction and the Approval Certificate shall be submitted to the Consultant as soon as possible. All costs and fees for inspections shall be borne by this contractor.

1.5 DRAWINGS

- .1 The drawings and this specification have been assembled together as a responsibility of the consultant. The same is true for the other consultants, i.e. architect, structural engineer, civil engineer, fire protection engineer, electrical engineer, etc.
- .2 The drawings and specifications are not assembled together for responsibility/division between subcontractors. The division of work between subcontractors remains the responsibility of the buildings' contractor (also known as the prime contractor or general contractor).
- .3 All subcontractors are encouraged to perform work amicably utilizing all of the drawings and specifications published by all of the consultants.
- .4 Plumbing and HVAC Drawings do not show structural and related details. Take information involving accurate measurements of building from building drawings, or at building. Make, without additional charge, any necessary changes, or additions to runs of piping, conduits, and ducts to accommodate structural conditions. Location of pipes, ducts, conduits and other equipment may be altered by Consultant without extra charge provided change is made before installation and does not necessitate major additional material.
- .5 As work progresses and before installing piping, ductwork, heating units, registers, diffusers, fixtures and any other fittings and equipment which may interfere with interior treatment and use of building, provide detail drawings, or obtain directions for exact location of such equipment and fitments.
- .6 Plumbing and HVAC drawings indicate general location and route of pipes, ducts and conduits which are to be installed. Where required work is not shown or only shown diagrammatically, install same at maximum height in space to conserve head room (minimum 2200 mm (88") clear) and interfere as little as possible with free use of space through which they can pass. Follow building lines, conceal piping, conduits and ducts in furred spaces, ceilings and walls unless specifically shown otherwise. Install work close to structure so furring will be small as practical.

- .7 Install piping and ductwork to clear structural members and any fireproofing. Locate HVAC work to permit installation of specified insulation. Do not remove or damage structural fireproofing. Leave space to permit fireproofing and insulation to be inspected and repaired.
- .8 Before commencing work, check and verify all sizes, locations, grade and invert elevations, levels, and dimensions to ensure proper and correct installation. Verify existing/municipal services.
- .9 Locate all HVAC and electrical equipment in such a manner as to facilitate easy and safe access to and maintenance and replacement of any part.
- .10 In every place where there is indicated space reserved for future or other equipment, leave such space clear, and install piping and other work so that necessary installation and connections can be made for any such apparatus. Obtain instructions whenever necessary for this purpose.
- .11 Relocate equipment and/or material installed but not co-ordinated with work of other Sections and/or installed incorrectly as directed, without extra charge.
- .12 Where drawings are done in metric and product not available in metric, the corresponding imperial trade size shall be utilized.

1.6 INTERFERENCE AND COORDINATION DRAWINGS

- .1 Prepare interference and equipment placing drawings to ensure that all components will be properly accommodated within the constructed spaces provided.
- .2 Prepare drawings to indicate co-ordination and methods of installation of a system with other systems where their relationship is critical. Ensure that all details of equipment apparatus, and connections are coordinated.
- .3 Ensure that clearances required by jurisdictional authorities and clearances for proper maintenance are indicated on drawings.
- .4 Upon consultant's request submit copies of interference drawings to consultant.
- .5 Due to the nature of the building and the complexity of the building systems provide the following:
 - .1 Interference drawings, showing coordination of architectural, structural, plumbing, HVAC, and electrical systems for the consultant's review prior to fabrication.
 - .2 Detailed layout drawings, clearly showing fasteners and hangers.
- .6 Provide CAD drawings (minimum file version AutoCAD 2013) in addition to hard copies.

1.7 QUALITY ASSURANCE

- .1 Perform work in accordance with applicable provisions of local plumbing code, gas ordinances, and adoptions thereof for all HVAC systems. Provide materials and labor necessary to comply with rules, regulations, and ordinances.
- .2 In case of differences between building codes, provincial laws, local ordinances, utility company regulations, and Contract Documents, the most stringent shall govern. Promptly notify Consultant in writing of such differences.

1.8 ALTERNATES AND SUBSTITUTIONS

- .1 Throughout HVAC Division are lists of "Alternate Equipment" manufacturers acceptable to Consultant if their product meets characteristics of specified described equipment. Submitted Bids shall be based on the supply of named articles and or products as specified in the Bid Documents.
- .2 Each bidder may elect to use "Alternate Equipment" from lists of Alternates where listed. Include for any additional costs including all costs for revisions to electrical contract to suit Alternate used. Prices are not required in Tender for Alternates listed except where specifically noted as "Separate Price". Complete the Supplementary Tender Form.
- .3 When two or more suppliers/manufacturers are named in the Bid Documents, only one supplier/manufacturer of the products named will be acceptable; however, it is the responsibility of this Division to ensure "Alternate Equipment" fits space allocated and gives performance specified. If an "Alternate Equipment" nor "equal" specified product unit is proposed and does not fit space allotted in Consultant's opinion, supply of specified described equipment will be required without change in Contract amount. Should electrical characteristics for "alternate" or "equal" equipment differ from equipment specified it shall be the responsibility of the equipment manufacturer to pay all costs associated with the revisions to the electrical contract. Only manufacturers listed will be accepted for their product listing. All other manufacturers shall be quoted as substitution stating conditions and credit amount.
- .4 If item of material specified is unobtainable, state in Tender proposed substitute and amount added or deducted for its use. Extra monies will not be paid for substitutions after Contract has been awarded.
- .5 If pipe or item, of size or weight indicated, is unobtainable, supply next larger size or heavier weight without additional charge.

1.9 EXAMINATION

- .1 Site Reviews
 - .1 Examine premises to understand conditions which may affect performance of work of this Division before submitting proposals for this work.
 - .2 No subsequent allowance for time or money will be considered for any consequence related to failure to examine site conditions.
- .2 Drawings
 - .1 Plumbing and HVAC Drawings show general arrangement of piping, ductwork, equipment, etc. Follow as closely as actual building construction and work of other trades will permit.
 - .2 Consider Architectural and Structural Drawings part of this work insofar as these drawings furnish information relating to design and construction of building. These drawings take precedence over Plumbing, HVAC, and Fire Protection Drawings.

- .3 Because of small scale of Drawings, it is not possible to indicate all offsets, fittings, and accessories, which may be required. Investigate structural and finish conditions affecting this work and arrange work accordingly, providing such fittings, valves, and accessories required to meet conditions.
- .3 Ensure that items to be furnished fit space available. Make necessary field measurements to ascertain space requirements including those for connections and furnish and install equipment of size and shape so final installation shall suit true intent and meaning of Contract Documents. If approval is received by Addendum or Change Order to use other than originally specified items, be responsible for specified capacities and for ensuring that items to be furnished will fit space available.

1.10 SEQUENCING SCHEDULING AND COORDINATION

- .1 It is understood that while Drawings are to be followed as closely as circumstances permit, this Division will be held responsible for installation of systems according to the true intent and meaning of Contract Documents. Anything not clear or in conflict will be explained by making application to Consultant. Should conditions arise where certain changes would be advisable, secure Consultant's approval of these changes before proceeding with work.
- .2 Coordinate work of various trades in installing interrelated work. Before installation of HVAC items, make proper provision to avoid interferences in a manner approved by Consultant. Each Contractor shall refer to all sections of the specification for their responsibilities with other trades. Changes required in work specified in HVAC Division caused by neglect to do so shall be made at no cost to Owner.
- .3 Arrange pipes, ducts, and equipment to permit ready access to valves, unions, traps, starters, motors, control components, and to clear openings of doors and access panels.
- .4 Furnish and install inserts and supports required by HVAC Division unless otherwise noted. Furnish sleeves, inserts, supports, and equipment that are an integral part of other Divisions of the Work to Sections involved in sufficient time to be built into construction as the Work proceeds. Locate these items and see that they are properly installed. Expense resulting from improper location or installation of items above shall be borne by HVAC Division.
- .5 Be responsible for required excavation, backfilling, cutting, and patching incident to work of this Division and make required repairs afterwards to satisfaction of Consultant. Cut carefully to minimize necessity for repairs to existing work. Do not cut beams, columns, or trusses.
 - .1 Patch and repair walls, floors, ceilings, and roofs with materials of same quality and appearance as adjacent surfaces unless otherwise shown. Surface finishes shall exactly match existing finishes of same materials.
 - .2 Each Section of this Division shall bear expense of cutting, patching, repairing, and replacing of work of other Sections required because of its fault, error, tardiness, or because of damage done by it.
 - .3 Cutting, patching, repairing, and replacing pavements, sidewalks, roads, and curbs to permit installation of work of this Division is responsibility of Section installing work.

- .6 Adjust locations of pipes, ducts, equipment, fixtures, etc., to accommodate work from interferences anticipated and encountered. Determine exact route and location of each pipe and duct prior to fabrication.
 - .1 Make offsets, transitions, and changes in direction of pipes, ducts, and electrical raceways as required to maintain proper head room and pitch of sloping lines whether or not indicated on Drawings.
 - .2 Furnish and install traps, air vents, sanitary vents, pull boxes, etc., as required to effect these offsets, transitions, and changes in direction.
- .7 Slots and openings through floors, walls, ceilings, and roofs shall be provided by this contractor but performed by a trade specializing in this type of work. This Division shall see that they are properly located and do any cutting and patching caused by its neglect to do so.

1.11 REQUEST FOR INFORMATION (RFI) PROCEDURES

- .1 RFIs shall be submitted to the consultant minimum two (2) weeks prior to answer being required. Failure to submit an RFI in a timely manner will forfeit delay claims and schedule extension requests by the contractor.
- .2 All RFIs will be submitted with the following information:
 - .1 RFI number
 - .2 Name of project
 - .3 Date of initiation
 - .4 Date response required by (minimum two (2) weeks)
 - .5 Subject
 - .6 Submitter's name
 - .7 Drawing/specification reference
 - .8 Photograph of the issue (if applicable)
 - .9 Description of the issue
 - .10 Contractor's proposed resolution

1.12 CONTRACT BREAKDOWN

- .1 Provide breakdown of Contract exclusive of HST to acceptance of consultants prior to first draw submission.
- .2 Provide labour and material cost for each item.
- .3 Breakdown shall indicate total contract amount.
- .4 Contract breakdown shall be as follows as a minimum.
 - .1 Mobilization and shop drawings (max. \$2,000.00)
 - .2 Demolition
 - .3 Boilers
 - .4 Reheat coils
 - .5 Circulation pumps
 - .6 Heating piping

- .7 Piping insulation
- .8 Ductwork
- .9 Duct insulation
- .10 Grilles and diffusers
- .11 Fire stopping
- .12 Fans and equipment
- .13 HVAC system commissioning
- .14 Heat pump equipment
- .15 HVAC units
- .16 ERV
- .17 Air terminal units
- .18 Building automation systems
- .19 Testing, adjusting, and balancing
- .20 Refrigeration piping
- .21 HVAC contractor closeout requirements (min. of 3% for the first \$500,000.00, 1% from \$500,000.00 to \$5,000,000.00, and 0.5% beyond. Shall not be less than \$5,000.00.)
- .5 Progress claims, when submitted are to be itemized against each item of the contract breakdown, this shall be done in table form showing contract amount, work complete to date, previous draw, amount this draw and balance.
- .6 **Mobilization amount may only be drawn when all required shop drawings have been reviewed by the consultant.**

1.13 COMMISSIONING CONTRACT BREAKDOWN

- .1 This contractor shall work with the HVAC system commissioning contractor as specified elsewhere. The following commissioning breakdown shall be indicated on the contract breakdown draw.

1.14 SHOP DRAWINGS AND PRODUCT DATA

- .1 Furnish complete catalog data for manufactured items of equipment to be used in the Work to Consultant for review within 14 days after award of Contract.
- .2 Upon receipt of reviewed shop drawing, product is to be ordered immediately.
- .3 Provide a complete list of shop drawings to be submitted prior to first submission.
- .4 Before submitting to the Consultant, review all shop drawings to verify that the products illustrated therein conform to the Contract Documents. By this review, the Contractor agrees that it has determined and verified all field dimensions, field construction criteria, materials, catalogue numbers, and similar data and that it has checked and coordinated each shop drawing with the requirements of the work and of the Contract Documents. The Contractor's review of each shop drawings shall be indicated by stamp, date and signature of a qualified and responsible person possessing by the appropriate authorization.

- .5 If material or equipment is not as specified or submittal is not complete, it will be rejected by Consultant.
- .6 Additional shop drawings required by the contractor for maintenance manuals, site copies etc., shall be photocopies of the "reviewed" shop drawings. All costs to provide additional copies of shop drawings shall be borne by the contractor.
- .7 Submit all shop drawings for the project as a package. Partial submittals will not be accepted.**
- .8 Catalog data or shop drawings for equipment, which are noted as being reviewed by Consultant or their Engineer shall not supersede Contract Documents.
- .9 Review comments of Consultant shall not relieve this Division from responsibility for deviations from Contract Documents unless Consultant's attention has been called to such deviations in writing at time of submission, nor shall they relieve this Division from responsibility for errors in items submitted.
- .10 Check work described by catalog data with Contract Documents for deviations and errors.
- .11 Shop drawings and product data shall show:
 - .1 Mounting arrangements.
 - .2 Operating and maintenance clearances. e.g., access door swing spaces.
- .12 Shop drawings and product data shall be accompanied by:
 - .1 Detailed drawings of bases, supports, and anchor bolts.
 - .2 Acoustical sound power data, where applicable.
 - .3 Points of operation on performance curves.
 - .4 Manufacturer to certify as to current model production.
 - .5 Certification of compliance to applicable codes.
- .13 State sizes, capacities, brand names, motor HP, accessories, materials, gauges, dimensions, and other pertinent information. List on catalog covers page numbers of submitted items. Underline applicable data.
- .14 Shop drawings shall be submitted electronically as per the following directions:
 - .1 Electronic Submissions:
 - .1 Electronically submitted shop drawings shall be prepared as follows:
 - .1 Use latest software to generate PDF files of submission sheets.
 - .2 Scanned legible PDF sheets are acceptable. Image files are not acceptable.
 - .3 PDF format shall be of sufficient resolution to clearly show the finest detail.
 - .4 PDF page size shall be standardized for printing to letter size (8.5"x11"), portrait with no additional formatting required by the consultant. Submissions requiring larger detail sheets shall not exceed 11"x17".
 - .5 Submissions shall contain multiple files according to section names as they appear in Specification.

- .6 File names shall include consultant project number and description of shop drawing section submitted.
- .7 Each submission shall contain an index sheet listing the products submitted, indexed in the same order as they appear in the Specification. Include associated PDF file name for each section.
- .8 On the shop drawing use an "electronic mark" to indicate what is being provided.
- .9 **Each file shall bear an electronic representation of the "company stamp" of the contractor. If not stamped the file submission will not be reviewed.**
- .2 Email submissions shall include subject line to clearly identify the consultant's project number and the description of the shop drawings submitted.
- .3 Electronic attachments via email shall not exceed 10MB. For submissions larger than 10MB, multiple email messages shall be used. Denote related email messages by indicating "1 of 2" and "2 of 2" in email subject line for the case of two messages.
- .4 Electronic attachments via web links (URL) shall directly reference PDF files. Provide necessary access credentials within link or as username/password clearly identified within body of email message.
- .5 On site, provide one (1) copy of the "reviewed" shop drawings in a binder as noted above.
- .6 Contractor to print copies of "reviewed" shop drawings and compile into maintenance manuals in accordance with requirements detailed in this section.

1.15 EQUIPMENT NAMEPLATE DATA

- .1 Between the manufactures design published literature, the shop drawing submission literature, and the nameplate data on the equipment, they can all read differently.
- .2 Most of the confusion and differences are coming out of the electrical power installation.
- .3 The contractors installing and connecting the equipment are responsible for the coordination of this data through the construction period.
- .4 The contractors shall share and/or request this information through out the project and monitor/make adjustments, provide recommendations accordingly based on any discrepancies.
- .5 The contractors are responsible for any cost associated with the changing data.
- .6 The final installation must meet the "Nameplate Data" on the equipment on site.

1.16 OPERATION AND MAINTENANCE MANUAL

- .1 Provide operation and maintenance data for incorporation into manual as in submittals' requirements.

- .2 Operation and maintenance manual to be approved by, and final copies deposited with, Consultant before final inspection.
- .3 Submit one (1) copy of Operation and Maintenance Manual to Consultant for review and approval. Submission of individual data will not be accepted unless directed by Consultant. Submission can be done electronically in PDF format or as a hard copy.
 - .1 Electronic submission/PDF file is required to be bookmarked. Any submission received without bookmarking will be immediately returned as unacceptable.
 - .2 Hard copy submission shall be in a three-ring binder (minimum 50 mm (2") ring) and labelled as 'Operation and Maintenance Manual' with project name and location. Dividers are to be used for binder organization.
- .4 Make changes as required and re-submit as directed by Consultant.
- .5 Operation data to include:
 - .1 Control schematics for each system including environmental controls.
 - .2 Description of each system and its controls.
 - .3 Description of operation of each system at various loads together with reset schedules and seasonal variances.
 - .4 Operation instruction for each system and each component.
 - .5 Description of actions to be taken in event of equipment failure.
 - .6 Valves schedule and flow diagram.
 - .7 Colour coding chart.
 - .8 Spare parts equipment list.
 - .9 Manufacturers standard or extended warranty information.
- .6 Maintenance data shall include:
 - .1 Servicing, maintenance, operation, and trouble-shooting instructions for each item of equipment.
 - .2 Data to include schedules of tasks, frequency, tools required and task time.
- .7 Performance data to include:
 - .1 Equipment manufacturer's performance data sheets with point of operation as left after commissioning is complete.
 - .2 Equipment performance verification test results.
 - .3 Special performance data as specified elsewhere.
 - .4 Testing, adjusting, and balancing reports as specified in Testing, Adjusting, and Balancing Section.
 - .5 Copy of all substantial performance final certificates.
- .8 Miscellaneous data to include:
 - .1 Letter of contractor's warranty and guarantee.
 - .2 Index sheet.
 - .3 Tabbed format for each section.
 - .4 Manufacturers approved shop drawings.

- .5 Spare parts list and source.
- .6 List of Manufacturers and suppliers address for each piece of equipment.
- .9 Final Submittals:
 - .1 Upon acceptance of Operation and Maintenance Manual by the Consultant, provide the following:
 - .1 Provide two (2) copies of final Operation and Maintenance Manuals, as well as a PDF file of the entire approved manual on a USB stick. Only one (1) USB stick is to be provided containing both the approved manual and as-built drawings.

1.17 AS-BUILT DRAWINGS

- .1 Site records:
 - .1 Contractor shall provide two (2) sets of reproducible HVAC drawings. Provide sets of white prints as required for each phase of the work. Mark thereon all changes as work progresses and as changes occur. This shall include changes to existing HVAC systems, control systems, and low voltage control wiring.
 - .2 On a weekly basis, transfer information to reproducibles, revising reproducibles to show all work as actually installed.
 - .3 Use different colour waterproof ink for each service.
 - .4 Make available for reference purposes and inspection at all times.
- .2 As-built drawings submittal for TAB and review:
 - .1 Prior to start of Testing, Adjusting, and Balancing (TAB), finalize production of as-built drawings.
 - .2 Identify **each drawing** in lower right-hand corner in letters at least 3 mm (1/8") high as follows: - "AS-BUILT DRAWINGS: THIS DRAWING HAS BEEN REVISED TO SHOW HVAC SYSTEMS AS INSTALLED" (Company Name) (Signature of Contractor) (date).
 - .3 TAB to be performed using as-built drawings.
 - .4 Submit copy to Consultant for review and approval. When returned, make corrections as directed.
- .3 As-built drawings final submittal:
 - .1 Once approved, submit completed, reproducible paper as-built drawings as well as a scanned PDF file copy on USB stick with Operation and Maintenance Manuals.

1.18 WARRANTIES

- .1 In addition to guarantee specified in General Conditions, guarantee heating, cooling, and plumbing systems to be free from noise in operation that may develop from failure to construct system in accordance with Contract Documents.
- .2 Provide certificates of warranty for each piece of equipment made out in favor of Owner. Clearly record "start-up" date of each piece of equipment on certificate. Include certificates as part of Operation and Maintenance Manual.

- .3 If HVAC sub-contractor with offices located more than 80 km (50 miles) from Project site is used, provide service/warranty work agreement for warranty period with local HVAC sub-contractor approved by Consultant. Include copy of service/warranty agreement in warranty section of Operation and Maintenance Manual.
- .4 Contractor shall rectify any installation deficiencies in the boiler or pressurized other systems identified by a TSSA Inspector for a period of three (3) years from ready for takeover.
- .5 Warranty period shall start from date of ready for takeover. Warranty period shall start from date of ready for takeover. Warranty start date based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .5 Warranty Duration:
 - .1 One (1) year warranty period applies unless otherwise noted.
- .6 Warranty Coverage:
 - .1 Applies to parts and labour.

1.19 READY FOR TAKEOVER

- .1 Complete the following to the satisfaction of the consultant prior to request for ready for takeover.
 - .1 As-built Drawings
 - .2 Maintenance Manuals
 - .3 System Start up
 - .4 TAB Reports
 - .5 HVAC System Commissioning
 - .6 Instructions to Owners

1.20 REVISION TO CONTRACT

- .1 Provide the following:
 - .1 Itemized list of material with associated costs.
 - .2 Labour rate and itemized list of labour for each item.
 - .3 Copy of manufacturers/supplier's invoice if requested.

1.21 DELIVERY, STORAGE, AND HANDLING

- .1 Follow Manufacturer's directions in delivery, storage, and protection of equipment and materials. Contractor to include all costs associated with delivery storage and handling in tender price.
- .2 Deliver equipment and material to site and tightly cover and protect against dirt, water, and chemical or environmental damaging conditions but have readily accessible for inspection. Store items subject to moisture damage (such as controls) in dry, heated space.
- .3 Remove any damaged materials from the site.

1.22 DESIGNATED SUBSTANCES AND HAZARDOUS MATERIALS

- .1 If designated substances and/or hazardous materials are suspected or identified cease all work in the immediate area in accordance with OHSA and notify consultant.
- .2 Each contractor and on site employee of the contractor shall have "asbestos awareness training".
- .3 The Contractor shall ensure that employees who may come into contact with designated substances and/or hazardous materials due to the nature of the work that they perform, have received training that enables them to recognize designated substances and/or hazardous materials and that enables them to react in accordance with the Occupational Health and Safety Act and regulations thereto should contact with designated substances and/or hazardous materials occur during the course of their work.
- .4 It is the responsibility of the contractor to review the designated substances and/or hazardous materials book in the building prior to starting any work.
- .5 Existing occupied buildings (depending upon their age) may contain designated substances and/or hazardous materials in thermal insulating materials and some manufactured products, such as vinyl asbestos floor tile. Any insulating materials, on pipes, fittings, boilers, tanks, ductwork, etc. may contain designated substances and/or hazardous materials and shall not be disturbed.
- .6 A survey of each building documenting the location and condition of designated substances and/or hazardous materials -containing materials is available for your mandatory review prior to commencing any work on premises.

1.23 PHASING OF WORK

- .1 This work for this project shall be constructed in phases. Refer to the architectural drawings for phasing information and details. Misinterpretation of the drawings with respect to the extent of the phasing of the work shall not relieve the contractor of the work required to complete the entire contract.
- .2 Provide all necessary services or temporary services to suit phasing of construction with respect to all HVAC services and fire protection.
- .3 Life safety systems in the building are to remain fully operational in occupied areas for building staff and occupants during renovations.
- .4 Provide all necessary tests and certificates at completion of each phase to suit requirements of local authorities and consultants for occupancy of completed areas.

1.24 TSSA INSPECTION

- .1 Prior to final completion of the project, this contractor shall make application, arrange, and pay for a TSSA inspection of all piping systems and equipment installations, including, but not limited to medical gasses, refrigeration, fuel piping, compressed air, heating plant, cooling plant, and associated equipment installed under the contract.
- .2 Provide a copy of the TSSA report in the maintenance manuals for each system.

1.25 ENERGY EFFICIENCY

- .1 The HVAC systems of this building must achieve the energy efficiency levels by conforming to ANSI/ASHRAE/IESNA 90.1 "Energy Standard for Buildings Except Low-Rise Residential Buildings" and Chapter 2 of Division 3 of SB-10 prescriptive method from the Ontario Building Code.
- .2 All equipment, products, and installations must conform to the Codes and Standards.

END OF SECTION

Part 1 General

1.1 OCCUPANCY REQUIREMENTS

- .1 The contractor shall provide the following documentation to the consultant's satisfaction prior to receiving occupancy. Failure to provide the proper documentation will result in the occupancy not being granted. List of required documentation:
 - .1 Final Certificates (required prior to consultant's release of conformance letter).
 - .1 Mandatory TSSA Gas Pressure Test (CSA B149.1)
 - .2 Seismic Restraint Engineers' Letter.
 - .3 TSSA report for new boiler/pressure vessel installation or written confirmation from TSSA that they opted to not inspect the system. (Low pressure systems that have either a wetted heating surface of 30 sq ft (2.89 sq m) or less, or a power rating of 100 MBH (30 kW) or less are exempt.
 - .4 Contractor letter verifying all refrigeration leak detection systems and their interlocks to downstream devices have been installed and tested.

Part 2 Not Used

Part 3 Not Used

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 National Air Duct Cleaners Association (NADCA): "Assessment, Cleaning & Restoration of HVAC Systems (ACR).
- .3 National Air Duct Cleaners Association (NADCA): "Understanding Microbial Contamination in HVAC Systems".
- .4 National Air Duct Cleaners Association (NADCA): "Introduction to HVAC System Cleaning Services".
- .5 National Air Duct Cleaners Association (NADCA): Standard 05 "Requirements for the Installation of Service Openings in HVAC Systems".
- .6 Underwriters' Laboratories (UL): UL Standard 181.
- .7 American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE): Standard 62, "Ventilation for Acceptable Indoor Air Quality".
- .8 Environmental Protection Agency (EPA): "Building Air Quality".
- .9 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): "HVAC Duct Construction Standards - Metal and Flexible".
- .10 North American Insulation Manufacturers Association (NAIMA): "Cleaning Fibrous Glass Insulated Air Duct Systems".

1.2 SPECIAL PROVISIONS

- .1 Qualification of the HVAC System Cleaning Contractor
 - .1 Membership:
 - .1 The HVAC system cleaning contractor shall be a certified member of the National Air Duct Cleaners Association (NADCA) or shall maintain membership in a nationally recognized non-profit industry organization dedicated to the cleaning of HVAC systems.
 - .2 Certification:
 - .1 The HVAC system cleaning contractor shall have a minimum of one (1) Air System Cleaning Specialist (ASCS) certified by NADCA on a full time basis or shall have staff certified by a nationally recognized certification program and organization dedicated to the cleaning of HVAC systems.
 - .3 Supervisor Qualifications:
 - .1 A person certified as an ASCS by NADCA, or maintaining an equivalent certification by a nationally recognized program and organization, shall be responsible for the total work herein specified.

- .4 Experience:
 - .1 The HVAC system cleaning contractor shall submit records of experience in the field of HVAC system cleaning as requested by the owner. Bids shall only be considered from firms, which are regularly engaged in HVAC system maintenance with an emphasis on HVAC system cleaning and decontamination.
- .5 Equipment, Materials and Labour:
 - .1 The HVAC system cleaning contractor shall possess and furnish all necessary equipment, materials and labour to adequately perform the specified services.
 - .1 The contractor shall assure that its employees have received safety equipment training, medical surveillance programs, individual health protection measures, and manufacturer's product and material safety data sheets (MSDS) as required for the work by the U.S. Occupational Safety and Health Administration, and as described by this specification. For work performed in countries outside of the U.S.A., contractors should comply with applicable national safety codes and standards.
 - .2 The contractor shall maintain a copy of all current MSDS documentation and safety certifications at the site at all times, as well as comply with all other site documentation requirements of applicable OSHA programs and this specification.
 - .3 Contractor shall submit to the owner all Material Safety Data Sheets (MSDS) for all chemical products proposed to be used in the cleaning process.
- .6 Licensing:
 - .1 The HVAC system cleaning contractor shall provide proof of maintaining the proper license(s), if any, as required to do work in this state. Contractor shall comply with all Federal, state and local rules, regulations, and licensing requirements.

1.3 STANDARDS

- .1 NADCA Standards: The HVAC system cleaning contractor shall perform the services specified here in accordance with the current published standards of the National Air Duct Cleaners Association (NADCA).
- .2 All terms in this specification shall have their meaning defined as stated in the NADCA Standards.
- .3 NADCA Standards must be followed with no modifications or deviations being allowed.

1.4 DOCUMENTS

- .1 Mechanical Drawings: The owner shall provide the HVAC system cleaning contractor with one (1) copy of the following documents:
 - .1 Project drawings and specifications.
 - .2 Approved construction revisions pertaining to the HVAC system.
 - .3 Any existing indoor air quality (IAQ) assessments or environmental reports prepared for the facility.

Part 2 Products

2.1 SCOPE OF WORK

- .1 This section defines the minimum requirements necessary to render HVAC components clean, and to verify the cleanliness through inspection and/or testing in accordance with items specified herein and applicable NADCA Standards.
- .2 The Contractor shall be responsible for the removal of visible surface contaminants and deposits from within the HVAC system in strict accordance with these specifications.
- .3 The HVAC system includes any interior surface of the facility's existing air distribution system for conditioned spaces and/or occupied zones. This includes the entire heating, air-conditioning and ventilation system that is within the scope of renovation. The interior surfaces of RTHRV-EX and HVAC-01-EX, mixing box, coil compartment, condensate drain pans, humidifiers and dehumidifiers, supply air ducts, fans, fan housing, fan blades, air wash systems, spray eliminators, turning vanes, filters, filter housings, and reheat coils are all considered part of the HVAC system. The HVAC system also includes all existing heat pumps in areas of renovation.

Note: Users of this specification must modify the above paragraph to succinctly and specifically define those systems and components requiring cleaning.

2.2 HVAC SYSTEM COMPONENT INSPECTIONS AND SITE PREPARATIONS

- .1 HVAC System Component Inspections: Prior to the commencement of any cleaning work, the HVAC system cleaning contractor shall perform a visual inspection of the HVAC system to determine appropriate methods, tools, and equipment required to satisfactorily complete this project. The cleanliness inspection should include air handling units and representative areas of the HVAC system components and ductwork. In HVAC systems that include multiple air-handling units, a representative sample of the units should be inspected.
- .2 The cleanliness inspection shall be conducted without negatively impacting the indoor environment through excessive disruption of settled dust, microbial amplification or other debris. In cases where contamination is suspected, and/or in sensitive environments where even small amounts of contaminant may be of concern, environmental engineering control measures should be implemented.
- .3 Damaged system components found during the inspection shall be documented and brought to the attention of the consultant.

.4 Site Evaluation and Preparations:

- .1 Contractor shall conduct a site evaluation, and establish a specific, coordinated plan which details how each area of the building will be protected during the various phases of the project.

.5 Inspector Qualifications:

- .1 Qualified personnel should perform the HVAC cleanliness inspection to determine the need for cleaning. At minimum, such personnel should have an understanding of HVAC system design, and experience in utilizing accepted indoor environmental sampling practices, current industry HVAC cleaning procedures, and applicable industry standards.

2.3 GENERAL HVAC SYSTEM CLEANING REQUIREMENTS

.1 Containment:

- .1 Debris removed during cleaning shall be collected and precautions must be taken to ensure that Debris is not otherwise dispersed outside the HVAC system during the cleaning process.

.2 Particulate Collection:

- .1 Where the Particulate Collection Equipment is exhausting inside the building, HEPA filtration with 99.97% collection efficiency for 0.3-micron size (or greater) particles shall be used. When the Particulate Collection Equipment is exhausting outside the building, Mechanical Cleaning operations shall be undertaken only with Particulate Collection Equipment in place, including adequate filtration to contain Debris removed from the HVAC system. When the Particulate Collection Equipment is exhausting outside the building, precautions shall be taken to locate the equipment down wind and away from all air intakes and other points of entry into the building.

.3 Controlling Odors:

- .1 Measures shall be employed to control odors and/or mist vapors during the cleaning process.

.4 Component Cleaning:

- .1 Cleaning methods shall be employed such that all HVAC system components must be Visibly Clean as defined in applicable standards (see NADCA Standards). Upon completion, all components must be returned to those settings recorded just prior to cleaning operations.

.5 Air-Volume Control Devices:

- .1 Dampers and any air-directional mechanical devices inside the HVAC system must have their position marked prior to cleaning and, upon completion, must be restored to their marked position.

- .6 Service Openings:
 - .1 The contractor shall utilize service openings, as required for proper cleaning, at various points of the HVAC system for physical and mechanical entry, and inspection.
 - .2 Contractor shall utilize the existing service openings already installed in the HVAC system where possible.
 - .3 Other openings shall be created by this contractor where needed and they must be created so they can be sealed by this contractor in accordance with industry codes and standards.
 - .4 Closures must not significantly hinder, restrict, or alter the airflow within the system.
 - .5 Closures must be properly insulated to prevent heat loss/gain or condensation on surfaces within the system.
 - .6 Openings must not compromise the structural integrity of the system.
 - .7 Construction techniques used in the creation of openings should conform to requirements of applicable building and fire codes, and applicable NFPA, SMACNA and NADCA Standards.
 - .8 Cutting service openings into flexible duct is not permitted. Flexible duct shall be disconnected at the ends as needed for proper cleaning and inspection.
 - .9 Rigid fiberglass duct systems shall be resealed in accordance with NAIMA recommended practices. Only closure techniques that comply with UL Standard 181 or UL Standard 181a are suitable for fiberglass duct system closures.
 - .10 All service openings capable of being re-opened for future inspection or remediation shall be clearly marked and shall have their location reported to the consultant in project report documents.
- .7 Ceiling sections (tile):
 - .1 The contractor may remove and reinstall ceiling sections to gain access to HVAC systems during the cleaning process.
- .8 Air distribution devices (registers, grilles, and diffusers):
 - .1 The contractor shall clean all air distribution devices.
- .9 Air handling units, terminal units (VAV, Dual duct boxes, etc.), blowers and exhaust fan:
 - .1 The contractor shall ensure that supply, return, and exhaust fans and blowers are thoroughly cleaned. Areas to be cleaned include blowers, fan housings, plenums (except ceiling supply and return plenums), scrolls, blades, vanes, shafts, baffles, dampers, and drive assemblies. All visible surface contamination deposits shall be removed in accordance with NADCA Standards. Contractor shall:
 - .1 Clean all air handling units (AHU) internal surfaces, components and condensate collectors and drains.
 - .2 Assume that a suitable operative drainage system is in place prior to beginning wash down procedures.
 - .3 Clean all coils and related components, including evaporator fins.

.10 Duct Systems:

.1 This Contractor shall:

- .1 Create service openings in the system as necessary in order to accommodate cleaning of otherwise inaccessible areas. Provide access doors specified in duct accessories to replace openings.
- .2 Mechanically clean all duct systems to remove all visible contaminants, such that the systems are capable of passing Cleaning Verification Tests (see NADCA Standards).

2.4 HEALTH AND SAFETY

.1 Safety Standards:

- .1 Cleaning contractors shall comply with applicable federal, state, and local requirements for protecting the safety of the contractor's employees, building occupants, and the environment. In particular, all applicable standards of the Occupational Safety and Health Administration (OSHA) shall be followed when working in accordance with this specification.

.2 Occupant Safety:

- .1 No processes or materials shall be employed in such a manner that they will introduce additional hazards into occupied spaces.

.3 Disposal of Debris:

- .1 All Debris removed from the HVAC System shall be disposed of in accordance with applicable federal, state and local requirements.

2.5 MECHANICAL CLEANING METHODOLOGY

.1 Source Removal Cleaning Methods:

- .1 The HVAC system shall be cleaned using Source Removal mechanical cleaning methods designed to extract contaminants from within the HVAC system and safely remove contaminants from the facility. It is the contractor's responsibility to select Source Removal methods that will render the HVAC system Visibly Clean and capable of passing cleaning verification methods (See applicable NADCA Standards) and other specified tests, in accordance with all general requirements. No cleaning method, or combination of methods, shall be used which could potentially damage components of the HVAC system or negatively alter the integrity of the system.
 - .1 All methods used shall incorporate the use of vacuum collection devices that are operated continuously during cleaning. A vacuum device shall be connected to the downstream end of the section being cleaned through a predetermined opening. The vacuum collection device must be of sufficient power to render all areas being cleaned under negative pressure, such that containment of debris and the protection of the indoor environment are assured.
 - .2 All vacuum devices exhausting air inside the building shall be equipped with HEPA filters (minimum efficiency), including hand-held vacuums and wet-vacuums.

- .3 All vacuum devices exhausting air outside the facility shall be equipped with Particulate Collection including adequate filtration to contain Debris removed from the HVAC system. Such devices shall exhaust in a manner that will not allow contaminants to re-enter the facility. Release of debris outdoors must not violate any outdoor environmental standards, codes or regulations.
- .4 All methods require mechanical agitation devices to dislodge debris adhered to interior HVAC system surfaces, such that debris may be safely conveyed to vacuum collection devices. Acceptable methods will include those which will not potentially damage the integrity of the ductwork, nor damage porous surface materials such as liners inside the ductwork or system components.
- .2 Methods of Cleaning Fibrous Glass Insulated Components:
 - .1 Fibrous glass thermal or acoustical insulation elements present in any equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment, while the HVAC system is under constant negative pressure, and not permitted to get wet in accordance with applicable NADCA and NAIMA standards and recommendations.
 - .2 Cleaning methods used shall not cause damage to fibrous glass components and will render the system capable of passing Cleaning Verification Tests (see NADCA Standards).
- .3 Damaged Fibrous Glass Material:
 - .1 Evidence of damage: If there is any evidence of damage, deterioration, delaminating, friable material, mold or fungus growth, or moisture such that fibrous glass materials cannot be restored by cleaning or resurfacing with an acceptable insulation repair coating, they shall be identified for replacement.
 - .2 Replacement: When requested or specified, Contractor must be capable of remediating exposed damaged insulation in air handlers and/or ductwork requiring replacement.
 - .3 Replacement material: In the event fiber glass materials must be replaced, all materials shall conform to applicable industry codes and standards, including those of UL and SMACNA.
 - .4 Replacement of damaged insulation is not covered by this specification.
- .4 Cleaning of Coils:
 - .1 Any cleaning method may be used which will render the Coil Visibly Clean and capable of passing Coil Cleaning Verification (see applicable NADCA Standards). Coil drain pans shall be subject to Non-Porous Surfaces Cleaning Verification. The drain for the condensate drain pan shall be operational. Cleaning methods shall not cause any appreciable damage to, displacement of, inhibit heat transfer, or erosion of the coil surface or fins, and shall conform to coil manufacturer recommendations when available. Coils shall be thoroughly rinsed with clean water to remove any latent residues.

.5 Antimicrobial Agents and Coatings:

- .1 Antimicrobial agents shall only be applied if active fungal growth is reasonably suspected, or where unacceptable levels of fungal contamination have been verified through testing.
- .2 Application of any antimicrobial agents used to control the growth of fungal or bacteriological contaminants shall be performed after the removal of surface deposits and debris.
- .3 When used, antimicrobial treatments and coatings shall be applied in strict accordance with the manufacturer's written recommendations and EPA registration listing.
- .4 Antimicrobial coatings shall be applied according to the manufacturer's written instructions. Coatings shall be sprayed directly onto interior ductwork surfaces, rather than "fogged" downstream onto surfaces.

2.6 CLEANLINESS VERIFICATION

.1 General:

- .1 Verification of HVAC System cleanliness will be determined after mechanical cleaning and before the application of any treatment or introduction of any treatment-related substance to the HVAC system, including biocidal agents and coatings.

.2 Visual Inspection:

- .1 The HVAC system shall be inspected visually to ensure that no visible contaminants are present.
- .2 If no contaminants are evident through visual inspection, the HVAC system shall be considered clean; however, the consultant reserves the right to further verify system cleanliness through Surface Comparison Testing or the NADCA vacuum test specified in the NADCA standards.
- .3 If visible contaminants are evident through visual inspection, those portions of the system where contaminants are visible shall be re-cleaned and subjected to re-inspection for cleanliness.
- .4 NADCA vacuum test analysis shall be performed by a qualified third party experienced in testing of this nature through the HVAC commissioning contract.

.3 Verification of Coil Cleaning:

- .1 Cleaning must restore the coil pressure drop to within 10 percent of the pressure drop measured when the coil was first installed. If the original pressure drop is not known, the coil will be considered clean only if the coil is free of foreign matter and chemical residue, based on a thorough visual inspection (see NADCA Standards).

2.7 PRE-EXISTING SYSTEM DAMAGE

- .1 Contractor is not responsible for problems resulting from prior inappropriate or careless cleaning techniques of others.

2.8 POST-PROJECT REPORT

- .1 At the conclusion of the project, the Contractor shall provide a report to the consultant indicating the following:
 - .1 Success of the cleaning project, as verified through visual inspection and/or gravimetric analysis.
 - .2 Areas of the system found to be damaged and/or in need of repair.

Part 3 Execution

Not Applicable.

END OF SECTION

Part 1 General

1.1 TESTS

- .1 Give 48 hours' written notice of date for tests.
- .2 Insulate or conceal work only after testing and approval by Consultant.
- .3 Conduct tests in presence of Consultant.
- .4 Bear costs including retesting and making good.
- .5 Piping:
 - .1 General: Maintain test pressure without loss for 4 h unless otherwise specified.
 - .2 Hydraulically test steam and hydronic piping systems at 1-1/2 times system operating pressure or minimum 860 kPa, whichever is greater.
 - .3 Test natural gas systems to CSA-B149.1-00, TSSA requirements and requirements of authorities having jurisdiction.
- .6 Equipment: Test as specified in relevant sections.
- .7 Prior to tests, isolate all equipment or other parts which are not designed to withstand test pressures or test medium.

1.2 SYSTEM START UP

- .1 Provide adjusting testing and start up of all equipment prior to testing and balancing (TAB) specified elsewhere.
- .2 Provide Consultant with written notice verifying all equipment operation and installation is complete.
- .3 Start up shall be in presence of the following: Owner or Representative, Contractor, Building Automation Systems (BAS) Contractor, and Manufacturer's Representative. Each person shall witness and sign off each piece of equipment. Consultant's attendance will be determined by Consultant.
- .4 Simulate system start up and shut down and verify operation of each piece of equipment.
- .5 Arrange with all parties and provide 72 hours' notice for start up procedure.
- .6 Arrange with building automation systems contractor to sequence all components and ensure system operation.

1.3 COMMISSIONING

- .1 Co-ordinate and direct each step of the commissioning process and recommend acceptance or non-acceptance to the Owner/Owner's Representative.
- .2 Prepare, in writing, documentation of any deficiencies discovered during the commissioning process. Submit to Consultant and Owner/Owner's Representative.

- .3 The Commissioning Process is detailed in *ASHRAE Guideline 1-1996 HVAC Commissioning Process*. The commissioning plan may be modified to reflect the actual construction schedule and design.
- .4 Provide a pre-functional test of all HVAC system and sub-system elements, including control devices, shall be checked for the following:
 - .1 Verify that each element has been properly installed, properly identified, and that all connections (including electrical) have been made correctly.
 - .2 Verify that each element has been checked for proper lubrication, drive rotation, belt tension, control sequence, flow direction, or other conditions which may cause damage or reduce system performance.
 - .3 Verify that tests, meter readings, and specific HVAC/electrical performance characteristics agree with those required by equipment or system manufacturer.
 - .4 Controls calibration to be completed in accordance with the specification.
 - .5 The TAB shall be done in accordance with the specifications.
- .5 A functional performance testing shall be done during two separate periods – one during the cooling season and one during the heating season. The first (cooling) testing period shall occur as soon after completion of installation as practical. The heating testing period shall occur as soon as weather conditions make it practical to test warm-up, zone heating and economizer functions. These tests ensure that all equipment and systems operate in accordance with design intent. The tests are dynamic tests and test the systems through all possible modes of operation.
- .6 Reports:
 - .1 The Contractor shall be responsible for recording, documenting, and maintaining detailed inspection and testing data on the test documentation reports. The data record shall be comprehensive and concise.
 - .2 All data must be recorded as soon as possible during the course of the inspection and testing.
 - .3 All documentation shall have the date, time, and names of persons participating in the inspection and testing.
 - .4 All test instruments shall be documented for valid calibration.
 - .5 The recording work sheets, inspection check lists, and Performance Testing plans must all be approved by the Engineer and the Owner's Representative prior to the start of the testing.
 - .6 Include all commissioning documentation in the maintenance manuals.
- .7 HVAC System Execution:
 - .1 Operate equipment and systems shall be tested in the presence of the Owner's Representative and the Consultant to demonstrate compliance with specified requirements. To minimize the time of Commissioning Team members, testing shall be done in four seasonal single blocks of time insofar as possible.
 - .2 Notify the consultant, in writing, fourteen (14) days prior to tests scheduled under requirements of this Section.

- .3 Testing shall be conducted under specified design operating conditions as recommended or approved by the Consultant.
- .4 All elements of systems shall be tested to demonstrate that total systems satisfy all requirements of these Specifications. Testing shall be accomplished on hierarchical basis. Test each piece of equipment for proper operation, followed by each sub-system, followed by entire system, followed by any inter-ties of other major systems.
- .5 All special testing materials and equipment shall be provided by the appropriate contractor.
- .6 Provide three copies of all test reports and records to the Consultant.
- .8 The verification testing procedures shall address all operating characteristics of all HVAC equipment and systems, including:
 - Equipment Checklist
 - Boiler(s)
 - Rooftop Heating/Cooling Unit(s)
 - Exhaust Fans
 - Air Handling Unit(s)
 - Heat Recovery Unit(s)
 - Pumps
 - Controllers/Valves/Dampers
 - Relays/Sensors/Transducers
 - System Checklist
 - Boiler(s)
 - Air Handling Units
 - Heat Recovery Unit(s)
 - Pumps

1.4 DEMONSTRATION AND OPERATING AND MAINTENANCE INSTRUCTION

- .1 Supply tools, equipment and personnel to demonstrate and instruct operating and maintenance personnel in operating, controlling, adjusting, troubleshooting and servicing of all systems and equipment during regular work hours, prior to acceptance.
- .2 HVAC Contractor to schedule and coordinate the demonstration all on the same day, starting at a pre-approved time and continuing consequently until complete.
- .3 Where specified elsewhere in HVAC Division, qualified manufacturers' representatives who are knowledgeable about the project to provide demonstrations and instructions.
- .4 Use operation and maintenance manual, as-built drawings, audio visual aids, etc. as part of instruction materials.
- .5 Instruction duration time requirements as specified in appropriate sections.
- .6 Where deemed necessary, Consultants may record these demonstrations on video tape for future reference.

1.5 TRIAL USAGE

- .1 Consultant or Owner may use equipment and systems for test purposes prior to acceptance. Supply labour, material, and instruments required for testing.
- .2 Trial usage to apply to following equipment and systems:
 - .1 HVAC
 - .2 Exhaust air
 - .3 Hydronic water systems
 - .4 Boilers and pumps
 - .5 Control systems

1.6 DEFICIENCIES

- .1 During the course of construction, the Consultants will monitor construction and provide written reports of work progress, discussions, and instruction to correct work.
- .2 Instruction to correct work shall be done within the work period before the next review.
- .3 The Contractor shall not conceal any work until inspected.
- .4 The Contractor shall expedite 100% complete rough-in work and have inspected prior to concealing services and equipment especially above ceiling.
- .5 Upon completion of the project, the Consultant will do a final review. Upon receiving the final inspection report, the Contractor must correct and sign back the inspection report indicating the deficiencies are completed. A re-inspection will only be done once Consultant receives this in writing.

1.7 EQUIPMENT INSTALLATIONS

- .1 Unions or flanges: Provide for ease of maintenance and disassembly.
- .2 Space for servicing, disassembly and removal of equipment and components: Provide as recommended by manufacturer or as indicated.
- .3 Equipment drains: Pipe to floor drains.
- .4 Install equipment, rectangular cleanouts and similar items parallel to or perpendicular to building lines.

1.8 ANCHOR BOLTS AND TEMPLATES

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

1.9 PROTECTION OF OPENINGS

- .1 Protect equipment and systems openings from dirt, dust, and other foreign materials with materials appropriate to system.

1.10 ELECTRICAL

- .1 Electrical work to conform to Electrical Division including the following:
 - .1 Supplier and installer responsibility and related HVAC responsibility is indicated in Equipment Schedule on HVAC and/or electrical drawings,
 - .2 Power wiring and conduit is specified in Electrical Division except for conduit, wiring and connections below 50 V which are related to control systems specified in HVAC Division. Follow Electrical Division for quality of materials and workmanship.
 - .3 Electrically operated equipment shall be C.S.A. approved label. Special Inspection Label of Provincial Authority having jurisdiction will be accepted in lieu of C.S.A. approval. Each motor shall have an approved starter. Starter will be supplied and installed by Electrical Division unless otherwise indicated.
 - .4 All starters for HVAC equipment to be provided by this contractor. Wired by Electrical Division.

1.11 CONTROL WIRING

- .1 Furnish and install all components, devices, and control wiring for all HVAC equipment, HVAC systems, lighting, and other electrical loads to make all equipment operable to satisfaction of Owner and Consultant and to manufacturer's requirements and recommendations.
- .2 All electrical wiring, HVAC wiring and installations shall comply with local and national electrical and HVAC codes.
- .3 Supply and install wiring as required for all devices and systems. Install wiring in EMT conduit and otherwise comply with all requirements of the Electrical Division. Approved plenum wire may be used for sensor and network communication wiring where it complies with appropriate building codes and regulatory authorities.
- .4 All wiring concealed in walls and chases, and all exposed wiring shall be run in conduit.
- .5 Provide recessed conduit and backer boxes where controls are wall mounted. Surface mounted boxes and conduit are acceptable in service rooms.
- .6 Free-run plenum rated cable shall be run in cable hangers where provided by electrical division or tied neatly to pipe and duct hangers in the ceiling. Avoid wiring that droops. Follow building lines and do not run wiring "as the crow flies".

1.12 MOUNTING HEIGHTS

- .1 Mounting height of equipment is from finished floor to equipment unless specified or indicated otherwise. Coordinate with block coursing (if applicable).
- .2 If mounting height of equipment is not specified or indicated, verify before proceeding with installation.
- .3 Install equipment at following heights unless indicated otherwise.
 - .1 Thermostats (Operable, Barrier Free) 1200 mm (47.2")
 - .2 Thermostats (Non Barrier Free) 1500 mm (59")

- .4 Also follow direction of architectural drawings and where discrepancies occur clarify prior to rough-in.

1.13 MOTORS

- .1 Provide high efficiency motors for HVAC equipment as specified.
- .2 If delivery of specified motor will delay delivery or installation of any equipment, install motor approved by Consultant for temporary use. Final acceptance of equipment will not occur until specified motor is installed.
- .3 Motors under 373 W, (1/2 hp): speed as indicated, continuous duty, built-in overload protection, resilient mount, single phase, voltage as indicated.
- .4 Motors 373 W, (1/2 hp) and larger: EEMAC Class B, squirrel cage induction, speed as indicated, continuous duty, drip proof, ball bearing, maximum temperature rise 40°C (72°F), 3 phase, voltage as indicated.

1.14 BELT DRIVES

- .1 Fit reinforced belts in sheave matched to drive. Multiple belts to be matched sets.
- .2 Use cast iron or steel sheaves secured to shafts with removable keys unless otherwise specified.
- .3 For motors under 7.5 kW 10 hp: Standard adjustable pitch drive sheaves, having plus or minus 10% range. Use mid-position of range for specified r/min.
- .4 Minimum drive rating: 1.5 times nameplate rating on motor. Keep overhung loads within manufacturer's design requirements on prime mover shafts.
- .5 Motor slide rail adjustment plates to allow for centre line adjustment.
- .6 Provide sheave changes as required for final air balancing.

1.15 GUARDS

- .1 Provide guards for unprotected devices.
- .2 Guards for belt drives:
 - .1 Expanded metal screen welded to steel frame.
 - .2 Minimum 1.2 mm (18 gauge) thick sheet metal tops and bottoms.
 - .3 40 mm (1 1/2") diameter holes on both shaft centres for insertion of tachometer.
 - .4 Removable for servicing.
- .3 Provide means to permit lubrication and use of test instruments with guards in place.
- .4 Install belt guards to allow movement of motors for adjusting belt tension.

- .5 Guard for flexible coupling:
 - .1 "U" shaped, minimum 1.6 mm (16 gauge) thick galvanized mild steel.
 - .2 Securely fasten in place.
 - .3 Removable for servicing.
- .6 Unprotected fan inlets or outlets:
 - .1 Wire or expanded metal screen, galvanized, 20 mm (3/4") mesh.
 - .2 Net free area of guard: not less than 80% of fan openings.
 - .3 Securely fasten in place.
 - .4 Removable for servicing.
- .7 Duct Openings
 - .1 Provide reinforced expanded mesh grating, style 3 (3 lbs/sq.ft.) cover on accessible unprotected duct openings over 300 mm (12") wide and as indicated. This includes all ductwork terminating in air handling units and plenums.
 - .2 Securely fasten in place.
 - .3 Removable for servicing.

1.16 PIPING AND EQUIPMENT SUPPORTS

- .1 Equipment supports supplied by equipment manufacturer: Specified elsewhere in HVAC Division.
- .2 Piping and equipment supports not supplied by equipment manufacturer: Fabricate from structural grade steel meeting requirements of - Structural Steel Section. Submit structural calculations with shop drawings.
- .3 Mount base mounted equipment on chamfered edge housekeeping pads, minimum of 100 mm (4") high and 150 mm (6") larger than equipment dimensions all around. Concrete specified elsewhere.
- .4 Where housekeeping pads incorporate existing pads provide 10 mm dowels into existing pads. New pad height shall match existing.

1.17 SLEEVES

- .1 Pipe sleeves: at points where pipes pass through masonry, concrete or fire rated assemblies and as indicated. Grout sleeves in place.
- .2 Schedule 40 steel pipe.
- .3 Sleeves with annular fin continuously welded at midpoint:
 - .1 Through foundation walls.
 - .2 Where sleeve extends above finished floor.
 - .3 Through fire rated walls and floors.
- .4 Sizes: minimum 6 mm (1/4") clearance all around, between sleeve and uninsulated pipe or between sleeve and insulation.
- .5 Terminate sleeves flush with surface of concrete and masonry walls, concrete floors on grade and 25 mm (1") above other floors.

- .6 Fill voids around pipes:
 - .1 Caulk between sleeve and pipe in foundation walls and below grade floors with waterproof fire retardant non-hardening mastic.
 - .2 Where sleeves pass through walls or floors, provide space for firestopping. Where pipes/ducts pass through fire rated walls, floors and partitions, maintain fire rating integrity.
 - .3 Ensure no contact between copper tube or pipe and ferrous sleeve.
 - .4 Fill future-use sleeves with lime plaster or other easily removable filler.
 - .5 Coat exposed exterior surfaces of ferrous sleeves with heavy application of zinc rich paint to CGSB 1-GP-181M+Amdt-Mar-78.
- .7 Provide minimum 20 gauge duct sleeves where ducts pass through masonry concrete or fire rated assemblies. Maintain minimum 25 mm clearance all around or to the requirements of the authority having jurisdiction. Seal at wall as indicated.

1.18 FIRE STOPPING

- .1 This contractor shall work with all other contractors on the project in providing one common method of fire stopping all penetrations made in fire rated assemblies.
- .2 Approved fire stopping and smoke seal material in all fire separations and fire ratings within annular space between pipes, ducts, insulation and adjacent fire separation and/or fire rating.
- .3 Do not use cementitious or rigid seals around penetrations for pipe or ductwork where penetrating through walls, floors, ceilings, etc.
- .4 Insulated pipes and ducts: ensure integrity of insulation and vapour barrier at fire separation.
- .5 Provide materials and systems capable of maintaining effective barrier against flame, smoke and gases. Ensure continuity and integrity of fire separation.
- .6 Comply with the requirements of CAN4-S115-M35, and do not exceed opening sized for which they have been tested.
- .7 Systems to have an F or FT rating (as applicable) not less than the fire protection rating required for closures in a fire separation. Provide "fire wrap" blanket around services penetrating fire walls. Extent of blanket must correspond to ULC recommendations.
- .8 The fire stopping materials are not to shrink, slump or sag and to be free of asbestos, halogens and volatile solvents.
- .9 Firestopping materials are to consist of a component sealant applied with a conventional caulking gun and trowel.
- .10 Fire stop materials are to be capable of receiving finish materials in those areas which are exposed and scheduled to receive finishes. Exposed surfaces are to be acceptable to consultant prior to application of finish.
- .11 Firestopping shall be inspected and approved by local authority prior to concealment or enclosure.

- .12 Install material and components in accordance with ULC certification, manufacturers instructions and local authority.
- .13 Submit product literature and installation material on fire stopping in shop drawing and product data manual. Maintain copies of these on site for viewing by installers and consultant.
- .14 Manufacturer of product shall provide certification of installation. Submit letter to the consultant.
- .15 Acceptable Alternate Manufacturers to approval of local authority:
 - .1 Minnesota Mining and Manufacturing
 - .2 Fryesleeve Industries Inc.
 - .3 General Electric Pensil Firestop Systems
 - .4 International Protective Coatings Corp.
 - .5 Rectorseal Corporation (Metacaulk)
 - .6 Proset Systems
 - .7 3M
 - .8 AD Systems
 - .9 Hilti
- .16 Ensure firestop manufacturer representative performs onsite inspections and certifies installation. Submit inspection reports/certification at time of substantial completion.

1.19 ESCUTCHEONS

- .1 On pipes and ductwork passing through walls, partitions, floors and ceilings in exposed finished areas and on water and drain pipes inside millwork and cabinets.
- .2 Chrome or nickel plated brass or Type 302 stainless steel, one piece type with set screws.
- .3 Outside diameter to cover opening or sleeve.
- .4 Inside diameter to fit around finished pipe.

1.20 PAINTING

- .1 Refer to Section Interior Painting and specified elsewhere.
- .2 Apply at least one coat of corrosion resistant primer paint to ferrous supports and site fabricated work.
- .3 Apply two coats of paint to exposed piping service in service room, base colour as specified in HVAC Identification Section.
- .4 Prime and touch up marred finished paintwork to match original.
- .5 Restore to new condition, or replace equipment at discretion of consultant, finishes which have been damaged too extensively to be merely primed and touched up.

1.21 SPARE PARTS

- .1 Furnish spare parts in accordance with general requirements and as follows:
 - .1 One set of packing seals for each pump.
 - .2 One casing joint gasket for each size pump.
 - .3 One set of belts for each type or each size of machinery.
 - .4 One filter cartridge or set of filter media for each filter or filter bank in addition to final operating set.
- .2 Provide list of equipment in maintenance manuals indicating corresponding spare parts required. List of spare parts to be signed off by receiving personnel.

1.22 SPECIAL TOOLS

- .1 Provide one set of special tools required to service equipment as recommended by manufacturers and in accordance with Maintenance Materials Special Tools and Spare Parts.

1.23 ACCESS DOORS

- .1 Provide access doors to concealed HVAC equipment for operating, inspecting, adjusting and servicing.
- .2 Flush mounted 600 x 600 mm (24" x 24") for body entry and 300 x 300 mm (12" x 12") for hand entry unless otherwise noted. Doors to open 180°, have rounded safety corners, concealed hinges, screwdriver latches and anchor straps.
- .3 Material:
 - .1 Special areas such as tiled or marble surfaces: Use stainless steel with brushed satin or polished finish as directed by Consultant.
 - .2 Remaining areas: Use prime coated steel.
 - .3 Fire rated areas: Provide ULC listed access doors.
 - .4 Washrooms or high moisture area ceilings: Aluminum with mill finish suitable for painting.
- .4 Installation:
 - .1 Locate so that concealed items are accessible.
 - .2 Locate so that hand or body entry (as applicable) is achieved.
- .5 Acceptable Manufacturers:
 - .1 Le Hage
 - .2 Zurn
 - .3 Acudor
 - .4 Nailor Industries Inc.

1.24 DIELECTRIC COUPLINGS

- .1 General:
 - .1 To be compatible with and to suit pressure rating of piping system.
 - .2 Where pipes of dissimilar metals are joined.
- .2 Pipes NPS 50 mm (2") and under: Isolating unions.
- .3 Pipes NPS 65 mm (2 1/2") and over: Isolating flanges.

1.25 DRAIN VALVES

- .1 Locate at low points and at section isolating valves unless otherwise specified.
- .2 Minimum NPS 20 mm (3/4") unless otherwise specified: bronze, with hose end male thread and complete with cap and chain.
- .3 Drain valves on potable water systems shall be complete with vacuum breaker.

1.26 REPAIRS, CUTTING, AND RESTORATION

- .1 Patch and repair walls, floors, ceilings, and roofs with materials of same quality and appearance as adjacent surfaces unless otherwise shown. Surface finishes shall exactly match existing finishes of same materials.
- .2 Each Section of this Division shall bear expense of cutting, patching, and repairing to install their work and/or replacing of work of other Sections required because of its fault, error, tardiness, or because of damage done by it.
- .3 Cutting, patching, repairing, and replacing pavements, sidewalks, roads, and curbs to permit installation of work of this Division is responsibility of Section installing work.
- .4 All patching, painting and making good of the existing walls, floors, ceilings, partitions and roof will be at the expense of this Contractor, but performed by the Contractor specializing in the type of work involved unless otherwise noted.

1.27 EXISTING SYSTEMS

- .1 Connections into existing systems to be made at time approved by Consultant. Request written approval of time when connections can be made.
- .2 Be responsible for damage to existing plant by this work.

1.28 CLEANING

- .1 Clean interior and exterior of all systems including strainers. Vacuum interior of ductwork and air handling units prior to turn over to owner.
- .2 In preparation for final acceptance, clean and refurbish all equipment and leave in operating condition including replacement of all filters in all air and piping systems.

1.29 DISCONNECTION AND REMOVAL

- .1 Disconnect and/or remove equipment, piping, ductwork, etc. as indicated.
- .2 Cap and conceal all redundant and obsolete connections.

- .3 Provide a list of equipment to be removed to the owner, for his acceptance of same. Remove all equipment from site, which the owner does not retain.
- .4 Store equipment to be retained by owner on site where directed by consultant.

1.30 OWNER SUPPLIED EQUIPMENT

- .1 Connect to equipment supplied by the owner and make operable.

1.31 DEMOLITION

- .1 The general requirements are indicated on the drawings and on the outline specification in Division 1.
- .2 The general execution of the demolition is to be carried out in a clean and efficient manner.
- .3 Demolition of existing ceiling, walls etc., to facilitate removal of existing services or equipment or installation of new to be kept to a minimum and then restored to match existing.
- .4 All openings or holes created by removal of existing HVAC systems which are not being reused are to be patched with the same material surrounding surfaces.
- .5 All new holes and openings to facilitate HVAC systems are to be patched to match surrounding surfaces.
- .6 Protect all existing furnishings, materials, and equipment. Any damage occurring as a result of the work of this Division shall be repaired or replaced at the expense of this Division.
- .7 Where work involves breaking into or connecting to existing services, carry out work at times directed by the Owners in an expedient manner with minimum disruption to the facility and systems downtime.
- .8 Where unknown services are encountered, immediately advise Consultant and confirm findings in writing.
- .9 Where the location of any services has been shown on the plans, such information is not guaranteed. It is this Division's responsibility to verify locations, invert elevations, etc., immediately after moving on site. Should for any reason the information obtained necessitate changes in procedure or design, advise the Consultant at once. If verification of existing conditions is not done at the outset and any problems arise, the responsibility for same is entirely this Division's.

1.32 EXISTING CONCRETE SLAB X-RAY/SCANNING

- .1 This Contractor shall retain the services of a qualified company to provide an X-ray and/or scan of the existing buried services in wall and/or floors prior to starting any work in the affected area.
- .2 Failure to locate existing piping, conduit, rebar, etc. shall not relieve this Contractor of repair of same prior to installing his service.
- .3 This Contractor shall be responsible for all repairs and/or replacement of existing services caused by cutting the existing concrete slabs and/or walls.

1.1 TSSA INSPECTION

- .1 Prior to final completion of the project, this contractor shall make application, arrange, and pay for a TSSA inspection of all piping systems and equipment installations, including, but not limited to medical gasses, refrigeration, fuel piping, compressed air, heating plant, cooling plant, and associated equipment installed under the contract.
- .2 Provide a copy of the TSSA report in the maintenance manuals for each system.

1.2 INTEGRATED LIFE SAFETY SYSTEMS TESTING

- .1 HVAC systems in this building, including but not limited to smoke control dampers, smoke control fans, high speed low velocity ceiling fans, makeup air units, and heat tracing for fire protection systems may be subject to Integrated Life Safety Systems testing.
- .2 The HVAC Contractor shall co-ordinate with the Integrated Life Safety Systems Testing Agent as follows:
 - .1 Confirm which HVAC systems are to be included as part of the testing process.
 - .2 Verify in writing to the Integrated Life Safety Systems Testing Agent that HVAC commissioning of the affected systems/devices is complete prior to the scheduled testing date(s).
 - .3 Participate in the Integrated Life Safety Systems Testing to confirm proper operation of all associated systems.
 - .4 This contractor shall work with the Integrated Life Safety Systems Testing Agent to reset all systems back to normal operating mode after the testing is complete.
- .3 Include all costs associated with Integrated Life Safety System Testing in the tender value.
- .4 Refer to Division 1/Division 26 Integrated Life Safety Systems Testing specifications for additional information/requirements.

1.3 REFRIGERANT CONTAINING EQUIPMENT

- .1 A2L refrigerants are classified as mildly flammable. CSA B52-2023 has specific safety clauses related to the use of refrigerants with this classification within buildings.
- .2 This Contractor shall be responsible to ensure that the installation requirements of CSA B52-2023 are met.
- .3 Throughout this specification various pieces of equipment have been specified with refrigerant leak detection systems. Field wiring of the alarm status of this system to various downstream system components is required under Annex P of the standard and is the responsibility of this Contractor. These devices include the following:
 - .1 Open all zone dampers connected to the affected system.
 - .2 Disable electric reheat coils within the affected system.
 - .3 Activate field installed safety shut off valves on the affected refrigeration systems.

- .4 De energize any potential sources of ignition with the ductwork system of the affected system.
- .5 Energize fans within the ductwork system.
- .6 Activate any designated refrigeration leak ventilation systems.

1.4 FREEZE PROTECTION

- .1 Do not run lines in outside walls, or locations where freezing may occur. Piping next to outside walls shall be in furred spaces with insulation between the piping and the outside wall. Insulation of piping shall not be considered freeze protection.

1.5 SCAFFOLDING, RIGGING, AND HOISTING

- .1 Provide all scaffolding, rigging, hoisting, and services necessary for erection and delivery into the premises of any equipment and apparatus furnished; remove same from premises when no longer required. Conform to OSHA requirements and standards.

1.6 COOPERATION WITH OTHER TRADES

- .1 Give full cooperation to other trades and furnish in writing to other trades, with copies to the engineer, any information necessary to permit the work of all trades to be installed satisfactorily and with the least possible interference or delay.
- .2 Where plumbing work will be installed in close proximity to, or will interfere with work of other trades, assist in working out space conditions to make a satisfactory adjustment. Prepare composite working drawings and sections at a suitable scale, not less than ¼ inches = 1-foot – 0-inches, clearly showing how the HVAC work is to be installed in relation to the work of other trades. If work is installed before coordinating with other trades, or if it causes any interference with work of other trades, make the necessary changes in the work to correct the conditions and bear all costs.
- .3 Furnish to other trades necessary templates, patterns, setting drawings, and shop details for the proper installation of work and for coordinating adjacent work.

1.7 WATERPROOFING SEAL MATERIALS

- .1 Modular, compressed seal assemblies consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and pipe sleeve or wall opening, assembled with stainless steel bolts and pressure plates and designed so when bolts are tightened the links expand to seal the opening watertight. Select seal assemblies to suit pipe size and sleeve size or wall opening size.
- .2 Standard of quality assurance manufacturers are:
 - .1 Thunderline Corp. (Power Plant Supply Co.) "Link Seal" Model S-316
 - .2 The Metraflex Co. "MetraSeal" type ES
 - .3 Or approved equivalent.

1.8 SLEEVE, CUT, AND FORMED OPENING LOCATION DRAWINGS

- .1 Prepare and submit for review, drawings indicating size and location of required sleeves, recesses, and formed openings in poured or precast concrete work.
- .2 Such drawings are to be completely and accurately dimensioned and relate sleeve, recesses, and formed openings to suitable grid lines and elevation datum, and are to take into account structural items such as grade beams, column caps, and column drop slabs.
- .3 Begin to prepare such drawings immediately upon notification of acceptance of bid and award of Contract.

1.9 SUSTAINABLE CONSTRUCTION

- .1 Construction Waste Management:
 - .1 Recycle all waste materials to avoid land fill sites where possible.
 - .2 All metal contents shall be recycled.
 - .3 All cardboard and paper shall be recycled.
 - .4 All plastic packaging shall be recycled.
 - .5 All wood shall be directed to the appropriate recycled wood section at the landfill site.
- .2 This Contractor is responsible for their own waste management system and cost associated with the disposal. This can be their own on site system, daily removal, back to shop, or a communal system shared with other contractors on site.
- .3 In all cases the cost to remove materials on site are the cost of this Contractor.

END OF SECTION

Part 1 General

1.1 GENERAL

- .1 This section is to read in conjunction with Division 1, the general condition, and the General Requirements of the mechanical trades.

1.2 REFERENCES

- .1 Tested to ANSI/UL Standard 508.
- .2 UL-508 certified for the building and assembly.
- .3 CSA or C-UL stickers shall be applied to both the VFD and option panels.
- .4 Manufacturers shall be ISO 9001 certified facilities.

1.3 SUBMITTALS

- .1 Submit manufacturer's performance data including dimensional drawings, power circuit diagrams, installation and maintenance manuals, warranty description, VFD's FLA rating, certification agency file numbers and catalogue information.
- .2 The specification lists the minimum VFD performance requirements for this project. Each supplier shall list any exceptions to the specification. If no departures from the specification are identified, the supplier shall be bound by the specification.
- .3 Harmonic filtering. The manufacturer shall, with the aid of the buyer's electrical power single line diagram, providing the data required by IEEE-519, perform an analysis to initially demonstrate the supplied equipment will meet the IEEE standards after installation. If, as a result of the analysis, it is determined that additional filter equipment is required to meet the IEEE recommendations, then the cost of such equipment shall be included in the bid. A harmonic analysis shall be submitted with the approval drawings to verify compliance with the latest version of IEEE-519 voltage and current distortion limits as shown in table 10.2 and 10.3 at the point of common coupling (PCC). The PCC shall be defined as the consumer-utility interface or primary side of the main distribution transformer.

Part 2 Products

2.1 ACCEPTABLE MANUFACTURERS

- .1 Danfoss Graham.
- .2 ABB.
- .3 AC Tech.

2.2 GENERAL

- .1 The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump and fan control and to eliminate the need for motor derating.
- .2 With the motor's rated voltage applied to the VFD input, the VFD shall allow the motor to produce full rated power at rated amps, RMS fundamental volts, and speed without using the motor's service factor. VFD's utilizing sine weighted/coded modulation (with or without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.
- .3 Include an input full-wave bridge rectifier and maintain a fundamental power factor near unity regardless of speed or load.
- .4 Provide DC link reactors on both the positive and negative rails of the DC bus to minimize power line harmonics. VFD's without DC link reactors shall provide a minimum 5% impedance line reactor.
- .5 Full load amp rating shall meet or exceed NEC Table 430-150. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 160% of rated current for up to 0.5 second while starting.
- .6 Provide full torque at any selected frequency from 28 Hz to base speed to allow driving direct drive fans without derating.
- .7 An automatic energy optimization selection feature shall be provided in the VFD. This feature shall automatically and continually monitor the motor's speed and load and adjust the applied voltage to maximize energy savings and provide up to an additional 3% to 10% energy savings.
- .8 Input and output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD. Switching rate may be up to 1 time per minute on the input and unlimited on the output.
- .9 An automatic motor adaptation test algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to run the test.
- .10 Galvanic and/or optical isolation shall be provided between the VFD's power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFD's not including either galvanic or optical isolation on both analog I/O and discrete I/O shall include additional isolation modules.
- .11 VFD shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD efficiencies while reducing motor noise.
- .12 VFD's operating 600/3/60 motors not designed to meet Nema MG1 Part 31 should include Output dv/dt (LC) Reactors.

2.3 PROTECTIVE FEATURES

- .1 VFD shall be provided with an integral disconnect and Integral Fast Blow Semi-Conductor fuses sized as specified by ULC. Fuses shall be Bussman JJS type or equivalent.
- .2 A minimum of Class 20 I2t electronic motor overload protection for single motor applications and thermal-mechanical overloads for multiple motor applications shall be provided.
- .3 Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over-voltage, under-voltage, VFD over-temperature and motor over-temperature. The VFD shall display all faults in plain English. Codes are not acceptable.
- .4 Protect VFD from sustained power or phase loss. The VFD shall provide full rated output with an input voltage as low as 90% of the nominal.
- .5 The VFD shall incorporate a motor preheat circuit to keep the motor warm and prevent condensation build up in the stator.
- .6 To prevent breakdown of the motor winding insulation, the VFD shall be designed to comply with IEC Part 34-17. Motors shall have inverter rated insulation (1600V).
- .7 VFD shall include a "signal loss detection" circuit to sense the loss of an analog input signal such as 4 to 20 mA or 2 to 10 V DC and shall be programmable to react as desired in such an instance.
- .8 VFD shall function normally when the keypad is removed while the VFD is running and continue to follow remote commands. No warnings or alarms shall be issued as a result of removing the keypad.
- .9 VFD shall catch a rotating motor operating forward or reverse up to full speed.
- .10 VFD shall be rated for 100,000 amp interrupting capacity (AIC).
- .11 VFD shall have externally mounted EMI electromagnetic suppressor to limit the EMI and RFI output from the VFD. VFD to be mounted in an all metal cabinet to limit radiated RFI.
- .12 VFD shall include current sensors on all three output phases to detect and report phase loss to the motor. The VFD will identify which of the output phases is low or lost.
- .13 VFD shall continue to operate without faulting until input voltage reaches 300 V AC on 208/230 volt VFD's, and 701V AC on 575 volt VFD's.
- .14 For remote VFD installations, provide an output filter (load side reactor) at each VFD to protect the equipment motor. Coordinate installation with equipment manufacturer.

2.4 INTERFACE FEATURES

- .1 Hand/Start, Off/Stop and Auto/Start selector switches shall be provided to start and stop the VFD and determine the speed reference.
- .2 The VFD shall be able to be programmed to provide a 24 V DC output signal to indicate that the VFD is in Auto/Remote mode.
- .3 The VFD shall provide digital manual speed control. Potentiometers are not acceptable.

- .4 Lockable, alphanumeric backlit display keypad can be remotely mounted up to 10 feet away using standard 9-pin cable.
- .5 The keypads for all sizes of VFD's shall be identical and interchangeable.
- .6 To set up multiple VFD's, it shall be possible to upload all set-up parameters to the VFD's keypad, place that keypad on all other VFD's in turn and download the set-up parameters to each VFD. To facilitate setting up VFD's of various sizes, it shall be possible to download from the keypad only size independent parameters.
- .7 Display shall be programmable to display in 9 languages including English, Spanish and French.
- .8 The display shall have four lines, with 20 characters on three lines and eight large characters on one line.
- .9 A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.
- .10 A quick set-up menu with factory preset typical HVAC parameters shall be provided on the VFD eliminating the need for macros.
- .11 The VFD shall include a standard RS-485 communications port for connection to a Johnson Controls N2 and Siemens FLN serial communication system. The connection shall be software selectable and addressable by the user. The option for Lonworks and BacNet communication must also be available.
- .12 As a minimum, the following points shall be controlled and/or accessible:
VFD Start/Stop, Speed reference, Fault diagnostics, and Meter points as follows:
Motor power in HP, Motor power in kW, Motor kW-hr, Motor current, Motor voltage, Hours run, Feedback signal #1, Feedback signal #2, DC link voltage, Thermal load on motor, and Thermal load on VFD, Heat sink temperature.
- .13 Four additional Form C 230 volt programmable relays shall be available for factory or field installation within the VFD.
- .14 Two set-point control interface (PID control) shall be standard in the unit. VFD shall be able to look at two feedback signals, compare with two set-points and make various process control decisions.
- .15 Floating point control interface shall be provided to increase/decrease speed in response to contact closures.
- .16 Four simultaneous displays shall be available. They shall include frequency or speed, run time, output amps and output power. VFD's unable to show these four displays simultaneously shall provide panel meters.
- .17 Sleep mode shall be provided to automatically stop the VFD when its speed drops below set "sleep" level for a specified time. The VFD shall automatically restart when the speed command exceeds the set "wake" level.
- .18 The sleep mode shall be functional in both follower mode and PID mode.

- .19 Run permissive circuit shall be provided to accept a "system ready" signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of sending an output signal as a start command to actuate external equipment before allowing the VFD to start.
- .20 The following displays shall be accessible from the control panel in actual units: Reference Signal Value in actual units, Output Frequency in Hz or percent, Output Amps, Motor HP, Motor kW, kWhr, Output Voltage, DC Bus Voltage, VFD Temperature in degrees, and Motor Speed in engineering units per application (in GPM, CFM, etc.). VFD will read out the selected engineering unit either in a linear, square or cubed relationship to output frequency as appropriate to the unit chosen.
- .21 The display shall be programmed to read in inches of water column (in-wg) for an air handler application, pressure per square inch (psi) for a pump application, and temperature (oF) for a cooling tower application.
- .22 VFD shall be able to be programmed to sense the loss of load and signal a no load/broken belt warning or fault.
- .23 If the temperature of the VFD's heat sink rises to 80°C, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. If the temperature of the heat sink continues to rise the VFD shall automatically reduce its output frequency to the motor. As the VFD's heat sink temperature returns to normal, the VFD shall automatically increase the output frequency to the motor and return the carrier frequency to its normal switching speed.
- .24 The VFD shall have temperature controlled cooling fans for quiet operation and minimized losses.
- .25 The VFD shall store in memory the last 10 faults and related operational data.
- .26 Eight programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.
- .27 Two programmable relay outputs, one Form C 240 V AC, one Form A 30 V AC, shall be provided for remote indication of VFD status.
- .28 Three programmable analog inputs shall be provided and shall accept a direct-or-reverse acting signal. Analog reference inputs accepted shall include two voltage (0 to 10 V DC, 2 to 10 V DC) and one current (0 to 20 mA, 4 to 20 mA) input.
- .29 Two programmable 0 to 20 mA analog outputs shall be provided for indication of VFD status. These outputs shall be programmable for output speed, frequency, current and power. They shall also be programmable to provide a selected 24 V DC status indication.
- .30 Under fire mode conditions, the VFD shall be able to be programmed to automatically default to a preset speed.
- .31 A contact/relay shall be provided to shut the fans down upon fire alarm signal.

2.5 ADJUSTMENTS

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

- .2 Sixteen preset speeds shall be provided.
- .3 Four acceleration and four deceleration ramps shall be provided. Accel and decel time shall be adjustable over the range from 0 to 3,600 seconds to base speed. The shape of these curves shall be automatically contoured to ensure no-trip acceleration and deceleration.
- .4 Four current limit settings shall be provided.
- .5 If the VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: under-voltage, over-voltage, current limit and inverter overload.
- .6 The number of restart attempts shall be selectable from 0 through 20 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds.
- .7 An automatic "on delay" may be selected from 0 to 120 seconds.

2.6 SERVICE CONDITIONS

- .1 Unit shall operate in ambient temperature of -10°C to 40°C (14°F to 104°F).
- .2 Unit shall operate in 0 to 95% relative humidity, non-condensing.
- .3 Operate in elevation up to 3,300 feet without derating.
- .4 Maximum AC line voltage variation, -10 to +10% of nominal with full output.
- .5 No side clearance shall be required for cooling of any units. All power and control wiring shall be done from the bottom.

2.7 FACTORY TESTING

- .1 To ensure quality and minimize infantile failures at the jobsite, the manufacturer shall test the complete VFD. The VFD shall operate a dynamometer at full load and speed and shall be cycled during the test.
- .2 All optional features shall be functionally tested at the factory for proper operation.

2.8 BYPASS SWITCH

- .1 Bypass Controller - Automatic transfer to line power via contactors. When in the "Drive" mode, the bypass contactor is open and the drive output contactor is closed. In the "Bypass" position, the drive output contactor is open, and the bypass contactor is closed via Start/stop command. Start/stop via customer supplied maintained contact shall be Dry type 115V compatible and shall function in both the "Drive" and "Bypass" modes. The design shall include single-phase protection in both the VFD and bypass modes.

Part 3 Execution

3.1 START-UP SERVICE

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

3.2 EXAMINATION

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

3.3 INSTALLATION

- .1 Install to manufacturer's recommendations.
- .2 Install to the requirements of the local Hydro codes. Obtain hydro permits and pay all fees.
- .3 Install in an accessible location and proper service height from floor.
- .4 Install in clean, dry, and conditioned environment.
- .5 The VFD is to be covered and protected from installation dust and contamination until the environment is cleaned and ready for operation. The VFD shall not be operated while the unit is covered.
- .6 Wiring of devices to be to the standards of Electrical Division.
- .7 Provide one manufacturer of VFD's throughout the project.

3.4 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 The VFD shall be warranted by the manufacturer for a period of five (5) years from date of Ready for Takeover. The warranty shall include parts, labour, travel costs and living expenses incurred by the manufacturer to provide factory authorized on-site service. The warranty shall be provided by the VFD manufacturer.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ANSI/ASME B40.100, Pressure Gauges and Gauge Attachments.
- .3 CAN/CGSB-14.4, Thermometers, Liquid-in-Glass, Self Indicating, Commercial/Industrial Type.
- .4 CAN/CGSB-14.5, Thermometers, Bimetallic, Self-Indicating, Commercial/Industrial Type.

1.2 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with general requirements.
- .2 Submit manufacturer's product data for following items:
 - .1 Thermometers.
 - .2 Pressure gauges.
 - .3 Stop cocks.
 - .4 Siphons.
 - .5 Wells.

Part 2 Products

2.1 GENERAL

- .1 Design point to be at mid point of scale or range.
- .2 Ranges: suitable for application.

2.2 DIRECT READING THERMOMETERS

- .1 Industrial, variable angle type, liquid filled, 225 mm (9") scale length: to CAN/CGSB 14.4.
 - .1 Acceptable Manufacturers:
 - .1 Trerice
 - .2 Winters 91T
 - .3 Wiess

2.3 REMOTE READING THERMOMETERS

- .1 100 mm (4") diameter liquid filled activated dial type: to CAN/CGSB-14.5, accuracy within one scale division, brass movement, stainless steel capillary, stainless steel spiral armour, stainless steel bulb and polished stainless steel case for wall mounting.
 - .1 Acceptable Manufacturers:
 - .1 Trerice
 - .2 Winters Contractor

2.4 THERMOMETER WELLS

- .1 Copper pipe: copper or bronze.
- .2 Steel pipe: brass or stainless steel.

2.5 PRESSURE GAUGES

- .1 115 mm (4 1/2"), dial type: to ANSI/ASME B40.100, Grade 2A, stainless steel phosphor bronze bourdon tube having 0.5% accuracy full scale unless otherwise specified.
 - .1 Acceptable Manufacturers:
 - .1 Tetric
 - .2 Winters
 - .3 Wiess
 - .2 Provide:
 - .1 Snubber for pulsating operation.
 - .2 Diaphragm assembly for corrosive service.
 - .3 Gasketed pressure relief back with solid front.
 - .4 Bronze stop cock.

Part 3 Execution

3.1 GENERAL

- .1 Install so they can be easily read from floor or platform. If this cannot be accomplished, install remote reading units.
- .2 Install between equipment and first fitting or valve.

3.2 THERMOMETERS

- .1 Install in wells on all piping. Provide heat conductive material inside well.
- .2 Install in locations as indicated and on inlet and outlet of:
 - .1 Water heating and cooling coils.
 - .2 Water Boilers
 - .3 Boiler Room HWS and HWR.
 - .4 In other locations indicated.
- .3 Install wells as indicated only for balancing purposes.
- .4 Use extensions where thermometers are installed through insulation.

3.3 PRESSURE GAUGES

- .1 Install in following locations:
 - .1 Suction and discharge of pumps.
 - .2 Upstream and downstream of PRV's.
 - .3 Upstream and downstream of control valves.

- .4 Inlet and outlet of coils.
- .5 Outlet of boilers.
- .6 In other locations as indicated.
- .2 Install gauge cocks for balancing purposes, elsewhere as indicated.
- .3 Use extensions where pressure gauges are installed through insulation.

3.4 NAMEPLATES

- .1 Install engraved lamicoid nameplates as specified elsewhere identifying medium.

END OF SECTION

Part 1 General

1.1 GENERAL PROVISIONS

- .1 Conform to the General Provisions of General Requirements Section.
- .2 This project is one of a retrofit nature in part, and which will require some demolition.
- .3 Allow for all remedial work in areas indicated on the drawings and as generally defined in the relevant sections of the specifications.

1.2 RELATED WORK SPECIFIED ELSEWHERE

- .1 Electrical Division.

1.3 SCOPE OF WORK

- .1 The scope of work is essentially the selected disconnection and/or removal of services and/or equipment, piping, ductwork, etc. as indicated or required to complete the work.

Part 2 Products

2.1 GENERAL

- .1 This Division is to liaise with the Owners or Consultant for equipment being removed that may be suitable for reuse to that specified or handed over to the Owner.
- .2 This Division is to take full responsibility for any special tools or equipment required to disassemble or remove material from building.

Part 3 Execution

3.1 GENERAL

- .1 The general requirements are indicated on the drawings and on the outline specification in Division 1.
- .2 The general execution of the demolition is to be carried out in a clean and efficient manner.
- .3 Demolition of existing ceilings, walls, etc., to facilitate removal of existing services or equipment or installation of new to be kept to a minimum and then restored to match existing.
- .4 All openings or holes created by removal of existing HVAC systems which are not being reused are to be patched with the same material surrounding surfaces.
- .5 All new holes and openings to facilitate HVAC systems are to be patched to match surrounding surfaces.
- .6 Protect all existing furnishings, materials, and equipment. Any damage occurring as a result of the work of this Division shall be repaired or replaced at the expense of this Division.

- .7 Where work involves breaking into or connecting to existing services, carry out work at times directed by the Owners in an expedient manner with minimum disruption to the facility and systems downtime.
- .8 Where unknown services are encountered, immediately advise Consultant and confirm findings in writing.
- .9 Where the location of any services has been shown on the plans, such information is not guaranteed. It is this Division's responsibility to verify locations, invert elevations, etc., immediately after moving on site. Should for any reason the information obtained necessitate changes in procedure or design, advise the Consultant at once. If verification of existing conditions is not done at the outset and any problems arise, the responsibility for same is entirely this Division's.
- .10 Disconnect and/or remove equipment, piping, ductwork, etc. as indicated.
- .11 Cap and conceal all redundant and obsolete connections.
- .12 Provide a list of equipment to be removed to the Owner, for his acceptance of same. Remove all equipment from site which the Owner does not retain.
- .13 Maintain equipment to be retained by Owner on site where directed by Consultant.
- .14 Demolition of all parts of the work must be completed within the confines of the work area and in such a way as the dust produced and risk to injury of will not adversely affect the building users.
- .15 Demolished areas of the existing building will remain in their current use in some cases. Demolition in these areas must be kept to the minimum required to complete the work.
- .16 Demolition shall take place within areas isolated from all other areas with appropriate hoarding, scaffolding, netting, fencing or other means of security between building users and the work.
- .17 Co-ordinate making safe electrical devices, capping plumbing and removal of fixtures prior to commencement of demolition.
- .18 All piping and equipment to be removed and/or abandoned shall be drained prior to capping and/or abandoning. Disposal of all liquids shall be to the approval of authority of having jurisdiction and/or provincial regulations.

3.2 EXISTING SYSTEM DRAINAGE

- .1 Drain all existing piping systems including all related equipment as required to facilitate system renovations.
- .2 Disposal of existing system shall be to the requirements of the local and/or provincial regulations.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 American Society for Testing and Materials
 - .1 ASTM A53/A53M, Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
 - .2 ASTM A105/A105M, Specification for Carbon Steel Forgings for Piping Applications.
 - .3 MSS SP 58 (Manufacturers Standardization Society of the Valve and Fitting Industry – Pipe Hangers and Supports, Materials, Design and Manufacture).

1.2 DELEGATED ENGINEERING DESIGN AND PRODUCT SUBMITTAL

- .1 Provide a delegated engineering design for all hydronic and domestic water risers to good engineering practice.
 - .1 Design Limitation: No more than 1,800 lbs shall be point loaded per core slab plank per floor.
- .2 The design shall include analysis documentation signed and sealed by a licensed Professional Engineer with a minimum of five (5) years of experience in the design of piping risers and associated support systems.
- .3 Submittal Requirements:
 - .1 Submit detailed calculations addressing thermal expansion, and where applicable to project location, seismic restraint requirements for the piping systems.
 - .2 Submit schematic drawing of the installed Riser system indicating components used and locations.
 - .3 Submit maximum anchor reaction loads for review and approval by the Structural Engineer of Record.
 - .4 Provide detailed drawings for each anchor, including dimensions and attachment method to the building structure.
 - .5 Provide detailed drawings and specifications for field assembly and structural attachment of pipe alignment guides.
 - .6 Provide product submittals for each required guide, anchor and expansion device.
 - .1 Manufacturer, model number, line contents, pressure and temperature rating.
 - .2 Movement handled; axial, lateral, angular and the amounts of each.
 - .3 Nominal size and dimensions including details of construction and assembly.

1.3 CLOSEOUT SUBMITTALS

- .1 Submit maintenance data in accordance with general requirements.
- .2 Submit sign off letter from Professional Engineer who completed the expansion compensation design.
- .3 Data to include:
 - .1 Servicing requirements, including any special requirements, stuffing box packing, lubrication and recommended procedures.

Part 2 Products

2.1 ACCEPTABLE MATERIALS

- .1 All materials furnished under this section shall be from a single supplier, designed and engineered as a complete system:
 - .1 Mason Industries
 - .2 Kinetics Noise Control Inc.
 - .3 Flex Pression Ltd.

2.2 ANCHORS AND GUIDES

- .1 Anchors:
 - .1 Provide as indicated in expansion compensation design drawings.
- .2 Alignment guides:
 - .1 Provide as indicated in expansion compensation design drawings.
 - .2 To accommodate specified thickness of insulation.
 - .3 Vapour barriers, jackets to remain uninterrupted.

2.3 ALIGNMENT GUIDES

- .1 Wall Mounted:
 - .1 Spider type, designed to maintain axial alignment of piping.
 - .2 Guides shall not carry dead weight loads.
 - .3 Guides shall allow for movement of insulation with pipe.
- .2 Floor Mounted:
 - .1 Anchored to floor or ceiling and designed to maintain axial alignment of piping.
 - .2 Guides shall be provided with plastic inserts.
 - .3 Guides shall not carry dead weight loads.
 - .4 Guides shall allow for movement of insulation with pipe.

2.4 SLIP TYPE EXPANSION JOINTS

- .1 Application: For axial pipe movement, as indicated.
- .2 Repacking: Under full line pressure.

- .3 Body and packing housings: Class 150, 1Mpa carbon steel pipe to ASTM A53/A53M, Grade B. Wall thickness to match pipe and with raised face slip-on flanges to match pipe. One-piece body construction.
- .4 Slip or traverse sleeves: Carbon steel pipe to ASTM A53/A53M, Grade B, hard chrome plated.
- .5 Anchor base: Construction steel, welded to body.
- .6 Guides (internal and external): Embody into packing housing with concentric alignment of slip or traverse sleeve with packing housing.
- .7 Extension limit stop: Stainless steel, to prevent over-extension with accessible and removable pins.
- .8 Packing rings: 6 minimum, P7FE (teflon) or graphite impregnated non-asbestos fiber.
- .9 Thermal plastic packing: P7FE (teflon) or graphite impregnated non-asbestos fiber slug supplied loose.
- .10 Lubricating fittings: Pet cocks with grease nipple.
- .11 Plunger body and plunger:
 - .1 Plunger body: heavy wall carbon steel welded to body.
 - .2 Plunger: carbon steel with hex head for use with socket wrench.
- .12 Lubricant: To manufacturer's recommendations.
- .13 Lubricant gun: Complete with hose assembly.
- .14 Drip connection: 20 MPa (2900 psi) forged steel to ASTM A105. Include half coupling with drain plug.
- .15 Lubricant fittings, plunger, gun not required for low friction self lubricating packing.

2.5 BELLOWS TYPE EXPANSION JOINTS

- .1 For axial, lateral or angular movements, as indicated.
- .2 Maximum operating pressure: 1034 kPa (150 psi).
- .3 Maximum operating temperature: 200°C (392°F).
- .4 Type A: Free flexing, factory tested to 1½ times maximum working pressure. Furnish test certificates.
- .5 Type B: Externally pressurized, constant volume, pressure balanced, designed to eliminate pressure thrust, factory tested to 1.5 times maximum working pressure. Furnish test certificates.
- .6 Bellows:
 - .1 Multiple bellows, hydraulically formed, two ply, austenitic stainless steel for specified fluid, pressure and temperature, water treatment and pipeline cleaning procedures.
- .7 Reinforcing or control rings:
 - .1 2 piece nickel iron.

- .8 Ends:
 - .1 Slip-on flanges to match pipe.
- .9 Liner:
 - .1 Austenitic stainless steel in direction of flow.
- .10 Shroud:
 - .1 Carbon steel, painted.

2.6 EXPANSION LOOPS

- .1 Steel braided hoses, U-loop assembly.
- .2 Corrugated metal inner hoses, braided outer sheaths, braid retaining collar and 90 degree elbows.
- .3 321 or 316 stainless steel corrugated hose
- .4 304 or 316 stainless steel braid and braid collar
- .5 Operating conditions:
 - .1 Working pressure: 1034 kPa (150 psi).
 - .2 Working temperature: 250°C (482°F).
 - .3 To match system requirements.

2.7 FLEXIBLE CONNECTIONS (METAL)

- .1 Application: To suit motion.
- .2 Minimum length in accordance with manufacturer's recommendations to suit offset.
- .3 Inner hose: Stainless steel corrugated.
- .4 Braided wire mesh stainless steel outer jacket.
- .5 Diameter and type of end connection: As indicated.
- .6 Operating conditions:
 - .1 Working pressure: 1034 kPa (150 psi).
 - .2 Working temperature: 250°C (482°F).
 - .3 To match system requirements.

2.8 FLEXIBLE SPHERICAL EXPANSION JOINT (EPDM)

- .1 Application: To suit motion.
- .2 Minimum length in accordance with manufacturer's recommendations to suit required offset / application.

- .3 Construction:
 - .1 Peroxide cured EPDM cover and liner and Kevlar reinforced tire cord fractioning.
 - .2 Solid steel rings within raised face rubber flange ends to prevent pullout.
 - .3 Ductile iron external ring between spheres.
 - .4 Ductile iron or steel flanges.
- .4 Provide control rods on all unanchored piping assemblies, on all spring mounted equipment connections, or when necessary to meet system pressure and temperature ratings.
- .5 Diameter and type of end connection: As indicated.
- .6 Operating conditions:
 - .1 Working pressure: 1034 kPa (150 psi).
 - .2 Working temperature: 250°C (482°F).
 - .3 To match system requirements.

2.9 EXPANSION COMPENSATORS (EXP)(2"-4")

- .1 All welded packless guided construction complete with multi ply stainless steel bellows.
- .2 Operating temperature (700°F).
- .3 Provide model HP3 for steel pipe and model HBFF3 for copper pipe.
- .4 Movement capability of 4" axial. Welded ends.
- .5 Material to match piping system.
- .6 Acceptable Manufacturers:
 - .1 Metraflex HP
 - .2 Mark David Canada
 - .3 Senior Flexonics
 - .4 Flexi-craft

2.10 EXPANSION COMPENSATORS (6"-16")

- .1 All welded packless guided construction complete with multi ply stainless steel bellows.
- .2 Operating temperature (700°F).
- .3 Movement capability of 4" axial. Welded ends.
- .4 Material to match piping system.
- .5 Acceptable Manufacturers:
 - .1 Metraflex Metragator
 - .2 Mark David Canada
 - .3 Senior Flexonics
 - .4 Flexi-craft

Part 3 Execution

3.1 INSTALLATION

- .1 Install expansion joints with cold setting, as indicated as instructed by Consultant. Make record of cold settings.
- .2 Install expansion joints and flexible connections in accordance with manufacturer's instructions.
- .3 Install pipe anchors and guides as indicated. Anchors to withstand 150% of axial thrust.

3.2 SITE REVIEW

- .1 The Professional Engineer who stamps the submitted expansion compensation shop drawings shall be responsible to conduct periodic site reviews of the installed systems.
- .2 The Professional Engineer shall provide written confirmation that the systems are installed to manufacturer recommendations and their design prior to project closeout.

3.3 APPLICATION

- .1 Provide on all vibration isolated equipment.
- .2 Provide where requested by equipment manufacturers installation manuals.
- .3 Install in accordance with manufacturer's recommendations.

3.4 THERMAL EXPANSION

- .1 Provide in long runs of heating mains exceeding 100 ft. in length.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 American National Standards Institute/ American Society of Mechanical Engineers (ANSI/ASME)
 - .1 ANSI/ASME B31.1, Power Piping, (SI Edition).
- .3 American Society for Testing and Materials (ASTM)
 - .1 ASTM A 125, Specification for Steel Springs, Helical, Heat-Treated.
 - .2 ASTM A 307, Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 - .3 ASTM A 563, Specification for Carbon and Alloy Steel Nuts.
- .4 Manufacturer's Standardization Society of the Valves and Fittings Industry (MSS)
 - .1 MSS SP-58, Pipe Hangers and Supports - Materials, Design, Manufacture Selection, Application, and Installation.

1.2 DESIGN REQUIREMENTS

- .1 Construct pipe hanger and support to manufacturer's recommendations utilizing manufacturer's regular production components, parts and assemblies.
- .2 Base maximum load ratings on allowable stresses prescribed by ASME B31.1 or MSS SP-58.
- .3 Ensure that supports, guides, anchors do not transmit excessive quantities of heat to building structure.
- .4 Design hangers and supports to support systems under all conditions of operation, allow free expansion and contraction, prevent excessive stresses from being introduced into pipework or connected equipment.
- .5 Provide for vertical adjustments after erection and during commissioning. Amount of adjustment to be in accordance with MSS SP-58.

1.3 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with general requirements.
- .2 Submit shop drawings and product data for following items:
 - .1 All bases, hangers and supports.
 - .2 Connections to equipment and structure.
 - .3 Structural assemblies.

1.4 MAINTENANCE DATA

- .1 Provide maintenance data for incorporation into manual specified in general requirements.

Part 2 Products

2.1 GENERAL

- .1 Fabricate hangers, supports and sway braces in accordance with ANSI B31.1 and MSS-SP-58.
- .2 Use components for intended design purpose only. Do not use for rigging or erection purposes.

2.2 PIPE HANGERS

- .1 Finishes:
 - .1 Pipe hangers and supports: to ANSI & ULC requirements
 - .2 Ensure steel hangers in contact with copper piping are copper plated.
- .2 Upper attachment structural: Suspension from upper flange of I-Beam or joist.
 - .1 Cold piping NPS 50 mm (2") maximum: Ductile iron C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip.
 - .1 Rod: 10 mm (3/8") UL listed
 - .2 Cold piping NPS 65 mm (2 1/2") or greater, all hot piping: Malleable iron beam clamp, eye rod, jaws and extension with carbon steel retaining clip, tie rod, nuts and washers, UL listed & FM approved.
- .3 Upper attachment structural: Suspension from upper flange of I-Beam.
 - .1 Cold piping NPS 50 mm (2") maximum: Ductile iron top-of-beam C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip, UL listed.
 - .2 Cold piping NPS 65 mm (2 1/2") or greater, all hot piping: Malleable iron top-of-beam jaw-clamp with hooked rod, spring washer, plain washer and nuts.
- .4 Upper attachment to concrete.
 - .1 Ceiling: Carbon steel welded eye rod, clevis plate, clevis pin and cotters with weldless forged steel eye nut. Ensure eye 6 mm (1/4") minimum greater than rod diameter.
 - .2 Concrete inserts: wedge shaped body with knockout protector plate ULC listed.
Note: Rapidex and Siporex are not considered concrete. Should one of these systems be encountered, piping/ductwork and/or equipment shall be supported from adjacent walls or from supplemental steel provided by this contractor attached to the adjacent walls/structure.
- .5 Shop and field-fabricated assemblies.
 - .1 Trapeze hanger assemblies: ASME B31.1.
 - .2 Steel brackets: ASME B31.1.
- .6 Hanger rods: threaded rod material to MSS SP-58.
 - .1 Ensure that hanger rods are subject to tensile loading only.
 - .2 Provide linkages where lateral or axial movement of pipework is anticipated.

- .7 Pipe attachments: material to MSS SP-58.
 - .1 Attachments for steel piping: carbon steel.
 - .2 Attachments for copper piping: copper plated black steel.
 - .3 Use insulation shields for all piping.
 - .4 Oversize pipe hangers and supports to accommodate thermal insulation. Provide 1.5 mm (16 gauge) saddles.
- .8 Adjustable clevis: material to MSS SP-58 UL listed, clevis bolt with nipple spacer and vertical adjustment nuts above and below clevis.
 - .1 Ensure "U" has hole in bottom for rivetting to insulation shields.

2.3 RISER CLAMPS

- .1 Steel or cast iron pipe: black carbon steel to MSS-SP-58, type 42, UL listed.
- .2 Copper pipe: carbon steel copper plated to MSS-SP-58, type 42.
- .3 Bolts: to ASTM A 307.
- .4 Nuts: to ASTM A 563.

2.4 INSULATION PROTECTION SHIELDS

- .1 Insulated cold piping:
 - .1 64 kg/m² (13.12 lbs/ft²) density insulation plus insulation protection shield to: MSS SP-69, galvanized sheet carbon steel. Length designed for maximum 3 m (10') span.
- .2 Insulated hot piping:
 - .1 Curved plate 300 mm (12") long, with edges turned up, welded-in centre plate for pipe sizes NPS 300 mm (12") and over, carbon steel to comply with MSS SP-58.

2.5 CONSTANT SUPPORT SPRING HANGERS

- .1 Springs: alloy steel to ASTM A 125, shot peened, magnetic particle inspected, with +/- 5% spring rate tolerance, tested for free height, spring rate, loaded height and provided with CMTR.
- .2 Load adjustability: [10]% minimum adjustability each side of calibrated load. Adjustment without special tools. Adjustments not to affect travel capabilities.
- .3 Provide upper and lower factory set travel stops.
- .4 Provide load adjustment scale for field adjustments.
- .5 Total travel to be actual travel + 20%. Difference between total travel and actual travel 25 mm (1") minimum.
- .6 Individually calibrated scales on each side of support calibrated prior to shipment, complete with calibration record.

2.6 VARIABLE SUPPORT SPRING HANGERS

- .1 Vertical movement: 15 mm (1/2") minimum, 50 mm (2") maximum, use single spring pre-compressed variable spring hangers.
- .2 Vertical movement greater than 50 mm (2"): use double spring pre-compressed variable spring hanger with 2 springs in series in single casing.
- .3 Variable spring hanger to be complete with factory calibrated travel stops. Provide certificate of calibration for each hanger.
- .4 Steel alloy springs: to ASTM A 125, shot peened, magnetic particle inspected, with +/-5% spring rate tolerance, tested for free height, spring rate, loaded height and provided with CMTR.

2.7 EQUIPMENT SUPPORTS

- .1 Fabricate equipment supports not provided by equipment manufacturer from structural grade steel meeting requirements of miscellaneous metals, specified herein. Submit calculations with shop drawings.

2.8 EQUIPMENT ANCHOR BOLTS AND TEMPLATES

- .1 Provide templates to ensure accurate location of anchor bolts.

2.9 HOUSE-KEEPING PADS

- .1 For base-mounted equipment: Reinforced concrete, at least 100 mm (4") high, 150 mm (6") larger all around than equipment, and with chamfered edges as indicated.
- .2 Size of housekeeping pads shall be determined from approved shop drawings.
- .3 Concrete: 30 Mpa concrete with reinforced wire mesh.
- .4 Install all housekeeping pads not indicated on architectural drawings.

2.10 OTHER EQUIPMENT SUPPORTS

- .1 From structural grade steel meeting requirements of structural steel section specified herein.
- .2 Submit structural calculations with shop drawings.

2.11 MANUFACTURER

- .1 Acceptable Manufacturers:
 - .1 Grinnell
 - .2 Anvil
 - .3 Myatt
 - .4 Taylor

Part 3 Execution

3.1 INSTALLATION

- .1 Install in accordance with:
 - .1 Manufacturer's instructions and recommendations.
- .2 Vibration Control Devices:
 - .1 Install on piping systems at pumps, boilers, chillers, cooling towers, elsewhere as indicated.
- .3 Clamps on riser piping:
 - .1 Support independent of connected horizontal pipework using riser clamps and riser clamp lugs welded to riser.
 - .2 Bolt-tightening torques to be to industry standards.
 - .3 Steel pipes: Install below coupling or shear lugs welded to pipe.
 - .4 Cast iron pipes: Install below joint.
- .4 Clevis plates:
 - .1 Attach to concrete with 4 minimum concrete inserts at each corner.
- .5 Provide supplementary structural steelwork where structural bearings do not exist or where concrete inserts are not in correct locations.
- .6 Use approved constant support type hangers where:
 - .1 Vertical movement of pipework is 15 mm (1/2") or more,
 - .2 Transfer of load to adjacent hangers or connected equipment is not permitted.
- .7 Use variable support spring hangers where:
 - .1 Transfer of load to adjacent piping or to connected equipment is not critical.
 - .2 Variation in supporting effect does not exceed 25% of total load.

3.2 HANGER SPACING

- .1 Plumbing piping: most stringent requirements of Canadian Plumbing Code, Provincial Code, or authority having jurisdiction.
- .2 Fire protection: to applicable fire code.
- .3 Gas and fuel oil piping: up to NPS 15 mm (1/2"): every 1.8 m (6').
- .4 Copper piping: up to NPS 15 mm (1/2"): every 1.5 m (5').

- .5 Within 300 mm (12") of each elbow and:

Maximum Pipe Size: NPS	Spacing Steel	Maximum Spacing Copper
up to 32 mm (1 1/4")	2.1 m (7')	1.8 m (6')
40 mm (1 1/2")	2.7 m (9')	2.4 m (8')
50 mm (2")	3.0 m (10')	2.7 m (9')
65 mm (2 1/2")	3.6 m (12')	3.0 m (10')
80 mm (3")	3.6 m (12')	3.0 m (10')
90 mm (3 1/2")	3.9 m (13')	3.3 m (11')
100 mm (4")	4.2 m (14')	3.6 m (12')
125 mm (5")	4.8 m (16')	
150 mm (6")	5.1 m (17')	
200 mm (8")	5.7 m (19')	

3.3 HANGER INSTALLATION

- .1 Install hanger so that rod is vertical under operating conditions.
- .2 Adjust hangers to equalize load.
- .3 Support from structural members. Where structural bearing does not exist or inserts are not in suitable locations, provide supplementary structural steel members.
- .4 Do "NOT" support piping, ductwork and equipment from roof deck, on bottom chord of floor and/or roof joist and/or from OWSJ bridging. Provide structural member between joist.

3.4 HORIZONTAL MOVEMENT

- .1 Angularity of rod hanger resulting from horizontal movement of pipework from cold to hot position not to exceed 4mm (5/32") from vertical.
- .2 Where horizontal pipe movement is less than 15 mm (1/2"), offset pipe hanger and support so that rod hanger is vertical in the hot position.

3.5 FINAL ADJUSTMENT

- .1 Adjust hangers and supports:
 - .1 Ensure that rod is vertical under operating conditions.
 - .2 Equalize loads.
- .2 Adjustable clevis:
 - .1 Tighten hanger load nut securely to ensure proper hanger performance.
 - .2 Tighten upper nut after adjustment.
- .3 C-clamps:
 - .1 Follow manufacturer's recommended written instructions and torque values when tightening C-clamps to bottom flange of beam.

.4 Beam clamps:

.1 Hammer jaw firmly against underside of beam.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 American National Standards Institute/ American Society of Mechanical Engineers (ANSI/ASME)
 - .1 ANSI/ASME B31.1, Power Piping, (SI Edition).
- .3 American Society for Testing and Materials (ASTM)
 - .1 ASTM A 125, Specification for Steel Springs, Helical, Heat-Treated.
 - .2 ASTM A 307, Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 - .3 ASTM A 563, Specification for Carbon and Alloy Steel Nuts.
- .4 Manufacturer's Standardization Society of the Valves and Fittings Industry (MSS)
 - .1 MSS SP-58, Pipe Hangers and Supports - Materials, Design, Manufacture Selection, Application, and Installation.
- .5 CSA B272-93 – Prefabricated Self-Sealing Roof Vent Flashings
- .6 CRCA (Canadian Roofing Contractor's Association)
- .7 SPRI (Single Ply Roofing Institute)
- .8 CUFCA (Canadian Urethane Foam Contractor's Association) and CGSB-51-GP-46MP, Manual for "Installers of Spray Polyurethane Foam Thermal Insulation"
- .9 CSA G40.21-M1987, M350W, and M300W (Structural Quality Steels)
- .10 CSA W47.1-1983 (Certificate of Companies for Fusion Welding of Structural Steel)
- .11 CSA W59-M1989 (Welded Steel Construction – Metal Arc Welding)
- .12 CSA G164-M1981 (Hot Dip Galvanizing of Irregularly Shaped Articles)

1.2 RELATED SECTIONS

- .1 Section 03300 – Cast-in-place Concrete
- .2 Section 05210 – Steel Joists
- .3 Section 05300 – Metal Deck
- .4 Section 06100 – Rough Carpentry
- .5 Section 07200 – Thermal Protection
- .6 Section 07500 – Membrane Roofing
- .7 Section 07900 – Joint Sealers

1.3 DESIGN REQUIREMENTS

- .1 Construct support systems to manufacturer's recommendations utilizing manufacturer's regular production components, parts and assemblies.
- .2 Base maximum load ratings on allowable stresses prescribed by ASME B31.1 or MSS SP-58.
- .3 Design supports to support systems under all conditions of operation, allow free expansion and contraction, prevent excessive stresses from being introduced into pipework or connected equipment.
- .4 Provide for vertical adjustments after erection and during commissioning. Amount of adjustment to be in accordance with MSS SP-58.

1.4 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with general requirements.
- .2 Submit shop drawings and product data for following items:
 - .1 All bases, hangers and supports.
 - .2 Connections to equipment and structure.
 - .3 Structural assemblies.
- .3 Manufacturer's installation instruction.

1.5 MAINTENANCE DATA

- .1 Provide maintenance data for incorporation into manual specified in general requirements.

1.6 QUALITY ASSURANCE

- .1 Roof accessories manufactures to have minimum five (5) years documented experience in the design and fabrication of roofing specialties and accessories.

1.7 SPECIAL WARRANTY

- .1 Warrant products installed under this section of work to be free of leaks, condensation, and defects in materials and/or manufacture for a period of twenty (20) years when installed in accordance with the manufacturer's written instructions.

Part 2 Products

2.1 PIPE/SUPPORT

- .1 Pipe/Support:
 - .1 Adjustable height 6061-T6, hollow aluminum with mill finish, urethane insulated supports, 2" (51 mm) diameter.
- .2 Stack Jack Flashing:
 - .1 Height to suit application.
 - .2 Fully urethane insulated.

- .3 Aluminum construction.
- .4 Complete with EPDM triple pressure grommet seal and EPDM base seal and other accessories as required to suit roof type.
- .3 Provide appropriate stainless steel mounting hardware to suit supported pipe/equipment.
- .4 Provide appropriate system support as specified in this section to suit application.
 - .1 Single Plain Pipe: Type 304 stainless steel pipe roller assembly to suite actual O.D pipe.
- .5 Acceptable Manufacturers:
 - .1 Thaler MERS 600 series.
 - .2 Acceptable equals if submitted and approved during tender period.

2.2 NON-PENETRATING ROOF EQUIPMENT SUPPORT (SMALL UNITS)

- .1 Provide zero penetration support on roof where indicated.
- .2 Supports shall be ballasted to resist wind loads.
- .3 Ballast system shall be fully engineered by manufacturer to withstand:
 - .1 Unit weight
 - .2 Wind loads based on prevailing wind conditions on roof of building.
- .4 Engineered shop drawings, stamped by a Professional Engineer shall be provided indicating loading and calculations that demonstrate that the stand is suitable for the proposed application.
- .5 Base shall be made of non-combustible material.
- .6 Frames shall be galvanized. All fastenings, rods, nuts, washers, etc. shall be stainless steel.
- .7 Provide shop drawings as specified. Install to manufacturers recommendations.
- .8 Acceptable Manufacturers:
 - .1 Portable pipe hanger
 - .2 Bigfoot systems
 - .3 Miro rooftop support
 - .4 Trikon Systems
 - .5 Walravin BIS Yet
 - .6 Ecofoot

2.3 EQUIPMENT ANCHOR BOLTS AND TEMPLATES

- .1 Provide templates to ensure accurate location of anchor bolts.

2.4 ROOF CURB MOUNTED EQUIPMENT

- .1 Install as per manufacturer's instructions on roof curbs provided by manufacturer as indicated.

- .2 Provide all necessary continuous pressure treated wood blocking and 24 gauge metal liner on all exposed wood as required to install roof curb level.

2.5 PIPING THROUGH ROOF

- .1 Provide Thaler MEF-9 or equal gas piping flashing where pipe and/or relief vent penetrates roof.

2.6 ROOF MOUNTED PIPE SUPPORT

- .1 Provide zero penetration pipe support on roof where indicated.
- .2 Base shall be made of high density polypropylene with UV protection. Maximum loading shall be 50 lb/sq.ft.
- .3 Frames shall be galvanized. All fastenings, rods, nuts, washers, hangers, etc. shall be stainless steel.
- .4 Provide shop drawings as specified. Install to manufacturers recommendations.
- .5 Acceptable Manufacturers:
 - .1 Portable pipe hanger
 - .2 Bigfoot systems
 - .3 Miro rooftop supports
 - .4 Walravin BIS Yeti
 - .5 Ecofoot

Part 3 Execution

3.1 INSTALLATION

- .1 Roof support install in accordance with:
 - .1 Manufacturer's instructions and recommendations.
 - .2 Provide protection against deterioration due to contact of dissimilar metals.
- .2 Flashing Installation:
 - .1 Install roof support flashing in accordance with manufacturer's printed instructions.
- .3 Vibration Control Devices:
 - .1 Install as indicated and at all roof mounted equipment that is not internally isolated.
- .4 Clevis plates:
 - .1 Attach to concrete with 4 minimum concrete inserts at each corner.
- .5 Provide supplementary structural steelwork where structural bearings do not exist or where concrete inserts are not in correct locations.

3.2 PIPE SUPPORT SPACING

- .1 Within 300 mm (12") of each elbow and:

Maximum Pipe Size: NPS	Spacing Steel	Maximum Spacing Copper
up to 32 mm (1 1/4")	2.1 m (7')	1.8 m (6')
40 mm (1 1/2")	2.7 m (9')	2.4 m (8')
50 mm (2")	3.0 m (10')	2.7 m (9')
65 mm (2 1/2")	3.6 m (12')	3.0 m (10')
80 mm (3")	3.6 m (12')	3.0 m (10')
90 mm (3 1/2")	3.9 m (13')	3.3 m (11')
100 mm (4")	4.2 m (14')	3.6 m (12')
125 mm (5")	4.8 m (16')	
150 mm (6")	5.1 m (17')	

- .2 Gas piping: every 1.8 m (6').

3.3 EXAMINATION

- .1 Report to the contractor in writing, defects of work prepared by other trades and other unsatisfactory site conditions. Verify site dimensions. Commencement of work will imply acceptance of prepared work.

3.4 ADJUSTING

- .1 Verify that all manufactured units have been installed in accordance with specifications and details and will function as intended. Adjust any items where necessary to ensure proper operation.

3.5 CLEANING

- .1 Clean manufactured units using materials and methods approved by manufacturer. Do not use cleaning techniques which could impair performance of the roofing system.

END OF SECTION

Part 1 General

1.1 APPLICATION

- .1 Seismic restraint is becoming more prominent with improved soil testing equipment. Seismic requirement is not site specific by geographical area but determined by site soil conditions.
- .2 Where the structural engineer or architect documents have $I_e \cdot S_a(0.2) \cdot F_a < 3.5$ seismic is not required on the plumbing, HVAC, electrical, or fire protection systems.
- .3 Where the structural engineer or architect documents have $I_e \cdot S_a(0.2) \cdot F_a \geq 3.5$ seismic is required on the plumbing, HVAC, electrical, or fire protection systems.
- .4 Seismic will always be required on fire protection systems when required by NFPA codes.
- .5 Seismic will always be required on any "Disaster Relief Building." For example, hospitals, police stations, ambulance building, etc.
- .6 When it is unclear in the tender documents request information from the structural engineer or architect for clarification.

1.2 SECTION INCLUDES

- .1 Seismic Requirements for single rod hanger support for conduit, pipe and other similar systems.
- .2 Seismic Requirements for trapeze type supports for cable tray, conduit, pipe and other similar systems.
- .3 Seismic requirements for all equipment and piping.

1.3 RELATED WORK SPECIFIED ELSEWHERE

- .1 Vibration Isolation Measures.

1.4 REFERENCE STANDARDS

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 National Building Code of Canada (NBC).
- .3 Canadian Standards Association
 - .1 CSA S832, Seismic Risk Reduction of Operation and Functional Components (OFCs) of Buildings.
 - .2 CAN/CSA-S16.1 Limit States Design of Steel Structures
 - .3 CAN3-S136 Design of Cold Steel Structural Members
 - .4 CSA W47.1 Certification of Companies for Fusion Welding of Steel
 - .5 CSA W59 Welded Steel Construction
- .4 SMACNA Seismic Restraint Manual Guidelines for Mechanical Systems
- .5 Canadian Institute of Steel Construction

- .6 Canadian General Standards Board
- .7 Underwriter Laboratories of Canada
- .8 Workers Compensation Board of BC
- .9 American Society of Testing and Materials
 - .1 ASTM A653/S653M, Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (galvannealed) by the Hot Dip Process.
 - .2 ASTM A879M Specification for Steel Sheet, Zinc Coated by the Electrolytic Process for Applications Requiring Designation of the Coating Mass on Each Surface.
 - .3 ASTM A307 Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 - .4 ASTM A325M Specification for Structural Bolts, Heat Treated 830MPa Minimum Tensile Strength.
- .10 All local codes.
- .11 NFPA-13: Installation of Fire Sprinkler Systems.
- .12 FEMA: Federal Emergency Management Activity.
- .13 FEMA: Seismic Restraint Installation Manuals 412. 413 and 414
 - .1 FEMA 412: Installing Seismic Restraints for Mechanical Equipment
 - .2 FEMA 413: Installing Seismic Restraints for Electrical Equipment
 - .3 FEMA 414: Installing Seismic Restraints for Duct and Pipe
- .14 ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.).
- .15 ASHRAE Applications Handbook; Seismic and Wind Restraint Design Chapter.

1.5 DEFINITIONS

- .1 A_v : Effective peak velocity related acceleration coefficient BOCA, SBC Code.
- .2 S_1 : Mapped Long Period Seismic Acceleration Coefficient IBC, TI-809-04, ASCE7.
- .3 S_s : Mapped Short Period Seismic Acceleration Coefficient IBC, TI-809-04, ASCE7.
- .4 v : Zonal Velocity Coefficient NBC-Canada.
- .5 VISCMA: The Vibration Isolation and Seismic Control Manufacturers Association has developed Testing and Rating Standards for Seismic Restraint Components that comply with Code and ASHRAE based requirements.
- .6 VISCMA 102-2007: Static Qualification Standards for Obtaining a VISCMA Compliant Seismic Component Rating.
- .7 Z : Seismic Zone defines Seismic Coefficient C_a used by UBC Code.

1.6 PERFORMANCE REQUIREMENTS

- .1 Design Ground Acceleration Coefficient (A_v , S_s , v , or Z depending on Code = X.XX).
- .2 (If IBC or TI-809-04) Design Long Period Ground Acceleration Coefficient (S_1 = X.XX).

- .3 Design Soil Type = (S_a , S_b , S_c , S_d) as appropriate. (If NBC Canada, the Foundation Factor).
- .4 Importance or Performance Factor appropriate to structure = I_p = X.XX.
- .5 If UBC Zone 4, Proximity to Fault and, if less than 10km, Fault Type.
- .6 Schedule or drawings indicating critical (I_p = 1.5) Duct/Piping systems, including systems whose importance factor may be increased by proximity to critical components.

1.7 DESCRIPTION OF SYSTEM

- .1 It shall be understood that the requirements of this seismic restraint section are in addition to other requirements as specified elsewhere for the support and attachment of equipment and HVAC services, and for the vibration isolation of same equipment. Nothing on the project drawings or specifications shall be interpreted as justification to waive the requirements of this seismic restraint section.
- .2 The work under this section shall include furnishing all labour, materials, tools, appliances, and equipment, and performing all operations necessary for the complete execution of the installation of seismic snubber restraint assemblies as shown, detailed, and/or scheduled on the drawing and/or specified in this section of the specifications.
- .3 All seismic snubber restraint assemblies shall meet the following minimum requirements:
 - .1 The snubber/restrained isolator for isolated equipment shall include a resilient element that will ensure that no un-cushioned shock can occur (this does not include cable restraints).
 - .2 It shall be possible to visually inspect the resilient material for damage and allow for replacement, if necessary.
 - .3 All snubbers are to include a maximum air gap of 0.25 in (6 mm).
 - .4 Seismic restraint systems shall be designed to offer seismic restraint in all directions, unless otherwise noted.
 - .5 Seismic restraint capacities to be verified by an independent test laboratory or certified by a registered Professional Engineer to ensure that the design intent of this specification is realized. Verification shall be by one of the following methods:
 - .1 An NRTL (National Recognized Testing Laboratory), or laboratory recommended by VISCMA.
 - .2 Certified by a Professional Engineer with at least 5 years of experience, using industry standard methods of analysis, which employ common engineering practices. Adherence to the ratings standard within ASHRAE SPC171 and VISCMA 102-2007 is required.
 - .3 By a nationally recognized agency, such as VISCMA, that has reviewed and approved the restraint.

1.8 SYSTEM DESIGN

- .1 Seismic restraint manufacturer shall be responsible for the structural design of attachment hardware as required to attach snubbers/restraints to both the equipment and supporting structure on vibration isolated equipment, or to directly attach equipment to the building structure for non-isolated equipment.
- .2 The contractor shall furnish, to the seismic restraint manufacturer, a complete set of approved shop drawings of all equipment that is to be restrained, from which the selection and design of seismic restraint devices and/or attachment hardware will be completed. The shop drawings furnished shall include, at a minimum, basic equipment layout, length, and width dimensions, and installed operating weights of the equipment to be restrained.
- .3 All piping, ductwork and equipment is to be restrained to meet code requirements. At a minimum, the seismic restraint manufacturer shall provide documentation on maximum restraint spacing for various restraint sizes and anchors, as well as "worst case" reaction loads for each restraint and/or anchor size.
- .4 The contractor shall ensure that all housekeeping pads used are adequately reinforced and are properly dowelled to the building structure, so as to withstand calculated seismic forces. In addition, the size of the housekeeping pad is to be coordinated with the seismic restraint manufacturer to ensure that adequate edge distances exist in order to obtain the desired equipment anchor capacities.

1.9 SEISMIC BRACING AND SUPPORT DESIGN REQUIREMENTS

- .1 Seismic restraint designer shall co-ordinate all attachments with the structural engineer of record.
- .2 Design analysis shall include calculated dead loads, static seismic loads, and capacity of materials utilized for the connection of the equipment or system to the structure.
- .3 Analysis shall detail anchoring methods, bolt diameter, and embedment depth.
- .4 All seismic restraint devices shall be designed to accept without failure the forces calculated per the applicable building code and as summarized in Section 3.01.
- .5 Friction from gravity loads shall not be considered resistance to seismic forces.
- .6 Fire protection systems shall meet the requirements of NFPA-13 and NFPA-14. Sway bracing used for seismic restraint purposes must be fitted with provisions to resist the vertical force component of the diagonal brace. Single diagonal brace for seismic restraint will not be approved.

1.10 ALTERNATE SYSTEMS

- .1 Provisions of the General Conditions and Supplemental Conditions of the specifications shall govern the use of alternate systems to those specified.
- .2 Manufacturers not listed as approved in "Part 2 Materials" of this section must secure approval to bid a minimum of ten (10) days prior to the project bid date.
- .3 Uncertified internal equipment seismic restraint systems are disallowed for use on this project.

1.11 QUALITY ASSURANCE

- .1 The contractor shall provide pre-engineered seismic restraint systems to meet total design lateral force requirements for support and restraint of piping, conduit, cable trays and other similar systems and equipment where required by the applicable building code.
- .2 System Supports/Restraints: Firms regularly engaged in the manufacture of products of the types specified in this section, whose products have been in satisfactory use in similar service for not less than 5 years.
- .3 Bolted framing channels and fittings shall have the manufacturers name, part number, and material heat code identification number stamped in the part itself for identification. Material certification sheets and test reports must be made available by the manufacturer upon request.
- .4 Only companies experienced in performing the work of this section shall do the installation.
- .5 All seismic restraint installations shall be independently reviewed by the Owners Representative for compliance with project specifications.

1.12 SUBMITTALS

- .1 Product Data: Include Seismic Rating Curve for each seismically rated isolator or restraint component.
- .2 Samples: The contractor shall submit samples of specified seismic snubber devices for approval.
- .3 Shop Drawings shall include the following:
 - .1 Design Calculations: Calculate requirements for selecting seismically rated vibration isolators and seismic restraints. Certification documents to be signed and sealed by a qualified Professional Engineer with at least 5 years of experience in the design of seismic restraints. Professional engineer shall have local jurisdiction and provide periodic field review and final certification upon completion of the project. All costs and fees associated with the engineering shall be the responsibility of this contractor.
 - .2 Vibration Isolation Bases: Dimensional drawings including anchorage and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads.
 - .3 Seismic-Restraint Details: Detailed submittal drawings of seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors. Include ratings for loads.

- .4 Equipment Manufacturer Seismic Qualification Certification: The Equipment Manufacturer must submit certification that each piece of provided equipment will withstand seismic forces identified in "Performance Requirements" Article above. Include the following:
 - .1 Basis for Certification: Indicate whether the "withstand" certification is based on actual test assembled components or on calculations.
 - .2 Indicate the equipment is certified to be durable enough to:
 - .1 structurally resist the design forces and/or
 - .2 will remain functional after the seismic event.
- .5 Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
- .6 Detailed description of the assumed equipment anchorage devices on which the certification is based.

1.13 DELIVERY, STORAGE, AND HANDLING

- .1 Deliver strut systems, pipe hangers and components carefully to avoid breakage, denting, and scoring finishes. Do not install damaged equipment.
- .2 Store strut systems, pipe hangers and components in original cartons and in clean dry space; protect from weather and construction traffic.

1.14 WORK FURNISHED BUT NOT INSTALLED

- .1 The materials and systems specified in this section shall be purchased by the HVAC contractor from a single seismic snubber restraint materials manufacturer to assure sole source responsibility for the performance of the seismic restraints used.
- .2 The materials and systems specified in this section can, at the contractor's option, be installed by the subcontractor who installs the seismic services.

1.15 COORDINATION

- .1 Coordinate size, shape, reinforcement and attachment of all housekeeping pads supporting seismically rated equipment. Concrete shall have a minimum compressive strength of 3,000 psi or as specified by the consultant.
- .2 Coordinate with seismic restraint manufacturer to locate and size structural supports underneath seismically restrained equipment (e.g. roof curbs, cooling towers, and other similar equipment).

1.16 INSTALLATION

- .1 Installation of all seismic restraint materials specified herein shall be accomplished following the manufacturer's written instructions. Installation instructions shall be submitted to the engineer for approval prior to the beginning of the work.

Part 2 Products

2.1 MATERIALS

- .1 Unless otherwise specified materials used in the Work shall conform to the following:
 - .1 All steel rolled sections and steel plates shall conform to CAN/CSA G40.21M-300W
 - .2 All steel hollow structural steel sections shall conform to CAN/CSA G40.21-350W Class C
 - .3 Structural steel bolts, nuts and washers shall conform to ASTM A325M
 - .4 Weld electrodes shall be SMAW-E-E480XX and SAW-F480-EXXX.

2.2 ACCEPTABLE MANUFACTURERS

- .1 All seismic snubbers and combination restraint/vibration isolation materials specified herein shall be provided by a single manufacturer to assure sole source responsibility for the proper performance of the materials used. Manufacturer is to be a member of VISCMA.
- .2 Anchor types and sizes are to be per the design data as provided by the seismic restraint manufacturer.
- .3 Materials and systems specified herein and detailed or scheduled on the drawings are based upon materials manufactured by Kinetics Noise Control Inc. Materials and systems provided by other manufacturers are acceptable, provided that they meet all requirements as listed in this specification.
- .4 Kinetics Noise Control Inc.
- .5 Cooper 'B' Line.
- .6 Unistrut Building Systems.
- .7 Mason Industries.

2.3 SEISMIC SNUBBER TYPES

- .1 GENERAL
(Isolator/Snubber Types contained herein are per ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.) Handbook, HVAC Applications, Seismic and Wind Restraint Design)
 - .1 Type A, Coil Spring Isolator Incorporated Within a Ductile Iron or Cast Aluminum Housing.
 - .1 Cast iron or aluminum housings are brittle when subjected to shock loading and are therefore not approved for seismic restraint applications.

- .2 Type B, Coil Spring Isolator Incorporated Within A Steel Housing
 - .1 Spring isolators shall be seismic control restrained spring isolators, incorporating a single or multiple coil spring element, having all of the characteristics of free standing coil spring isolators as specified in the vibration isolation portion of this specification. Springs shall be restrained using a housing engineered to limit both lateral and vertical movement of the supported equipment during an earthquake without degrading the vibration isolation capabilities of the spring during normal equipment operating conditions.
 - .2 Vibration isolators shall incorporate a steel housing and neoprene snubbing grommet system designed to limit motion to no more than ¼" (6 mm) in any direction and to prevent any direct metal-to-metal contact between the supported member and the fixed restraint housing. The restraining system shall be designed to withstand the seismic design forces in any lateral or vertical direction without yield or failure. Where the capacity of the anchorage hardware in concrete is inadequate for the required seismic loadings, a steel adapter base plate to allow the addition of more or larger anchors will be fitted to fulfill these requirements. In addition to the primary isolation coil spring, the load path will include a minimum ¼" (6 mm) thick neoprene pad.
 - .3 Spring elements shall be colour coded or otherwise easily identified. Springs shall have a lateral stiffness greater than 1.2 times the rated vertical stiffness and shall be designed to provide a minimum of 50% overload capacity. Non-welded spring elements shall be epoxy powder coated and shall have a minimum of a 1000-hour rating when tested in accordance with ASTM B-117.
 - .4 To facilitate servicing, the isolator will be designed in such a way that the coil spring element can be removed without the requirements to lift or otherwise disturb the supported equipment.
 - .5 Spring isolators shall be Model FHS as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (2).
- .3 Type C, Coil Spring Isolator Incorporated Within a Steel Housing
 - .1 Spring isolators shall be seismic control restrained spring isolators, incorporating one or more coil spring elements, having all the characteristics of free standing coil spring isolators per the vibration isolation section of this specification, for equipment which is subject to load variations and/or large external forces. Isolators shall consist of one or more laterally stable steel coil springs assembled into fabricated welded steel housings designed to limit movement of the supported equipment in all directions.

- .2 Housing assembly shall be made of fabricated steel members and shall consist of a top load plate complete with adjusting and leveling bolts, adjustable vertical restraints, isolation washers, and a bottom load plate with internal non-skid isolation pads and holes for anchoring the housing to the supporting structure. Housing shall be hot dipped galvanized for outdoor corrosion resistance. Housing shall be designed to provide a constant free and operating height within $\frac{1}{8}$ " (3 mm).
 - .3 The isolator housing shall be designed to withstand the project design seismic forces in all directions.
 - .4 Coil spring elements shall be selected to provide static deflections as shown on the vibration isolation schedule or as indicated or required in the project documents. Spring elements shall be colour coded or otherwise easily identified. Springs shall have a lateral stiffness greater than 1.2 times the rated vertical stiffness and shall be designed to provide a minimum of 50% overload capacity. Non-welded spring elements shall be epoxy powder coated and shall have a minimum of a 1000-hour rating when tested in accordance with ASTM B-117.
 - .5 Spring isolators shall be Model FLS and FLSS as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (3).
- .4 Type D, Coil Spring Isolator Incorporated with Integral Seismic Restraint
- .1 Spring isolators shall be single or multiple coil spring elements which have all of the characteristics of freestanding coil spring isolators as specified in the vibration isolation portion of this specification, incorporating lateral and vertically restrained seismic housing assemblies. Spring elements shall be readily replaceable without the need to list or remove the supported equipment.
 - .2 Restraint housing shall be sized to meet or exceed the force requirements of the application and shall have the capability of accepting coil springs of various sizes, capabilities, and deflections as required to meet the required isolation criteria. All spring forces shall be contained within the coil/housing assembly, and the restraint anchoring hardware shall not be exposed to spring generated forces under conditions of no seismic force. Spring element leveling adjustment shall be accessible from above and suitable for use with a conventional pneumatic or electric impact wrench.
 - .3 Restraint element shall incorporate a steel housing with elastomeric elements at all dynamic contact points. Elastomeric elements shall be replaceable. Restraint shall allow $\frac{1}{4}$ " (6 mm) free motion in any direction from the neutral position. Restraint shall have an overturning factor (ratio of effective lateral snubber height to short axis anchor spacing) of 0.33 or less to ensure optimum anchorage capacity.
 - .4 Spring isolators shall be Model FMS as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (4).

- .5 Type E, All Direction Neoprene Isolator
 - .1 Vibration Isolators shall be neoprene, molded from oil resistant compounds, designed to operate within the strain limits of the isolator so to provide the maximum isolation and longest life expectancy possible using neoprene compounds. Isolators shall include encapsulated cast-in-place top steel load transfer plate for bolting to equipment and a steel base plate with anchor holes for bolting to the supporting structure. Ductile iron or cast aluminum components are not acceptable alternatives and shall not be used due to brittleness when subjected to shock loading.
 - .2 Isolator shall be capable of withstanding the design seismic loads in all directions with no metal-to-metal contact.
 - .3 Isolator shall have minimum operating static deflections as shown on the project Vibration Isolation Schedule or as otherwise indicated in the project documents and shall not exceed published load capacities.
 - .4 Neoprene isolators shall be Model RQ as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections .2.01, 2.02 and 2.03 (5).
- .6 Type F, Light Capacity All Direction 3-Axis External Seismic Snubber Assembly
 - .1 Equipment shall be restrained against excessive movement during a seismic event by the use of 3-axis resilient snubbers, designed to withstand the project required seismic forces. A minimum of two (2) snubbers are to be used at each equipment installation, oriented to effectively restrain the isolated equipment in all three directions, and additional snubbers shall be used as required by seismic design conditions.
 - .2 Snubbers shall be of interlocking steel construction and shall be attached to the equipment structure and equipment in a manner consistent with anticipated design loads. Snubbers shall limit lateral and vertical equipment movement at each snubber location to a maximum of ¼" (6 mm) in any direction.
 - .3 Snubbers shall include a minimum ¼" (6 mm) thick resilient neoprene pads to cushion any impact and to avoid any potential for metal-to-metal contact. Maximum neoprene bearing pressure shall not exceed 1500 pounds / sq. inch (10.4 N / sq. mm). Snubber shall be capable of withstanding an externally applied seismic force of up to 3,000 pounds (1360 kg) in any direction. Snubber shall be installed only after the isolated equipment is mounted, piped, and operating so as to ensure that no contact occurs during normal equipment operation.
 - .4 Three-axis seismic snubbers shall be Model HS-5 as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and 2.01, 2.02, and 2.03 (6).

- .7 Type G, Lateral 2-Axis External Seismic Snubber Assembly
 - .1 Equipment shall be restrained against excessive lateral movement during a seismic event by the use of 2-axis horizontal resilient snubbers, designed to withstand the project required seismic forces. A minimum of two (2) snubbers are to be used at each equipment installation, oriented to effectively restrain the isolated equipment in all horizontal directions, and additional snubbers shall be used as required by seismic design conditions.
 - .2 Snubbers shall be interlocking steel construction and shall be attached to the equipment structure and equipment in a manner consistent with anticipated design loads. Snubbers shall limit lateral equipment movement at each snubber location to a maximum of ¼" (6 mm).
 - .3 Snubbers shall include a minimum of ¼" (6 mm) thick resilient neoprene pads to cushion any impact and to avoid any potential for metal-to-metal contact. Snubber shall be installed only after the isolated equipment is mounted, piped, and operating so as to ensure that no contact occurs during normal equipment operation.
 - .4 Two-axis lateral seismic snubbers shall be Model HS-2 as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (7).
- .8 Type H, Heavy Capacity All Direction 3-Axis External Seismic Snubber Assembly
 - .1 Equipment shall be restrained against excessive vertical and horizontal movement during a seismic event by the use of 3-axis resilient snubbers, designed to withstand the project required seismic forces. A minimum of two (2) snubbers are to be used at each equipment installation, oriented to effectively restrain the isolated equipment in all three directions, and additional snubbers shall be used as required by seismic design conditions.
 - .2 Snubbers shall be of welded interlocking steel construction and shall be attached to the equipment structure and equipment in a manner consistent with anticipated design loads. Snubbers shall limit lateral and vertical equipment movement at each snubber location to a maximum of ¼" (6 mm) in any direction.
 - .3 Snubbers shall include resilient neoprene pads with a minimum thickness of ¼" (6 mm) to cushion any impact and to avoid any potential for metal-to-metal contact. Snubber shall be capable of withstanding an externally applied seismic force up to 10,000 pounds (4,540 kg) in any direction. Snubber shall be installed only after the isolated equipment is mounted, piped, and operating so as to ensure that no contact occurs during normal equipment operation.
 - .4 Three-axis seismic snubbers shall be Model HS-7 as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (8).

- .9 Type I, Horizontal 1-Axis External Seismic Snubber Assembly
 - .1 Equipment shall be restrained against excessive horizontal one-axis movement during a seismic event by the use of single-axis resilient snubbers, designed to withstand the project required seismic forces. A minimum of four (4) snubbers are to be used at each equipment installation, oriented to effectively restrain the isolated equipment in all lateral directions.
 - .2 Snubbers shall be of steel construction and shall be attached to the equipment structure and equipment in a manner consistent with anticipated design loads. Snubbers shall limit lateral equipment movement at each snubber location in the direction of impact to a maximum of ¼" (6 mm).
 - .3 Snubbers shall include resilient neoprene pads with a minimum thickness of ¼" (6 mm) to cushion any impact and to avoid any potential for metal-to-metal contact. Snubber shall be installed only after the isolated equipment is mounted, piped, and operating so as to eliminate any contact during normal equipment operation.
 - .4 Single-axis seismic snubbers shall be Model HS-1 as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (9).
- .10 Type J, Cable Restraints for Suspended Piping and Ductwork
 - .1 Seismic wire rope cable restraints shall consist of steel wire strand cables, sized to resist project seismic loads, arranged to offer seismic restraint capabilities for piping, ductwork, and suspended equipment in all lateral directions.
 - .2 Building and equipment attachment brackets at each end of the cable shall be designed to permit free cable movement in all directions up to a 45-degree misalignment. Protective thimbles shall be used at sharp connection points as required to eliminate potential for dynamic cable wear and strand breakage.
 - .3 Restraints shall be sized to the capacity of the cable or to the capacity of the anchorage, whichever is lesser.
 - .4 Seismic wire rope connections shall be made using overlap wire rope "U" clips or seismically rated tool-less wedge insert lock connectors.
 - .5 Vertical suspension rods shall be braced as required to avoid potential for buckling due to vertical "up" forces. Braces shall be structural steel angle uniquely selected to be of sufficient strength to prevent support rod bending. Brace shall be attached to the vertical suspension rod by a series of adjustable straps. Clips shall be capable of securely locking brace to suspension rod without the need for hand tools.
 - .6 Where clevis hanger brackets are used for seismic restraint attachment, they will be fitted with clevis internal braces to prevent buckling of the hanger brackets.

- .7 Seismic cable shall be as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.03 through 1.07 inclusive, and sections 2.01, 2.02, and 2.03 (10).
- .8 Seismic cable building and equipment attachment brackets shall be Model KSCA, KSCU, or KSCC as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (10).
- .9 Seismic cable concrete anchor bolts shall be Model KCAB Wedge, Model KCCAB Cracked Concrete, or Model KUAB Undercut, as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (10).
- .10 Seismic wire rope connectors shall be (Model KWRC - 'U' clamp) / (Model KWGC - Tool-less wedge lock) as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (10).
- .11 Seismic vertical suspension stiffener rod clips shall be Model KHRC as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (10).
- .12 Clevis Internal Braces shall be Model KCHB as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed in sections 1.04 through 1.09 inclusive, and sections 2.01, 2.02, and 2.03 (10).

2.4 SEISMIC BRACING COMPONENTS

- .1 Steel strut shall be 1-5/8 wide in varying heights and mig-welded combinations as required to meet load capacities and designs. A material heat code, part number, and manufacturer's name shall be stamped on all strut and fittings to maintain traceability to material test reports.
- .2 Material for epoxy painted strut: ASTM A1011, SS, Grade 33.
- .3 Material for pre-galvanized strut: ASTM A653, SS, Grade 33.
- .4 Material for hot-dip galvanized strut: ASTM A1011, SS, Grade 33 and hot-dip galvanized after fabrication in accordance with ASTM A123.
- .5 Material for fittings and accessories: ASTM A907, Grade 33, Structural Quality or ASTM A1011, SS, Grade 33.
- .6 Fittings and accessories: Products shall be of the same manufacturer as strut and designed for use with that product.

2.5 UNIFORM BUILDING CODE REQUIREMENTS

- .1 Seismic Zone Factor to Table 16-I for area of jurisdiction.
- .2 Soil Profile Type to Table 16-J for area of jurisdiction.
- .3 Seismic Importance Factor to Table 16-K for area of jurisdiction.
- .4 Component Amplification Factor to Table 16-O for area of jurisdiction.
- .5 Component Response Mod. Factor to Table 16-O for area of jurisdiction.
- .6 Seismic Coefficient to Table 16-Q for area of jurisdiction.
- .7 The total height of the structure (h_r) and the height of the system to be restrained within the structure (h_x) shall be determined in co-ordination with architectural plans and the General Contractor.
- .8 Forces shall be calculated for individual supports using the above information. Exceptions to Table 16-O may be utilized. However, all use of exceptions shall be noted on submitted seismic bracing plan documents.

Part 3 Execution

3.1 GENERAL INSTALLATION

- .1 Installation of all seismic restraint materials specified in this section shall be accomplished as per the manufacturer's written instructions.
- .2 Refer to FEMA Manuals 412, 413, and 414 for typical industry standard installation guidelines.
- .3 Upon completion of installation of all seismic restraint materials and before start-up of restrained equipment, all debris shall be cleaned from beneath all protected equipment, leaving equipment free to contact snubbers/restraints.
- .4 Torque anchor bolts according to anchor manufacturer's written instructions to resist seismic forces.
- .5 All seismic restraint systems shall be installed in strict accordance with the manufacturer's seismic restraint guidelines manual and all certified submittal data.
- .6 Prior to installation, bring to the architect's/engineer's attention any discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection.
- .7 Brace support rods when necessary to accept compressive loads. Welding of compressive braces to the vertical support rods is not acceptable.
- .8 Seismic restraints shall be attached to the structural system. Looping restraints around the system is not acceptable.
- .9 Do not brace a system to two independent structures such as ceiling and wall.
- .10 Provide appropriately sized openings in walls, floors, and ceilings for anticipated seismic movement. Provide fire seal systems in fire-rated walls.

- .11 Seismic restraint cables shall be adjusted such that they are not visibly slack, or the flexibility is approximately 25mm under thumb pressure for a 1500mm cable length (equivalent ratio for other cable lengths).
- .12 All seismic restraint cables shall be at least 25mm clear of all other equipment and services.

3.2 EQUIPMENT INSTALLATION

- .1 All external utility connections to restrained equipment shall be designed to allow differential seismic motion without damage to the equipment or utility connections.
- .2 Adjust isolators and restraints after piping systems have been filled and equipment is at its operating weight, following the manufacturer's written instructions.
- .3 After equipment installation is completed, adjust limit stops following manufacturer's written instructions so that they are out of contact during normal operation.
- .4 Adjust snubbers according to manufacturer's written instructions.
- .5 Installation of seismic restraints shall not cause any change in position of equipment, resulting in stresses or misalignment.
- .6 No rigid connections between equipment and the building structure shall be made that degrade the noise and vibration isolation system specified.
- .7 Do not install any seismic restraint for equipment, cable trays or conduit that compromises isolation specified.

3.3 PIPING INSTALLATION

- .1 Hold down clamps must be used to attach pipe to all trapeze members before applying restraints.
- .2 Branch lines may not be used to restrain main lines.
- .3 Piping crossing building seismic or expansion joints, passing from building to building, or supported from different portions of the building shall be installed to allow differential support displacements without damaging the pipe, equipment connections, or support connections. Pipe offsets, loops, anchors, and guides shall be installed as required to provide specified motion capability and limit motion of adjacent piping.
- .4 Attach piping to the trapeze per seismic restraint manufacturer's design. Install cables so they do not bend across sharp edges of adjacent equipment or building structures.

3.4 FASTENING TO STRUCTURE

- .1 Bracing may occur from flanges of structural beams, upper truss cords of bar joists, cast in place inserts, or wedge-type concrete anchors. Consult structural engineer of record.
- .2 Overstressing of the building structure shall not occur from overhead support of equipment. Bracing attached to structural members may present additional stresses. The contractor shall submit loads to the structural engineer of record for approval in this event.

- .3 Coring is not permitted for the installation of concrete anchors. Use ground penetrating radar or equivalent method of embedment item detection to locate all embed items including reinforcing steel and electrical conduits. Concrete reinforcing steel and electrical conduits shall not be cut or damaged under any circumstances.
- .4 Install vertical braces to stiffen hanger rods and prevent buckling per seismic restraint manufacturer's design. Clamp vertical brace to hanger rods. Requirements apply equally to hanging equipment. Do not weld vertical braces to hanger rods.
- .5 If mounting hole diameter exceeds bolt diameter by more than 0.125" (3 mm), reduce clearance in hole with epoxy grout, flanged elastomeric bushings or welded washer.
- .6 Housekeeping Pads must be adequately reinforced and adequately sized for proper installation of equipment anchors. Refer to seismic restraint manufacturer's written instructions.

3.5 INSPECTION

- .1 The contractor shall notify the local representative of the seismic restraint materials manufacturer prior to installing any seismic restraint devices. The contractor shall seek the representative's guidance in any installation procedures with which he/she is unfamiliar.
- .2 Upon completion of the installation of all seismic restraint devices herein specified, the local representative of the seismic restraint manufacturer shall, at the contractor's request, inspect the completed system and report in writing any installation errors, improperly selected snubber devices, or other fault in the system which could affect the performance of the system.
- .3 The installing contractor shall submit a report upon request to the building architect and/or engineer, including the manufacturer's representative's final report, indicating that all seismic restraint material has been properly installed, or steps that are to be taken by the contractor to properly complete the seismic restraint work as per the specifications.

3.6 PIPING

- .1 Seismically restrain all piping listed below. Use Type J Cable Restraints for all piping supported by vibration isolation hanger assemblies, including:
 - .1 Natural gas piping equal to or greater than 1" (25 mm) in inside diameter.
 - .2 Brace remainder of piping to code requirements (IBC or TI-809-04) on in conformance with SMACNA (Sheet Metal and Air Conditioning Contractors National Association, Inc.) "Seismic Restraint Manual Guidelines for Mechanical Systems", Second Edition (Remaining Codes).

3.7 DUCTWORK

- .1 Seismically restrain all ductwork listed below. Use Type J Cable Restraints for all ductwork supported by vibration isolation hanger assemblies, including:
 - .1 All rectangular and oval ducts with cross sectional area equal to or greater than 6 sq. ft. (0.55 sq. meters).
 - .2 All round ducts with diameters equal to or greater than 32" (812 mm).
 - .3 Brace remaining ductwork to code requirements (IBC or TI-809-04) or in conformance with SMACNA (Sheet Metal and Air Conditioning Contractors National Association, Inc.) "Seismic Restraint Manual Guidelines for Mechanical Systems", Second Edition (Remaining Codes).

3.8 ROOF MOUNTED EQUIPMENT

- .1 Provide seismic restraint for all isolated and non-isolated roof curbs and associated equipment.
- .2 Provide seismically restrained steel coil spring isolation systems where isolation curbs are indicated and non-isolated seismic restraints for all other roof curb systems."

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ASHRAE Handbook (2013) – Noise and Vibration Control chapter.

1.2 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with general requirements.
- .2 Provide separate shop drawings for each isolated system complete with performance and product data.
- .3 Provide detailed engineered shop drawings, outlining the manufacturer's recommended product for each piece of mechanical equipment. Submission shall be specific to the reviewed and returned shop drawings for equipment on the project.

1.3 OPERATION AND MAINTENANCE DATA

- .1 Provide operation and maintenance data for incorporation into manual specified in general requirements.

Part 2 Products

2.1 GENERAL

- .1 Size and shape of bases type and performance of vibration isolation to be as indicated.
- .2 To be of the same manufacturer for all isolation.
- .3 Acceptable materials:
 - .1 Kinetics Noise Control
 - .2 Korfund
 - .3 Mason Industries

2.2 BASE TYPES

- .1 Provide Base Type as indicated in Table under section 2.4 of this specification.
- .2 Type A: No base, isolators attached directly to equipment. Refer to section 2.3 of this specification for isolator details.
- .3 Type B: Steel Equipment Base. Bases shall be of welded construction with cross members to form an integral support platform. Structural steel members shall be designed to match supported equipment.
 - .1 Vibration bases for fans shall have adjustable motor slide rails and shall accommodate motor overhang.
 - .2 Bases for exterior use shall be painted or hot-dipped galvanized for complete corrosion resistance.

- .3 Minimum clearance under steel equipment bases shall be 25 mm (1").
- .4 Used with spring or rubber isolators. Refer to section 2.3 of this specification for isolator details.
- .4 Type C: Concrete Inertia Base. Inertia bases shall be of welded steel construction with concrete in-fill supplied by the installing contractor on site and shall incorporate reinforcing bars, spaced 300 mm (12") maximum on centers each way.
 - .1 Inertia bases for pumps shall be of sufficient size to accommodate supports for pipe elbows at pump suction and discharge connections.
 - .2 Inertia bases for fans shall include motor slide rails.
 - .3 The weight of each inertia base shall be sufficient to lower the center of gravity to or below the isolator support plane.
 - .4 Inertia bases shall be a minimum of 150 mm (6") thick.
 - .5 Used with spring isolators. Refer to section 2.3 of this specification.
- .5 Type D: Roof Curbs
 - .1 Spring Isolation Roof Curb:
 - .1 Curb type isolator with integral spring isolators, designed to provide a complete roof curb installation. All rooftop air handling units shall be supported by vibration isolation curbs. The vibration isolation curbs shall be complete assemblies designed to resiliently support equipment at the specified elevation and shall constitute a fully enclosed air- and weather-tight system. The isolation curb shall consist of an upper support rail with supply and return duct supports on which the equipment and duct openings rest and a lower support curb which is attached to the roof structure, separated by free-standing, un-housed, laterally stable steel springs.
 - .2 Minimum 3" static deflection from spring isolators.

2.3 ISOLATOR TYPES

- .1 Provide Isolator Type as indicated in Table under section 2.4 of this specification.
- .2 Type 1 (Neoprene and Fiberglass Isolation Pads)
 - .1 Type A:
 - .1 Isolation pads shall be single ribbed or crossed, double ribbed elastomer-in-shear pads, in combination with steel shims when required, having minimum static deflections as tabulated. All pads shall be true elastomer-in-shear using alternately higher and lower ribs to provide effective vibration isolation, and shall be molded using 2500 PSI (176 kg/cm²) tensile strength, oil resistant compounds with no color additives. Pads shall be 45 to 65 durometer and designed to permit 60 or 120 PSI (4.2 or 8.4 kg/cm²) loading at maximum rated deflections. When two isolation pads are laminated, they shall be separated by, and bonded to, a galvanized steel shim plate.

- .3 Type 2 (Fiberglass & Neoprene Isolation Mount & Hangers)
 - .1 Type A:
 - .1 Neoprene Hangers:

Vibration isolators with maximum static deflection requirements under the operating load conditions not exceeding 0.40" shall be hangers consisting of an elastomer-in-shear insert encased in a welded steel bracket and provided with a stamped load transfer cap. The elastomer insert shall be neoprene, molded from oil resistant compounds and shall be color coded to indicate load capacity and selected to operate within its published load range.
- .4 Type 3 (Free Standing Steel Springs)
 - .1 Type C:
 - .1 Free Spring Floor Mounted Isolators:

Vibration isolators shall be free standing, un-housed, laterally stable springs wound from high strength spring steel. Springs shall have a lateral stiffness greater than 0.8 times the rated vertical stiffness and shall be designed to provide up to 50% overload capacity. Springs shall be supported either with a neoprene cup or a metal base plate complete with a ribbed neoprene pad, minimum 6 mm (0.25") thick, bonded to the base plate.

2.4 MINIMUM DEFLECTION REQUIREMENTS BASED ON EQUIPMENT TYPE

- .1 The following table is to be used to reference required base and isolator types, following the tagging convention outlined in Parts 2.2 and 2.3 above. Reference notes are detailed after the table.

				Equipment Location												
				Slab on Grade			Up to 20 ft (6 m) Floor Span			20 to 30 ft (6-9 m) Floor Span			30 to 40 ft (9-12 m) Floor Span			
Equipment Type	Equipment Category	Horsepower and Other	RPM	Base Type	Isolator Type	Min. Defl., in. (mm)	Base Type	Isolator Type	Min. Defl., in. (mm)	Base Type	Isolator Type	Min. Defl., in. (mm)	Base Type	Isolator Type	Min. Defl., in. (mm)	Reference Notes
Pumps	Inline	≤5 ≥7.5-25	All All	A C	3 3	0.75 1.50	A C	3 3	1.50 1.50	A C	3 3	1.50 1.50	A C	3 3	1.50 2.50	
Boilers	Water-tube, copper fin	All	All	A	1	0.12	A	1	0.12	A	1	0.12	B	4	0.25	
Axial Fans, Plenum Fans, Cabinet Fans, Fan Sections, Centrifugal Inline Fans	Up to 22 in. diameter 24 in. diameter and up	All ≤2 in. SP	All Up to 300 301 to 500 501 and up	A B B B	2 3 3 3	0.25 2.50 0.75 0.75	A C B B	3 3 3 3	0.75 3.50 1.50 1.50	A C C B	3 3 3 3	0.75 3.50 2.50 1.50	C C C B	3 3 3 3	0.75 3.50 2.50 1.50	4,9,8 9,8 9,8 9,8
Heat Pumps,	All	All	All	A	2	0.75	A	2	0.75	A	2	1.50	A/D	2	1.50	
Condensing Units	All	All	All	A	1	0.25	A	4	0.75	A	4	1.50	A/D	4	1.50	
Packaged Rooftop Equipment	All	All	All	A/D	1	0.25	D	3	0.75							5,8
Ducted Rotating Equipment	Small fans, fan-powered boxes	≤600 cfm ≥601 cfm		A A	1 1	0.50 0.75	A A	1 1	0.50 0.75	A A	1 1	0.50 0.75	A A	1 1	0.50 0.75	
Base Types:																
A. No base, isolators attached directly to equipment (Note 28)																
B. Structural steel rails or base (Notes 29 and 30)																
C. Concrete inertia base (Note 31)																
Isolator Type:																
1. Pad, rubber, or glass fiber																
2. Rubber floor isolator or hanger																
3. Spring floor isolator or hanger																
4. Restrained spring isolator																
5. Thrust restraint																
6. Air spring																

.2 Notes accompanying table:

- .1 For large equipment capable of generating substantial vibratory forces and structure borne noise, increase isolator deflection, if necessary, so isolator stiffness is less than one-tenth the stiffness of the supporting structure, as defined by the deflection due to load at the equipment support.
- .2 Pumps: Concrete inertia bases (type C) are preferred for all flexible-coupled pumps and are desirable for most close-coupled pumps, although steel bases (type B) can be used. Close-coupled pumps should not be installed directly on individual isolators (type A) because the impeller usually overhangs the motor support base, causing the rear mounting to be in tension. The primary requirements for type C bases are strength and shape to accommodate base elbow supports. Mass is not usually a factor, except for pumps over 55 kW, where extra mass helps limit excess movement due to starting torque and forces. Concrete bases (type C) should be designed for a thickness of one-tenth the longest dimension with minimum thickness as follows: (1) for up to 20 kW, 150 mm; (2) for 30 to 55 kW, 200 mm; and (3) for 75 kW and up, 300 mm. Pumps over 55 kW and multistage pumps may exhibit excessive motion at start-up ("heaving"); supplemental re-straining devices can be installed if necessary. Pumps over 90 kW may generate high starting forces; a vibration specialist should be consulted.
- .3 Certain designs cannot be installed directly on individual isolators (type A), and the equipment manufacturer should be consulted on the need for supplemental support (base type).
- .4 Compressors: Base-mounted compressors through 5 HP and horizontal tank-type air compressors through 10 HP can be installed directly on spring isolators (type 3) with structural bases (type B) if required, and compressors 15 to 100 HP on spring isolators (type 3) with inertia bases (type C) with a mass 1 to 2 times the compressor mass.
- .5 Fans and Air-Handling Equipment:
 - .1 For fans operating under 300 rpm, select isolator deflection so the isolator natural frequency is 40% or less than the fan speed.
 - .2 Flexible duct connectors must be installed at the intake and discharge of all fans and air-handling equipment to reduce vibration transmission
 - .3 Inertia bases (type C) are required for all class 2 and 3 fans and air-handling equipment.
- .6 To avoid isolator resonance problems, select isolator deflection so that resonance frequency is 40% or less of the lowest normal operating speed of equipment. Equipment such as variable-frequency drives, and high-speed equipment, such as screw chillers and vane axial fans, contain very-high-frequency vibration. To reduce high-frequency vibration transmission, add a 25 mm thick pad (type 1) to the base plate of spring isolators (type 3).
- .7 To limit undesirable movement, thrust restraints (type 5) are required for all ceiling-suspended and floor-mounted units operating at 1500 Pa or more total static pressure.

Part 3 Execution

3.1 INSTALLATION

- .1 Install vibration isolation equipment in accordance with manufacturers instructions and adjust mountings to level equipment.
- .2 Provide Roof Curb acoustic lining on all HVAC equipment above 4,000 cfm / 10 tonnes capacity.
- .3 Ensure piping, ducting and electrical connections to isolated equipment do not reduce system flexibility and that piping, conduit and ducting passage through walls and floors do not transmit vibrations.
- .4 Unless indicated otherwise, support piping connected to isolated equipment with spring mounts or spring hangers with 25 mm (1") minimum static deflection as follows:
 - .1 Up to NPS 100 mm (4"): first 3 points of support. NPS 125 mm (5") to NPS 200 mm (8"): first 4 points of support. NPS 250 mm (10") and Over: first 6 points of support.
 - .2 First point of support shall have a static deflection of twice deflection of isolated equipment, but not more than 50 mm (2").
- .5 Where isolation is bolted to floor use vibration isolation rubber washers.
- .6 Block and shim level bases so that ductwork and piping connections can be made to a rigid system at the operating level, before isolator adjustment is made. Ensure that there is no physical contact between isolated equipment and building structure.
- .7 Rooftop Units and Central Air Handling Units
 - .1 Packaged rooftop units shall be provided with standard curb mounted spring rails.
 - .2 Central air handling units (10,000 cfm or greater) shall be provided with spring isolation roof curbs.
- .8 Spring isolators shall not be used in series to ensure no harmonics issues. This contractor shall review internally isolated equipment against method of spring isolation and ensure no overlap.

3.2 SITE VISIT

- .1 Manufacturer to visit site and provide written certification that installation is in accordance with manufacturer's instructions and submit report to Consultant.
- .2 Provide Consultant with notice 24 h in advance of visit.
- .3 Make adjustments and corrections in accordance with written report.

3.3 TESTING

- .1 Experienced and competent sound and vibration testing professional engineer to take vibration measurement for HVAC systems after start up and TAB of systems to Testing Adjusting and Balancing Section.
- .2 Vibration measurements shall be taken for equipment-listed below:

- .3 Provide Consultant with notice 48 h in advance of commencement of tests.
- .4 Establish adequacy of equipment isolation and acceptability of noise levels in occupied areas and where appropriate, remedial recommendations including sound curves.
- .5 Submit complete report of test results including sound curves.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 Canadian General Standards Board (CGSB).
 - .1 CAN/CGSB-1.60, Interior Alkyd Gloss Enamel.
 - .2 CAN/CGSB-24.3, Identification of Piping Systems.
- .3 Canadian Standards Association (CSA).
 - .1 Natural Gas and Propane Installation Code CSA B149.1.
- .4 National Fire Protection Association
 - .1 NFPA 13, Installation of Sprinkler Systems.

1.2 PRODUCT DATA

- .1 Submit product data in accordance with General Requirements.
- .2 Product data to include paint colour chips, all other products specified in this section.

1.3 PRODUCT LITERATURE

- .1 Submit product literature in accordance with General Requirements.
- .2 Product literature to include nameplates, labels, tags, lists of proposed legends.

Part 2 Products

2.1 MANUFACTURER'S EQUIPMENT NAMEPLATES

- .1 Metal or plastic lamicoid nameplate mechanically fastened to each piece of equipment by manufacturer.
- .2 Lettering and numbers to be raised or recessed.
- .3 Information to include, as appropriate:
 - .1 Equipment: Manufacturer's name, model, size, serial number, capacity.
 - .2 Motor: voltage, Hz, phase, power factor, duty, frame size.

2.2 SYSTEM NAMEPLATES

- .1 Colours:
 - .1 Hazardous: red letters, white background.
 - .2 Elsewhere: black letters, white background (except where required otherwise by applicable codes).

- .2 Construction:
 - .1 3 mm (1/8") thick laminated plastic, matte finish, with square corners, letters accurately aligned, and machine engraved into core.

.3 Sizes:

- .1 Conform to following table:

Size	No. of Sizes mm (")	Height of Line mm (")	Letters mm (")
1	10 x 50 (3/8" x 2")	1 (3/64")	3 (1/8")
2	15 x 75 (1/2" x 3")	1 (3/64")	6 (1/4")
3	15 x 75 (1/2" x 3")	2 (5/64")	3 (1/8")
4	20 x 100 (3/4" x 4")	1 (3/64")	10 (3/8")
5	20 x 100 (3/4" x 4")	2 (6/64")	6 (1/4")
6	20 x 200 (3/4" x 8")	1 (3/64")	10 (3/8")
7	25 x 125 (1" x 5")	1 (3/64")	15 (1/2")
8	25 x 125 (1" x 5")	2 (5/64")	10 (3/8")
9	32 x 200 (1 1/4" x 8")	1 (3/64")	20 (3/4")

- .2 Use maximum of 25 letters/numbers per line.

.4 Locations:

- .1 Terminal cabinets, control panels: Use size #5.
- .2 Equipment in Mechanical Rooms: Use size #9.
- .3 Roof top equipment: use size #9.
- .4 Equipment above ceiling: use size #1 riveted to ceiling suspension system.

2.3 FIRE DAMPER/FIRE SMOKE DAMPER

.1 Colours:

- .1 Black letters, yellow background.

.2 Construction:

- .1 Self adhesive 50 mm x 25 mm, matte finish, with round corners.

.3 Locations:

- .1 Install on adjacent ceiling grid. Where fire stop flap is installed in gypsum ceiling install on diffuser/grille frame. Where fire damper is installed above gypsum ceiling install on adjacent wall.

2.4 EXISTING IDENTIFICATION SYSTEMS

- .1 Apply existing identification system to new work.
- .2 Where existing identification system does not cover for new work, use identification system specified this section.
- .3 Before starting work, obtain written approval of identification system from Consultant.

- .4 Upon completion of this project all references to room names and numbering shall be to the Owner's requirements which may or may 'NOT' be the numbering system used on the drawings. Each contractor shall verify the proper numbering scheme to be used prior to project completion.
- .5 All equipment shall be identified in sequence from the existing equipment and "NOT" duplicate numbering of equipment.

2.5 PIPING SYSTEMS GOVERNED BY CODE

- .1 Identification:
 - .1 Natural and propane gas: To CSA B149.1-00 and authority having jurisdiction and as indicated elsewhere.

2.6 IDENTIFICATION OF PIPING SYSTEMS

- .1 Identify contents by background colour marking, pictogram (as necessary), legend; direction of flow by arrows. To CAN/CGSB 24.3 except where specified otherwise.
- .2 Legend:
 - .1 Block capitals to sizes and colours listed in CAN/CGSB-24.3.
- .3 Arrows showing direction of flow:
 - .1 Outside diameter of pipe or insulation less than 75 mm (3"): 100 mm (4") long x 50 mm (2") high.
 - .2 Outside diameter of pipe or insulation 75 mm (3") and greater: 150 mm (6") long x 50 mm (2") high.
 - .3 Use double-headed arrows where flow is reversible.
- .4 Extent of background colour marking:
 - .1 To full circumference of pipe or insulation.
 - .2 Length to accommodate pictogram, full length of legend and arrows.
- .5 Materials for background colour marking, legend, arrows:
 - .1 Pipes and tubing 20 mm (3/4") and smaller: Waterproof and heat-resistant pressure sensitive plastic marker tags.
 - .2 All other pipes: Pressure sensitive vinyl with protective overcoating, waterproof contact adhesive undercoating, suitable for ambient of 100% RH and continuous operating temperature of 150°C (300°F) and intermittent temperature of 200°C (395°F).

.6 Colours and Legends:

- .1 Where not listed, obtain direction from Consultant.
- .2 Colours for legends, arrows: To following table:

Background colour:	Legend:	Arrows:
Yellow	White	Black
Green	White	Black
Red	White	Black

.7 Background colour marking and legends for piping systems:

CONTENTS	BACKGROUND COLOUR MARKING	LEGEND
Hot water heating supply	Yellow	HEATING SUPPLY
Hot water heating return	Yellow	HEATING RETURN
Refrigeration suction	Yellow	REF. SUCTION
Refrigeration liquid	Yellow	REF. LIQUID
Natural gas	Yellow	NATURAL GAS
Gas regulator vents		to Codes
Conduit for low voltage		
Control wiring	White	CONTROL WIRING ___ VOLTS
Dual temp. heat pump supply	Green	HP SUPPLY
Dual temp heat pump return	Green	HP RETURN

2.7 IDENTIFICATION DUCTWORK SYSTEMS

- .1 50 mm (2") high stencilled letters and directional arrows 150 mm (6") long x 50 mm (2") high.
- .2 Colours: Black, or co-ordinated with base colour to ensure strong contrast.

2.8 VALVES, CONTROLLERS

- .1 Brass tags with 15 mm (1/2") stamped identification data filled with black paint.
- .2 Include flow diagrams for each system, of approved size, showing charts and schedules with identification of each tagged item, valve type, service, function, normal position, location of tagged item.
- .3 Provide adhesive coloured tab (max. size 15 mm) indication on ceiling to locate valves/equipment above. Same applies to grid. Colour to be approved by consultant.

2.9 CONTROLS COMPONENTS IDENTIFICATION

- .1 Identify all systems, equipment, components, controls, sensors with system nameplates specified in this section.
- .2 Inscriptions to include function and (where appropriate) fail-safe position.
- .3 Provide equipment identification and/or indication on ceiling to locate devices/equipment above ceiling. Install identification on grid. Colours to be approved by consultant.

2.10 LANGUAGE

- .1 Identification to be in English.

Part 3 Execution

3.1 TIMING

- .1 Provide identification only after all painting specified has been completed.

3.2 INSTALLATION

- .1 Perform work in accordance with CAN/CGSB-24.3 except as specified otherwise.
- .2 Provide ULC and/or CSA registration plates as required by respective agency.

3.3 NAMEPLATES

- .1 Locations:
 - .1 In conspicuous location to facilitate easy reading and identification from operating floor.
- .2 Standoffs:
 - .1 Provide for nameplates on hot and/or insulated surfaces.
- .3 Protection
 - .1 Do not paint, insulate or cover in any way.

3.4 LOCATION OF IDENTIFICATION ON PIPING AND DUCTWORK SYSTEMS

- .1 On long straight runs in open areas in boiler rooms, equipment rooms, galleries, tunnels not more than 1.7 m (5'-8") intervals and more frequently if required to ensure that at least one is visible from any one viewpoint in operating areas and walking aisles.
- .2 Adjacent to each change in direction.
- .3 At least once in each small room through which piping or ductwork passes.
- .4 On both sides of visual obstruction or where run is difficult to follow.
- .5 On both sides of separations such as walls, floors, partitions.
- .6 Where system is installed in pipe chases, ceiling spaces, galleries, other confined spaces, at entry and exit points, and at each access opening.

- .7 At beginning and end points of each run and at each piece of equipment in run.
- .8 At point immediately upstream of major manually operated or automatically controlled valves, dampers, etc. Where this is not possible, place identification as close as possible, preferably on upstream side.
- .9 Identification to be easily and accurately readable from usual operating areas and from access points.
 - .1 Position of identification to be approximately at right angles to most convenient line of sight, considering operating positions, lighting conditions, risk of physical damage or injury and reduced visibility over time due to dust and dirt.

3.5 VALVES, CONTROLLERS

- .1 Valves and operating controllers, except at plumbing fixtures, radiation, or where in plain sight of equipment they serve: Secure tags with non-ferrous chains or closed "S" hooks.
- .2 Install one copy of flow diagrams, valve schedules mounted in frame behind non-glare glass where directed by Consultant. Provide one copy (reduced in size if required) in each operating and maintenance manual.
- .3 Number valves in each system consecutively. Where existing numbering system is installed start new numbering system at 100.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ANSI/ASME B31.1, Power Piping.
- .3 ANSI/ASME Boiler and Pressure Vessel Code:
 - .1 Section 1: Power Boilers.
 - .2 Section V: Nondestructive Examination.
 - .3 Section IX: Welding and Brazing Qualifications.
- .4 CSA W47.2, Certification of Companies for Fusion Welding of Aluminum.
- .5 CSA W48, Filler Metals and Allied Metals for Arc Welding.
- .6 CSA B51, Boiler, Pressure Vessel and Pressure Piping Code.
- .7 CAN/CSA-W117.2, Safety in Welding, Cutting and Allied Processes.
- .8 CSA W178.1, Certification of Welding Inspection Organizations.
- .9 CSA W178.2, Certification of Welding Inspectors.
- .10 AWS B2.1, Specification for Welding Procedure and Performance Qualification.
- .11 AWS C1.1, Recommended Practices for Resistance Welding.
- .12 AWS W1, Welding Inspection.
- .13 ANSI/AWWA C206, Field Welding of Steel Water Pipe.

1.2 WELDERS QUALIFICATIONS

- .1 Welding qualifications to be in accordance with CSA B51.
- .2 Use qualified and licensed welders possessing certificate for each procedure to be performed from authority having jurisdiction.
- .3 Furnish welder's qualifications to Consultant.
- .4 Each welder to possess identification stamp issued by authority having jurisdiction.
- .5 Certification of companies for fusion welding of aluminum to be in accordance with CSA W47.2.

1.3 INSPECTORS QUALIFICATIONS

- .1 Inspectors to be qualified to CSA W178.2.

1.4 WELDING PROCEDURES

- .1 Registration of welding procedures in accordance with CSA B51.
- .2 Copy of welding procedures to be available for inspection at all times.

- .3 Safety in welding, cutting and allied processes to be in accordance with CAN/CSA-W117.2.

Part 2 Products

2.1 ELECTRODES

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

Part 3 Execution

3.1 WORKMANSHIP

- .1 Welding to be in accordance with ANSI/ASME B31.1, ANSI/ASME Boiler and Pressure Vessel Code, Sections I and IX and ANSI/AWWA C206, using procedures conforming to AWS B3.0, AWS C1.1, and applicable requirements of provincial authority having jurisdiction.
- .2 Protect all adjacent areas.

3.2 INSTALLATION REQUIREMENTS

- .1 Identify each weld with welder's identification stamp.
- .2 Backing rings:
 - .1 Where used, fit to minimize gaps between ring and pipe bore.
 - .2 Do not install at orifice flanges.
- .3 Fittings:
 - .1 NPS 50 mm (2") and smaller: install welding type sockets.
 - .2 Branch connections: install welding tees or forged branch outlet fittings.

3.3 INSPECTION AND TESTS - GENERAL REQUIREMENTS

- .1 Review all weld quality requirements and defect limits of applicable codes and standards with Consultant before any work is started.
- .2 Formulate "Inspection and Test Plan" in co-operation with Consultant.
- .3 Do not conceal welds until they have been inspected, tested and approved by inspector.
- .4 Provide for inspector to visually inspect all welds during early stages of welding procedures in accordance with AWS W1. Repair or replace all defects as required by codes and as specified herein.

3.4 SPECIALIST EXAMINATIONS AND TESTS

- .1 General.
 - .1 Perform examinations and tests by specialist qualified in accordance with CSA W178.1 and CSA W178.2 and approved by Consultant.

- .2 To ANSI/ASME Boiler and Pressure Vessels Code, Section V, CSA B51 and requirements of authority having jurisdiction.
- .3 Inspect and test 25% of welds in accordance with "Inspection and Test Plan" by non-destructive visual examination and magnetic particle (hereinafter referred to as "particle") tests and/or full gamma ray radiographic (hereinafter referred to as "radiography") tests as specified.
- .2 Hydrostatically test all welds to requirements of ANSI/ASME B31.1.
- .3 Visual examinations: include entire circumference of weld externally and (wherever possible) internally.
- .4 Failure of visual examinations:
 - .1 Upon failure of any weld by visual examination, perform additional testing as directed by Consultant of a total of up to 10% of all welds, selected at random by Consultant by radiographic tests.

3.5 DEFECTS CAUSING REJECTION

- .1 As described in ANSI/ASME B31.1 and ANSI/ASME Boiler and Pressure Vessels Code.
- .2 In addition, hydronic water systems:
 - .1 Undercutting greater than 0.8 mm (1/32") adjacent to cover bead on outside of pipe.
 - .2 Undercutting greater than 0.8 mm (1/32") adjacent to root bead on inside of pipe.
 - .3 Undercutting greater than 0.8 mm (1/32") at combination of internal surface and external surface.
 - .4 Incomplete penetration and incomplete fusion greater than total length of 40 mm (1 1/2") in any 1500 mm (60") length of weld depth of such defects being greater than 0.8 mm (1/32").
 - .5 Repair all cracks and defects in excess of 0.8 mm (1/32") in depth.
 - .6 Repair defects whose depth cannot be determined accurately on the basis of visual examination or particle tests.

3.6 REPAIR OF WELDS WHICH FAILED TESTS

- .1 Re-inspect and re-test repaired or re-worked welds at Contractor's expense.

3.7 CLAIMS AGAINST OWNER FOR DELAYS

- .1 Claims against Owner for delays in completion of project will not be entertained for reasons of failures of welds to pass examinations.

3.8 OCCUPIED AREAS

- .1 Do not do any "Hot Work" in occupied areas.
- .2 Obtain "Hot Work" permits for working in existing building.

END OF SECTION

Part 1 General

1.1 GENERAL

- .1 This Section is to be read in conjunction with Division 1, the General Conditions and Section 20 02 51, the General Requirements of the Mechanical Trades, and the documents required by the BIDDING REQUIREMENTS and CONDITIONS OF THE CONTRACT sections.
- .2 All pricing shall be in accordance with Catholic School Board Services Association (CSBSA) Agreement.
- .3 All pricing submissions shall include the following supporting documents; Detailed List Summary, Poteau Analysis, Project schedule and summary letter.
- .4 The balancing contractor will work for the Owner.
- .5 TAB means to test, adjust and balance to perform in accordance with requirements of Contract Documents and to do all other work as specified in this section including all air handling systems and equipment, all plumbing systems and equipment and all temperature controls system, building automation systems and equipment.
- .6 This contractor must co-ordinate their work with that of the TAB contractor.

1.2 QUALIFICATIONS OF TAB AGENCIES

- .1 Names of all personnel it is proposed to perform TAB to be submitted to and approved by Consultant within 30 days of start of work.
- .2 Provide documentation confirming qualifications, successful experience.
- .3 Only the following NEBB (National Environmental Balancing Bureau) TAB contractors may quote: (Revised with AD01)
 - .1 Air Audit Inc.
110 Turnbull Court, Unit 11
Cambridge, Ontario
N1T 1K6
(519) 740-0871
 - .2 Designtest & Balance Co. Ltd
70 East Beaver Creed Road, Unit #35
Richmond Hill, ON
L4B 3B2
(905) 886-6513
 - .3 Air Velocities Control Ltd.
100 Premium Way
Mississauga, Ontario
L5B 1A2
(905) 279-4433

.4 Dynamic Flow Balancing Ltd.
 1200 Speers Road, Unit 36
 Oakville, Ontario
 L6L 4V6
 (905) 338-0808

1.3 PURPOSE OF TAB

- .1 Test to verify proper and safe operation, determine actual point of performance, evaluate qualitative and quantitative performance of equipment, systems and controls at design, average (95% design) and low (75% of design) loads using actual or simulated loads. TAB contractor to perform equipment evaluation upon start up and once during each season in the first year of operation.
- .2 Adjust and regulate equipment and systems so as to meet specified performance requirements and to achieve specified interaction with all other related systems under all normal and emergency loads and operating conditions. Confirm all equipment interlocks and functions of associated systems.
- .3 Balance systems and equipment to regulate flow rates to match load requirements over full operating ranges and temperatures. Refer to BAS for system operating functions.

1.4 EXCEPTIONS

- .1 TAB of systems and equipment regulated by codes, standards to be to satisfaction of authority having jurisdiction.

1.5 CO-ORDINATION

- .1 Schedule time required for TAB (including repairs, re-testing) into project construction and completion schedule so as to ensure completion before acceptance of project.
- .2 Do TAB of each system independently and subsequently, where interlocked with other systems, in unison with those systems. Co-ordinate with other trades to ensure all systems are interlocked as indicated elsewhere prior to TAB.

1.6 PRE-TAB REVIEW

- .1 Review contract documents before project construction is started and confirm in writing to Consultant adequacy of provisions for TAB and all other aspects of design and installation pertinent to success of TAB.
- .2 Review specified standards and report to Consultant in writing all proposed procedures which vary from standard.
- .3 During construction, co-ordinate location and installation of all TAB devices, equipment, accessories, measurement ports and fittings.
- .4 During construction indicate all tolerances of piping, ductwork etc conforms to specifications.

1.7 START-UP

- .1 Follow start-up procedures as recommended by equipment manufacturer unless specified otherwise.
- .2 Follow special start-up procedures specified elsewhere in the Mechanical Division.

1.8 OPERATION OF SYSTEMS DURING TAB

- .1 Operate systems for length of time required for TAB and as required by Consultant for verification of TAB reports.

1.9 START OF TAB

- .1 Notify Consultant in writing 3 days prior to start of TAB.
- .2 Start TAB only when building is essentially completed, including:
 - .1 Installation of ceilings, doors, windows, other construction affecting TAB.
 - .2 Application of weather-stripping, sealing, caulking.
 - .3 All pressure, leakage, other tests specified elsewhere in the Mechanical Division.
 - .4 All provisions for TAB installed and operational.
 - .5 Start-up, verification for proper, normal and safe operation of all mechanical and associated electrical and control systems affecting TAB including but not limited to:
 - .1 Proper thermal overload protection in place for electrical equipment.
 - .2 Air systems:
 - .1 Filters in place, clean.
 - .2 Duct systems clean.
 - .3 Ducts, air shafts, ceiling plenums are airtight to within specified tolerances.
 - .4 Correct fan rotation.
 - .5 Fire, smoke, volume control dampers installed and open.
 - .6 Coil fins combed, clean.
 - .7 Access doors, installed, closed.
 - .8 All outlets installed, volume control dampers open.
 - .3 Liquid systems:
 - .1 Flushed, filled, vented.
 - .2 Correct pump rotation.
 - .3 Strainers in place, baskets clean.
 - .4 Isolating and balancing valves installed, open.
 - .5 Calibrated balancing valves installed, at factory settings.
 - .6 Chemical treatment systems complete, operational.
 - .7 Control valves are properly piped.
 - .8 Coils and radiation are properly piped.
 - .9 BAS in operation.

1.10 APPLICATION TOLERANCES

- .1 Do TAB to following tolerances of design values:
 - .1 HVAC systems: plus 10%, minus 5%.
 - .2 Hydronic systems: plus or minus 10%.

1.11 ACCURACY TOLERANCES

- .1 Measured values to be accurate to within plus or minus 2% of actual values.

1.12 INSTRUMENTS

- .1 Prior to TAB, submit to Consultant list of instruments to be used together with serial numbers.
- .2 Calibrate in accordance with requirements of most stringent of referenced standard for either applicable system or HVAC system.
- .3 Calibrate within 3 months of TAB. Provide certificate of calibration to Consultant.

1.13 SUBMITTALS

- .1 Submit, prior to commencement of TAB:
 - .1 Proposed methodology and procedures for performing TAB if different from referenced standard.

1.14 PRELIMINARY TAB REPORT

- .1 Submit for checking and approval of Consultant, prior to submission of formal TAB report, sample of rough TAB sheets. Include:
 - .1 Details of instruments used.
 - .2 Details of TAB procedures employed.
 - .3 Calculations procedures.
 - .4 Summaries.

1.15 TAB REPORT

- .1 Format to be in accordance with NEBB, AABC, or SMACNA.
- .2 The following additional information shall be provided for all air systems:
 - .1 Minimum damper position (MAD/Economizer) and the corresponding BAS signal and the voltage to the actuator to meet the full ASHRAE occupied ventilation requirements.
 - .2 Minimum damper position (MAD/Economizer) and the corresponding BAS signal and the voltage to the actuator to meet the full ASHRAE unoccupied ventilation requirements.
 - .3 Static pressure reading for each HVAC/AHU unit with VAV/VVT boxes open to 80% of design airflow and bypass damper closed to 0%. Provide reading at normal MAD/economizer damper position, dampers fully closed and dampers fully open.

- .3 TAB report to show all results in SI or imperial units as indicated on plans and to include:
 - .1 Project as-built drawings.
 - .2 System schematics.

1.16 VERIFICATION

- .1 All reported results subject to verification by Consultant.
- .2 Provide manpower and instrumentation to verify up to 30% of all reported results.
- .3 Number and location of verified results to be at discretion of Consultant.
- .4 Bear costs to repeat TAB as required to satisfaction of Consultant.

1.17 SETTINGS

- .1 After TAB is completed to satisfaction of Consultant, replace drive guards, close all access doors, lock all devices in set positions, ensure sensors are at required settings. Replace all ceiling tile etc.
- .2 Permanently mark all settings to allow restoration at any time during life of facility. Markings not to be eradicated or covered in any way.

1.18 COMPLETION OF TAB

- .1 TAB to be considered complete only when final TAB Report received and approved by Consultant.

1.19 AIR SYSTEMS

- .1 Standard: TAB to be to most stringent of TAB standards of NEBB, AABC, SMACNA, ASHRAE.
- .2 Do TAB of all systems, equipment, components, controls specified in the Mechanical Division including but not limited to following:
 - .1 Air handling systems and equipment
 - .2 Duct testing to SMACNA standards.
- .3 Qualifications: personnel performing TAB to be current member in good standing of NEBB.
- .4 Quality assurance: Perform TAB under direction of qualified supervisor.
- .5 Measurements: to include, but not limited to, following as appropriate for systems, equipment, components, controls: air velocity, static pressure, flow rate, pressure drop (or loss), temperatures (dry bulb, wet bulb, dewpoint), duct cross-sectional area, RPM, electrical power, voltage, noise, vibration.
- .6 Locations of equipment measurements: To include, but not be limited to, following as appropriate:
 - .1 Inlet and outlet of each damper, filter, coil, humidifier, fan, and other equipment causing changes in conditions.
 - .2 At each controller, controlled device.

- .7 Locations of systems measurements to include, but not be limited to, following as appropriate: Each main duct, main branch, sub-branch, grille, register or diffuser.

1.20 HYDRONIC SYSTEMS

- .1 Definitions: for purposes of this section, to include low pressure hot water heating and dual temperature heat dump systems.
- .2 Standard: TAB to be the most stringent of TAB standards of NEBB, AABC, SMACNA, ASHRAE.
- .3 Do TAB of all systems, equipment, components, controls specified in Mechanical Division including but not limited to hydronic equipment testing.
- .4 Qualifications: personnel performing TAB to be current member in good standing of NEBB.
- .5 Quality assurance: perform TAB under direction of qualified supervisor.
- .6 Measurements: to include, but not limited to, following as appropriate for systems, equipment, components, controls: Flow rate, static pressure, pressure drop (or loss), temperature, specific gravity, density, RPM, electrical power voltage, noise, vibration.
- .7 Locations of equipment measurement: To include, but not be limited to, following as appropriate:
 - .1 Inlet and outlet of each boiler, coil, pump, PRV, control valve, other equipment causing changes in conditions.
 - .2 At each controller, controlled device.
- .8 Locations of systems measurements to include, but not be limited to, following as appropriate: Supply and return of each primary and secondary loop (main, main branch, branch, sub-branch of all hydronic systems, inlet connection of make-up water.

1.21 DUCT LEAKAGE TESTING

- .1 Co-ordinate leakage testing with the sheet metal contractor. TAB contractor will be responsible for all duct testing.
- .2 Duct to be tested in accordance with SMACNA HVAC Duct Leakage Test Manual and as indicated.

1.22 DOMESTIC HWC SYSTEMS

- .1 Meet all requirements as specified for hydronic systems.
- .2 Locations of equipment measurements: To include, but not be limited to, following as appropriate: Inlet and outlet of each heater, tank, pump, circulator, at each controller, controlled device.
- .3 Locations of systems measurements to include, but not be limited to, following as appropriate: main, main branch, branch, sub-branch.

1.23 OTHER PLUMBING SYSTEMS

- .1 This contractor shall test, adjust, and record the domestic water (in 1.24 change read "plumbing") system after the plumbing contractor has completed their work.
 - .1 Recirculating Systems: pump flows and pressures

1.24 OTHER TAB REQUIREMENTS

- .1 General requirements applicable to all work specified this paragraph:
 - .1 Qualifications of TAB personnel: as for air systems specified this section.
- .2 Quality assurance: as for air systems specified this section.
- .3 Building pressure conditions:
 - .1 Adjust HVAC systems, equipment, controls to ensure specified pressure conditions at all times.
 - .2 TAB procedures:

<u>Positive</u>	<u>Negative</u>
Corridors	Washrooms
- .4 Zone pressure differences:
 - .1 Adjust HVAC systems, equipment, controls to establish air pressure differentials, with all systems in all possible combinations of normal operating modes.
- .5 Smoke management systems:
 - .1 Test for proper operation of all smoke and fire dampers installed as component parts of air systems specified.
- .6 Provide duct testing as specified.
- .7 Provide AHU testing as specified.
- .8 Provide plenum testing as specified.
- .9 Changing of air handling equipment sheave and belts as required for specified air flow sheaves and belts supplied by unit manufacturer. Retest equipment after sheave change.

END OF SECTION

Part 1 General

1.1 GENERAL

- .1 The Mechanical Contractor shall provide the labour and material to conduct the closeout process as outlined in this specification section.
- .2 The mechanical contractor shall perform the closeout requirements specified in conjunction with the independent commissioning consultant (CC) retained by the owner.

Part 2 Products

2.1 GENERAL

- .1 The mechanical contractor and manufacturers shall provide all instrumentation and equipment necessary to conduct the tests specified. The Mechanical Contractor shall advise the Mechanical Consultant of instrumentation to be used and the dates the instruments were calibrated.

Part 3 Execution

3.1 THE CONTRACT CLOSE OUT PROCESS

- .1 The mechanical contractor close out process shall consist of:
 - Shop Drawings and As-built Drawings
 - Installation inspection and equipment verification
 - Plumbing and drainage system testing
 - Testing of piping systems
 - Independent contractor balancing of water systems
 - Testing of air systems
 - Independent contractor balancing of air systems
 - Testing of equipment and systems
 - BAS Commissioning
 - Verification of refrigeration leak detection systems
 - Commissioning Consultant performance testing
 - Commissioning meetings
 - Operating and maintenance manuals
 - Training
 - Systems Demonstration and turnover
 - Testing forms
 - Warranties
 - Contractor to provide list of equipment maintenance including schedule of maintenance parts, quantities, and model fixtures, etc.

3.2 SHOP DRAWINGS AND AS-BUILT DRAWINGS

- .1 Conform to General Requirements Section for shop drawings and as-built drawings requirements.

3.3 INSTALLATION INSPECTION AND EQUIPMENT VERIFICATION

- .1 The Mechanical Contractor shall co-ordinate with the Consultant who will inspect the mechanical installation.
- .2 The Mechanical Contractor shall complete the equipment verification forms for each piece of equipment. The forms shall be included in the operating and maintenance manual. The equipment data shall include:
 - Manufacturers name, address and telephone number
 - Distributors name, address and telephone number
 - Make, model number and serial number
 - Pumps - RPM, impeller sizes, rated flow
 - Fans - belt type and size, shive type and size
 - Electrical - volts, amps, fuse size, overload size
 - Any other special characteristics.

3.4 THE CONTRACTOR'S TESTING OF PIPING SYSTEMS

- .1 Test all piping systems in accordance with all applicable plumbing codes and General Requirements section.
- .2 All tests for the systems shall be performed in the presence of the Consultant or Commissioning Consultant. Complete the testing forms and forward to the Consultant.

3.5 THE INDEPENDENT CONTRACTORS TESTING AND BALANCING OF WATER SYSTEMS

- .1 Conform with the specification section, Testing, Adjusting and Balancing.
- .2 The Independent Contractor shall be hired by The Mechanical Contractor and shall report to the Commissioning Consultant.

3.6 THE CONTRACTORS TESTING OF AIR SYSTEMS

- .1 Conform with the specification section, Testing, Adjusting and Balancing.
- .2 All tests shall be performed in the presence of the Mechanical Consultant or the Commissioning Consultant. Complete the testing forms and forward to the Consultant.

3.7 THE INDEPENDENT CONTRACTORS TESTING AND BALANCING OF AIR SYSTEMS

- .1 Conform with specification section, Testing, Adjusting and Balancing.
- .2 The Independent Contractor shall be hired by The Mechanical Contractor and shall report to the Commissioning Consultant.

3.8 TESTING OF EQUIPMENT AND SYSTEMS

- .1 General:
 - .1 The Mechanical Contractor shall hire the services of the manufacturers technicians to test the equipment and associated systems. The technician shall record the results of the tests on the testing forms. The tests shall be witnessed by the Consultant or Owners representative. When the tests have been completed satisfactorily the technician and witnessing authority shall sign the forms. A copy of the forms shall be forwarded to the Consultant. The original shall be inserted into the operating and maintenance manual.
 - .2 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.
 - .3 Tests which have not been witnessed shall not be accepted and shall be repeated.
 - .4 The equipment and systems to be tested shall include:
 - Heat Pumps
 - Condensing Units
 - Boilers and Pumps
 - Air Handling Units
 - Life Safety and Fire Protection Systems
 - Building Automation Systems (BAS)
- .2 BAS Testing:
 - .1 The BAS Contractor shall test the system as described in General Requirements and/or Controls Sections.
 - .2 Co-ordinate with the Consultant and submit completed test forms monthly.
 - .3 Demonstrate to the Owner and Consultant the operation of the BAS when all tests have been completed.
- .3 Verification of Refrigeration Leak Detection System Operation:
 - .1 The commissioning process shall include the verification of the refrigeration leak detection system.
 - .2 All interlocks between leak detection systems installed and system components, as well as interlocks between field installed detection systems and associated safety system components shall be tested and verified to operate as per the requirements of CSA B52. Specifically, the following shall occur for each independent system on registration of a refrigerant leak:
 - .1 Open all zone dampers in the affected system.
 - .2 Disable all electric reheat coils within the affected system.
 - .3 Activate field installed safety shut off valves within the affected refrigeration system.
 - .4 Energize all fans within the affected ductwork system.
 - .5 Activate all refrigerant leak system specific ventilation systems.
 - .6 De-energize any other potential sources of ignition within the affected system.

3.9 CLOSEOUT SCHEDULE

- .1 The Mechanical Contractor shall include the schedule for all tests and equipment start-up tests in the construction schedule.
- .2 All testing forms and reports associated with the mechanical systems shall be directed to the Consultant with copies to the Owner and Consultant.
- .3 The forms and reports to be issued shall include:
 - Shop drawings, issued and accepted
 - Equipment verification forms
 - Testing forms
 - Reports resulting from tests
 - Testing schedule
 - Equipment Start-up Forms

3.10 OPERATION AND MAINTENANCE MANUAL

- .1 Conform to General Requirements section for the Operating and Maintenance Manual requirements.

3.11 OPERATOR TRAINING

- .1 Conform to General Requirements section for requirements for Instruction to Operating Staff.
- .2 The training shall be conducted in a classroom and at the equipment or system.
- .3 Training will begin when the operating and maintenance manuals have been delivered to The Owner and approved by the Consultant.
- .4 Each training session shall be structured to cover:

The operating and maintenance manual

 - Operating procedures
 - Maintenance procedures
 - Trouble-shooting procedures
 - Spare parts required
 - Submit a course outline to the Mechanical Consultant before training commences.

Provide course documentation for up to eight people.
- .5 The training sessions shall be scheduled and co-ordinated by the Mechanical Contractor.
- .6 Training shall be provided for the following systems:

<u>System</u>	<u>Minimum Training Times</u>
Condensing Units	2 hours
Boilers	2 hours
Air Handling Units	2 hours
Life Safety & Fire Protection Systems	2 hours
The Mechanical System	8 hours
Boilers	½ hour
Life Safety & Fire Protection	½ hour

- .7 The minimum training for the BAS shall be 16 hours. The training shall include:
- A walk through of the installation for the Building Owner to review the installation and equipment
 - Operation of the central computer
 - Operation of portable terminals
 - Control sequences
 - Report set-up and generation
 - Managing the system
 - Maintenance requirements
- Refer to Controls specification section for further information.
- .8 The training requirement for the mechanical system shall include a walk-through of the building by the Mechanical Contractor. During the walk through the Mechanical Contractor shall:
- Identify equipment
 - Identify starters associated with equipment
 - Identify valves and balancing dampers
 - Identify access doors
 - Review general maintenance of equipment
 - Review drain points in pipework systems
 - Identify maintenance items
- .9 When each training session has been completed The Owner shall sign the associated form to verify completion.

3.12 COMMISSIONING CONSULTANT

- .1 A Commissioning Consultant (CC) reports to the Owner.
- .2 The CC responsibilities shall include:
- Preparing the commissioning plan
 - Co-ordinating with the contractor to schedule tests
 - Preparing a test form manual
 - Witnessing selected tests
 - Receiving all test forms
 - Conducting performance test
 - Co-ordinating the contractors training
 - Chair commissioning meetings
- .3 The Mechanical Contractor shall co-operate with the CC.
- .4 The Mechanical Contractor shall provide assistance to the CC and have personnel available during the performance testing procedure. Each mechanical system shall be tested in the operational mode.
- .5 Performance testing shall begin when all systems have been completed, tested by the Mechanical Contractor and the Consultant has completed their final review.

3.13 MECHANICAL SYSTEM DEMONSTRATION AND TURNOVER

- .1 Refer to General Requirements section, Mechanical Project Completion.
- .2 The system demonstration and turnover to The Owner shall occur when:
 - The installation is complete
 - The acceptance test conducted by the Mechanical Consultant has been completed successfully
 - The Commissioning Consultant system performance testing has been completed successfully
 - Training has been completed
 - Operating and Maintenance Manuals have been accepted
 - Shop-drawings have been updated
 - As-built drawings have been completed
- .3 The systems demonstration shall be conducted by the Mechanical Contractor and the manufacturers. The demonstration shall cover a demonstration of equipment installation and operation.

3.14 TESTING FORMS

- .1 The Mechanical Contractor and manufacturers shall provide forms for testing. The forms must be approved by the Consultant and The Owner before they are used.

3.15 WARRANTIES

- .1 Equipment and system warranties shall not begin until the system demonstration and turnover has been conducted successfully and accepted by The Owner.
- .2 The Mechanical Contractor shall fill out the warranty form listing the equipment and systems and the start and finishing dates for warranty.
- .3 Refer to the general conditions specification section for the requirements during the warranty period.

3.16 CLOSEOUT PROCESS ALLOCATION

- .1 The mechanical contractor closeout process shall be as follows:
 - .1 3% for the first \$500,000 of contract value.
 - .2 1% of the contract value for value between \$500,000 to \$5,000,000.
 - .3 0.5% of contract value for the value in excess of \$5,000,000.
 - .4 Minimum Allocation for Close Out Documents is \$5,000.
- .2 The Mechanical Contractor shall submit all test and verification forms. The Consultant will use these forms to calculate percentage complete.
- .3 The monies shall not be paid out until the performance testing, O & M manuals, systems demonstration, and training including all required paperwork have been completed to the satisfaction of the consultant. Refer to General Requirements section for contract breakdown.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 Canadian General Standards Board (CGSB)
 - .1 CGSB 51-GP-52Ma-[89], Vapour Barrier Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
- .3 Underwriters Laboratories of Canada (ULC).
 - .1 CAN/ULC-S102, Surface Burning Characteristics of Building Materials and Assemblies.
- .4 American Society for Testing and Materials (ASTM).
 - .1 ASTM C177 Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Mean of the Guarded Hot-Plate Apparatus.
 - .2 ASTM C518 Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
 - .3 ASTM C 449M, Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.
 - .4 ASTM C1729 Standard Specification for Aluminum Jacketing for Insulation.
 - .5 ASTM C1290 Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.
 - .6 ASTM C1393 Standard Specification for Perpendicularly Oriented Mineral Fiber Roll and Sheet Thermal Insulation for Pipes And Tanks.
 - .7 ASTM C553, Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
 - .8 ASTM C612, Mineral Fiber Block and Board Thermal Insulation.
- .5 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).
 - .1 ASHRAE Standard 90.1.
- .6 Manufacturer's Trade Associations.
 - .1 Thermal Insulation Association of Canada (TIAC)
 - .2 North American Commercial and Industrial Insulation Standards.

1.2 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with general requirements.
- .2 Submit for approval manufacturer's catalogue literature related to installation, fabrication for duct jointing recommendations.
- .3 Submit completed detail plates from the North American Commercial and Industrial Insulation Standards manual, applicable to installation types required by this specification section.

1.3 INSTALLATION INSTRUCTIONS

- .1 Submit manufacturer's installation instructions in accordance with general requirements.
- .2 Installation instructions to include procedures to be used, installation standards to be achieved.

1.4 QUALIFICATIONS

- .1 Installer to have successfully completed apprenticeship program.
- .2 Installer to be specialist in performing work of this section and have at least 3 years successful experience in this size and type of project, qualified to standards of TIAC.

1.5 DELIVERY, STORAGE, AND HANDLING

- .1 Deliver materials to site in original factory packaging, labeled with manufacturer's name, address.
- .2 Protect from weather and construction traffic.
- .3 Protect against damage from any source.
- .4 Store at temperatures and conditions required by manufacturer.

1.6 DEFINITIONS

- .1 For purposes of this section:
 - .1 "CONCEALED" - insulated mechanical services and equipment in suspended ceilings and non-accessible chases and furred-in spaces.
 - .2 "EXPOSED" - will mean "not concealed" as defined herein.
 - .3 "ASJ+" – All Service Jacket – vapor retarder laminate of aluminium foil inner layer, reinforced with fiberglass scrim, bonded to a bleached kraft paper, with outer poly film leaving no paper exposed.
 - .4 "ASJ" – All Service Jacket (no outer film) – vapor retarder laminate of aluminium foil inner layer, reinforced with fiberglass scrim, bonded to a bleached kraft paper outer layer.
 - .5 "FSK" – Foil Scrim Kraft – vapor retarder laminate of aluminium foil outer layer, reinforced with fiberglass scrim, bonded to a natural kraft paper inner layer.
- .2 Insulation systems - insulation material, fasteners, jackets, and other accessories.

1.7 QUALITY ASSURANCE

- .1 Products shall not contain formaldehyde, asbestos, lead, mercury or mercury compounds or PBDE fire retardants.
- .2 **Products shall be Certified UL GREENGUARD Gold or Indoor Advantage Gold and formaldehyde free.**
- .3 **Recycled content: Mineral fiber products will contain a minimum of 50% recycled glass content certified and UL validated and are to be constructed using bio-based thermosetting binder.**

Part 2 Products

2.1 LIMITATION ON MATERIALS

- .1 Products shall not contain formaldehyde, asbestos, lead, mercury or mercury compounds or PBDE fire retardants.
- .2 Materials shall be: **“Certified Asthma and allergy friendly” and “verified Healthy Air.”**

2.2 FIRE AND SMOKE RATING

- .1 In accordance with CAN/ULC S102:
 - .1 Maximum flame spread rating: 25.
 - .2 Maximum smoke developed rating: 50.

2.3 INSULATION

- .1 Mineral fibre as specified herein includes glass fibre, rock wool, slag wool.
- .2 Thermal conductivity ("k" factor) not to exceed specified values at 24°C (75°F) mean temperature when tested in accordance with ASTM C177 or ASTM C518.
- .3 Type C-1: Rigid mineral fibre board to ASTM C612, with factory applied vapour retarder jacket meeting the requirement of ASTM C1136 Type II and IV (FSK):
 - .1 Jacket: to ASTM C1136 Type II and IV (FSK)
 - .2 Maximum "k" value: .033 W/M•°C (.23 BTU•IN/HR•FT²•°F)
- .4 Type C-2: Mineral fibre blanket to ASTM C553 Type I, II, and III, ASTM C1136 Type II and IV, and ASTM C1290 Type III:
 - .1 Jacket: to ASTM C1136, Type II and IV.
 - .2 Maximum "k" value: 0.042 W/M•°C (.29 BTU•IN/HR•FT²•°F)
- .5 Manufacturers:
 - .1 All materials must be supplied by the same manufacturer.
 - .2 Acceptable Manufacturers:
 - .1 Johns Manville **(with proof of Asthma and allergy friendly certification)**
 - .2 Knauf
 - .3 Manson

2.4 JACKETS

- .1 Canvas:
 - .1 220 g/m² (6 oz/sq.yd.) cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C 921.
 - .2 Lagging adhesive: Compatible with insulation.

2.5 ACCESSORIES

- .1 Vapour retarder lap adhesive:
 - .1 Water based, fire retardant type, compatible with insulation.
- .2 Indoor Vapour Retarder Finish:
 - .1 Compatible with insulation.
- .3 Insulating Cement: hydraulic setting on mineral wool, to ASTM C 449.
- .4 ULC Listed Canvas Jacket:
 - .1 220 g/m² (6oz/yd²) cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C 921.
- .5 Tape: self-adhesive, aluminum, reinforced, 75 mm (3") wide minimum.
- .6 Contact adhesive: quick-setting Childers CP-82 or equal.
- .7 Canvas adhesive: washable.
- .8 Tie wire: 1.5 mm (16 gauge) stainless steel.
- .9 Facing: 25 mm (1") stainless steel hexagonal wire mesh stitched on one face of insulation
- .10 Fasteners: weld pins, length to suit insulation, with 40 mm (1½") diameter clips.

Part 3 Execution

3.1 PRE-INSTALLATION REQUIREMENTS

- .1 Pressure testing of ductwork systems to be complete, witnessed, and certified.
- .2 Surfaces to be clean, dry, free from foreign material.

3.2 INSTALLATION

- .1 Install in accordance with North American Commercial and Industrial Insulation Standards.
- .2 Apply materials in accordance with manufacturers instructions and this specification.
- .3 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
 - .1 Hangers, supports to be outside vapour retarder jacket.
- .4 Supports, Hangers in accordance with general requirements.
 - .1 Apply high compressive strength insulation where insulation may be compressed by weight of ductwork.
- .5 Fasteners: At 300 mm (12") oc. in horizontal and vertical directions, minimum two rows each side.
- .6 Provide rigid insulation for exposed ductwork.

3.3 DUCTWORK INSULATION SCHEDULE

- .1 Insulation types and thicknesses conform to following table:

Application	Type	Thickness
Rectangular supply air ducts	C-1	25 mm (1")
Round supply air ducts	C-2	25 mm (1")
Supply, return, and fan exhaust ducts exposed (visible) in space being served	None	
Energy/heat recovery ventilator Exhaust ducts	C-1	25 mm (1")
Outdoor air intake ductwork and plenums	C-1	50 mm (2")
Exhaust plenums dampers and louvres	C-1	25 mm (1")
Interior acoustically lined ducts	None	
Last 1.5m of exhaust duct	C-1	25 mm (1")

- .2 Exposed round ducts 600 mm (24") and larger, smaller sizes where subject to abuse:

- .1 Use TIAC code C-1 insulation, scored to suit diameter of duct.

- .3 Finishes: Conform to following table:

Application	Rectangular	Round
Indoor, concealed	None	None
Indoor, exposed	Canvas	Canvas

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 Canadian General Standards Board (CGSB)
 - .1 ASTM C553, Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
 - .2 ASTM C612, Mineral Fiber Block and Board Thermal Insulation.
 - .3 CGSB 51-GP-52Ma, Vapour Barrier Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
- .3 Underwriters Laboratories of Canada (ULC)
 - .1 CAN/ULC-S102, Surface Burning Characteristics of Building Materials and Assemblies.
- .4 American Society for Testing and Materials (ASTM)
 - .1 ASTM C1729 Standard Specification for Aluminium Jacketing for Insulation.
 - .2 ASTM C1393 Standard Specification for Perpendicularly Oriented Mineral Fibre Roll and Sheet Thermal Insulation for Pipes and Tanks.
 - .3 ASTM C534 Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
 - .4 ASTM C533 Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
 - .5 ASTM C177 Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
 - .6 ASTM C518 Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
 - .7 ASTM C411, Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.
 - .8 ASTM C449, Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.
 - .9 ASTM C795, Specification for Thermal Insulation for Use with Austenitic Stainless Steel.
 - .10 ASTM C921, Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
- .5 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - .1 ASHRAE Standard 90.1.

- .6 Manufacturer's Trade Associations
 - .1 Thermal Insulation Association of Canada (TIAC)
 - .2 North American Commercial and Industrial Insulation Standards.

1.2 PRODUCT DATA

- .1 Submit Product Data in accordance general requirements.

1.3 SAMPLES SUBMITTALS

- .1 Submit samples in accordance with general requirements.
- .2 Submit for approval: completed detail plate assemblies of each type of insulation system, insulation, coating, and adhesive proposed. Mount sample on 15 mm (1/2") plywood board. Affix typewritten label beneath sample indicating service.

1.4 INSTALLATION INSTRUCTIONS

- .1 Submit properly completed detail plates from the North American Commercial and Industrial Insulation Standards manual, applicable to installation types required by this specification section.
- .2 Submit manufacturer's installation instructions in accordance with general requirements.
- .3 Installation instructions to include procedures to be used, installation standards to be achieved.

1.5 QUALIFICATIONS

- .1 Installer to have successfully completed apprenticeship program.
- .2 Installer to be specialist in performing work of this section and have at least three (3) years successful experience in this size and type of project, qualified to standards of TIAC.

1.6 DELIVERY, STORAGE AND HANDLING

- .1 Deliver materials to site in original factory packaging, labeled with manufacturer's name, address.
- .2 Protect from weather and construction traffic.
- .3 Protect against damage from any source.
- .4 Store at temperatures and conditions required by manufacturer.

1.7 DEFINITIONS

- .1 For purposes of this section:
 - .1 "CONCEALED" – insulated mechanical services and equipment in suspended ceilings and non-accessible chases and furred-in spaces.
 - .2 "EXPOSED" – will mean "not concealed" as defined herein.

- .3 "Insulation Systems" – insulation material, fasteners, jackets, and other accessories.
- .4 "ASJ+" All Service Jacket – vapor retarded laminate of aluminium foil inner layer reinforced with fibreglass scrim, bonded to a bleached kraft paper with outer poly film layer leaving no paper exposed.
- .5 "ASJ" All Service Jacket – (no outer film) vapor retarder laminate of aluminum foil inner layer reinforced with fibreglass scrim, bonded to a bleached kraft paper outer layer.
- .6 "FSK" Foil Scrim Kraft – vapor retarder laminate of aluminium foil outer layer, reinforced with fibreglass scrim, bonded to a natural kraft paper inner layer.
- .7 "PSK" Poly Scrim Kraft – vapor retarder laminate of polypropylene outer layer, reinforced with fibreglass scrim, bonded to a natural kraft paper inner layer.
- .8 "PVC" Poly Vinyl Chloride – polymer to manufacture non-metallic final protective finish jacket over insulation systems.

Part 2 Products

2.1 LIMITATION ON MATERIALS

- .1 Product shall not contain formaldehyde, asbestos, lead, mercury, or mercury compounds, or PBDE fire retardants.

2.2 FIRE AND SMOKE RATING

- .1 In accordance with CAN/ULC S102:
 - .1 Maximum flame spread rating: 25.
 - .2 Maximum smoke developed rating: 50.

2.3 INSULATION

- .1 Mineral fibre as specified herein includes glass fibre, rock wool, slag wool.
- .2 Thermal conductivity ("k" factor) not to exceed specified values at 24°C (75°F) mean temperature when tested in accordance with ASTM C177 or ASTM C518.
- .3 Type A-1: Fibre glass pipe and tank insulation
 - .1 Segmented, flexible fiberglass board bonded to laminated vapor retarder, ASJ or FSK.
 - .2 Complying with ASTM C1393, Type II or Type III Category 2.
 - .3 Maximum "k" value: 0.037W/M (or less) x C°@100°F (38°C) is 0.26BTU x IN/H FT² x °F
 - .4 Jacket: specified in 'Factory-Applied Jackets' Article

2.4 JACKETS

- .1 Canvas:
 - .1 220 g/m² (6 oz/sq yd) cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.
 - .2 Lagging adhesive: Compatible with insulation.

2.5 INSULATION SECUREMENTS

- .1 Tape: Self-adhesive, aluminum, [reinforced], 50 mm (2") wide minimum.
- .2 Contact adhesive: Quick setting.
- .3 Canvas adhesive: Washable.
- .4 Tie wire: 1.5 mm (16 gauge) diameter stainless steel.
- .5 Bands: Stainless steel, 20 mm (3/4") wide, 0.5 mm (26 gauge) thick.
- .6 Facing: 25 mm (1") galvanized steel hexagonal wire mesh on one face of insulation.
- .7 Fasteners: 4 mm (5/32") diameter pins with 40 mm (1½") clips. Length of pin to suit thickness of insulation. Pins to be CD weld, self-adhesive or glue applied – to be selected and confirmed with consultant in accordance with required service conditions.

2.6 VAPOUR RETARDER LAP ADHESIVE

- .1 Water based, fire retardant type, compatible with insulation.

2.7 INDOOR VAPOUR RETARDER FINISH

- .1 Compatible with insulation.

2.8 OUTDOOR VAPOUR RETARDER MASTIC

- .1 Compatible with insulation.
- .2 Reinforcing fabric: Open weave fibreglass fabric with a maximum weave of 10 x 10 squares per inch.

Part 3 Execution

3.1 PRE-INSTALLATION REQUIREMENTS

- .1 Pressure testing of equipment and adjacent piping systems to be complete, witnessed, and certified.
- .2 Surfaces to be clean, dry, free from foreign material.

3.2 INSTALLATION

- .1 Install in accordance with TIAC and North American Commercial and Industrial Insulation Standards.
 - .1 Hot equipment: To TIAC code 1503-H.
 - .2 Cold equipment: to TIAC code 1503-C.

- .2 Provide a completely insulated system allowing for insulation over all valves, fittings, air separators, pumps, buffer tanks, and other connected equipment to the system.
- .3 Elastomeric Insulation: to remain dry at all times. Overlaps to be to manufacturer instructions. Joints to be tight and sealed properly.
- .4 Provide vapour retarder as recommended by manufacturer.
- .5 Apply materials in accordance with insulation and equipment manufacturers instructions and this specification.
- .6 Below ambient/chilled water installation:
 - .1 All pipes, fittings, valves, strainers, flanges, unions, and other pipe system components and specialties must be properly insulated with correctly completed vapor retarded applied.
 - .2 All insulation material must have properly installed and sealed vapor retarding jacket, including circumferential and longitudinal seams.
 - .3 All penetrations, tears, and punctures must be repaired and sealed with a vapor retarding material with a .02 or lower perm rating.
 - .4 Vapor stops must be installed at 18' intervals, at all pipe insulation termination points, including fittings, flanges, and other changes in direction or other types of piping specialties.
 - .5 All fitting insulation must be of the same type, thickness, and density of the pipe insulation, be premoulded insulation covers or fabricated from the same material as the pipe insulation. Full thickness must be factory-applied, vapor-retarder facing is unacceptable.
 - .6 A complete vapor retarder must be installed on insulation over fittings before applying final finish. Vapor retarder must extend onto and be sealed to the vapor retarder or pipe insulation.
 - .7 Additional fitting covers, PVC or metal, must have a vapor retarder seal applied to all longitudinal and circumferential seams in addition to the vapor retarder applied to the fitting insulation.
 - .8 Additional field applied jackets must not use staples, screws, tacks or rivets for attachment, to avoid puncturing vapor retarder underneath.
 - .9 Insulating support inserts are to be high compressive strength insulation with a rigid shield. No calcium silicate is to be used for insulation on below-ambient operation piping.
- .7 Use two layers with staggered joints when required nominal wall thickness exceeds 75 mm (3").
- .8 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
 - .1 Hangers, supports to be outside vapour retarder jacket.
- .9 Supports, Hangers:
 - .1 Apply high compressive strength insulation, suitable for service, at oversized saddles and shoes where insulation saddles have not been provided.

3.3 REMOVABLE, PRE-FABRICATED, INSULATION AND ENCLOSURES

- .1 Flexible removable blanket insulation covers are not acceptable for below ambient (cold) operating piping systems. Rigid removable insulation jackets of the vapor retarder exterior material that can be vapor sealed at the seams, are acceptable on below ambient (cold) operation piping systems.
- .2 Application: At expansion joints, valves, primary flow measuring elements flanges and unions at equipment.
- .3 Installation to permit movement of expansion joint and to permit periodic removal and replacement without damage to adjacent insulation. Fabricate flexible, removable insulation in accordance with ASTM C 1695, Standard Specification for fabrication of flexible removable and reusable blanket insulation for hot service.

3.4 EQUIPMENT INSULATION SCHEDULES

- .1 Includes valves, valve bonnets, strainers, flanges, air separators, and fittings unless otherwise specified.
- .2 Hot Equipment:
 - .1 Type and Thickness:

ITEM	THICKNESS	TYPE
Hot Water Pumps	25 mm (1")	A1
Air Separator	25mm (1")	A1

- .3 Finishes:
 - .1 Equipment in mechanical rooms: TIAC code CEF/1 with canvas jacket.
 - .2 Equipment elsewhere: TIAC code CEF/2 with canvas jackets.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 Canadian General Standards Board (CGSB)
 - .1 CAN/CGSB-51.53, Poly (Vinyl Chloride) Jacketing Sheet, for Insulating Pipes, Vessels, and Round Ducts.
- .3 Underwriters Laboratories of Canada (ULC)
 - .1 CAN/ULC-S102, Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.
- .4 American Society for Testing and Materials (ASTM)
 - .1 ASTM C547, Type I and IV Standard Specification for Mineral Fiber Pipe Insulation.
 - .2 ASTM C177, Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
 - .3 ASTM C518, Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus to recognize the correct thermal insulation performance testing for blanket.
 - .4 ASTM C1393, Standard Specification for Perpendicularly Oriented Mineral Fiber Roll and Sheet Thermal Insulation for Pipes and Tanks
 - .5 ASTM C1695, Standard Specification for Fabrication of Flexible Removable and Reusable Blanket Insulation for Hot Service.
 - .6 ASTM C 335, Test Method for Steady State Heat Transfer Properties of Pipe Insulation.
 - .7 ASTM C 921, Practice for Determining the Properties Jacketing Materials for Thermal Insulation.
 - .8 ASTM C1729 Standard Specification for Aluminium Jacketing for Insulation.
 - .9 ASTM C553, Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
 - .10 CGSB 51-GP-52Ma, Vapour Barrier Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
- .5 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).
 - .1 ASHRAE Standard 90.1.
- .6 Manufacturer's Trade Associations
 - .1 Thermal Insulation Association of Canada (TIAC)
 - .2 North American Commercial and Industrial Insulation Standards

1.2 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with general requirements.
- .2 Submit properly completed detail plates from the North American Commercial and Industrial Insulation Standards manual, applicable to installation types required by this specific section.
- .3 Submit for approval manufacturer's catalogue literature related to installation, fabrication for pipe, fittings, valves, and jointing recommendations.

1.3 INSTALLATION INSTRUCTIONS

- .1 Submit manufacturer's installation instructions in accordance with general requirements.
- .2 Installation instructions to include procedures to be used, installation standards to be achieved.

1.4 QUALIFICATIONS

- .1 Installer to have successfully completed apprenticeship program.
- .2 Installer to be specialist in performing work of this section and have at least 3 years successful experience in this size and type of project, qualified to standards of TIAC.

1.5 DELIVERY, STORAGE, AND HANDLING

- .1 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .2 Protect from weather, construction traffic.
- .3 Protect against damage from any source.
- .4 Store at temperatures and conditions required by manufacturer.

1.6 DEFINITIONS

- .1 For purposes of this section:
 - .1 "CONCEALED" - insulated mechanical services in suspended ceilings and non-accessible chases and furred-in spaces.
 - .2 "EXPOSED" - will mean "not concealed" as defined herein.
 - .3 "ASJ+" – All Service Jacket – vapor retarder laminate of aluminium foil inner layer, reinforced with fiberglass scrim, bonded to a bleached kraft paper, with outer poly film leaving no paper exposed.
 - .4 "ASJ" – All Service Jacket (no outer film) – vapor retarder laminate of aluminium foil inner layer, reinforced with fiberglass scrim, bonded to a bleached kraft paper outer layer.
 - .5 "FSK" – Foil Scrim Kraft – vapor retarder laminate of aluminum foil outer layer, reinforced with fiberglass scrim, bonded to a natural kraft paper inner liner.

- .6 "PSK" – Poly Scrim Kraft – vapor retarder laminate of polypropylene outer layer, reinforced with fiberglass scrim, bonded to a natural kraft paper inner layer.
- .7 "PVC" – Poly Vinyl Chloride – polymer used to manufacture a non-metallic final protective finish jacket over insulation systems.

1.7 QUALITY ASSURANCE

- .1 Products shall not contain formaldehyde, asbestos, lead, mercury or mercury compounds or PBDE fire retardants.
- .2 Products shall be Certified UL GREENGUARD Gold or Indoor Advantage Gold and formaldehyde free.
- .3 Recycled content: Mineral fiber products will contain a minimum of 50% recycled glass content certified and UL validated and are to be constructed using bio-based thermosetting binder.

Part 2 Products

2.1 MATERIAL LIMITATIONS

- .1 Products shall not contain formaldehyde, asbestos, lead, mercury or mercury compounds or PBDE fire retardants.

2.2 FIRE AND SMOKE RATING

- .1 In accordance with CAN/ULC-S102:
 - .1 Maximum flame spread rating: 25.
 - .2 Maximum smoke developed rating: 50.

2.3 INSULATION

- .1 Mineral fibre as specified herein includes glass fibre, rock wool, slag wool.
- .2 Thermal conductivity ("k" factor) not to exceed specified values at 24°C (75°F) mean temperature when tested in accordance with ASTM C335, ASTM C177 or ASTM C518.
- .3 Type A-1: Rigid moulded or wound mineral fibre with factory applied vapour retarder jacket.
 - .1 Mineral fibre: to ASTM C547 Type I and IV.
 - .2 Jacket: to ASTM C1136, Type I, II, III, IV, X.
 - .3 Maximum "k" factor: to ASTM C547.
- .4 Type A-3: Tubular flexible elastomeric closed cell foam:
 - .1 Insulation to ASTM C534 Type I.
 - .2 Maximum "k" factor: to ASTM C534.
 - .3 To be certified by manufacturer to be free of potential stress corrosion cracking corrodents.

.5 Materials:

- .1 All materials must be supplied by the same manufacturer.
- .2 Acceptable Manufacturers:
 - .1 Knauf
 - .2 Manson
 - .3 Owens Corning

2.4 INSULATION SECUREMENT

- .1 Tape: Self-adhesive, aluminum, reinforced, 50 mm (2") wide minimum.
- .2 Contact adhesive: Quick setting.
- .3 Canvas adhesive: Washable.
- .4 Tie wire: 1.5mm (16 gauge) diameter stainless steel.
- .5 Bands: Stainless steel, 20 mm (3/4") wide, 0.5 mm (0.020") thick.

2.5 CEMENT

- .1 Thermal insulating and finishing cement:
 - .1 Air drying on mineral wool, to ASTM C 449M.
 - .2 Hydraulic setting on mineral wool, to ASTM C165

2.6 VAPOUR RETARDER LAP ADHESIVE

- .1 Water based, fire retardant type, compatible with insulation.

2.7 INDOOR VAPOUR RETARDER FINISH

- .1 Compatible with insulation.

2.8 OUTDOOR VAPOUR RETARDER FINISH

- .1 Compatible with insulation.
- .2 Reinforcing fabric: Open weave fibreglass fabric, with maximum weave of 10 x 10 squares per inch.

2.9 JACKETS

- .1 Polyvinyl Chloride (PVC):
 - .1 Minimum thickness: 20mil (0.020")
 - .2 One-piece moulded type [and sheet] to CAN/CGSB-51.53 with pre-formed shapes as required.
 - .3 Colours: white.
 - .4 Minimum service temperatures: -29°C (-20°F).
 - .5 Maximum service temperature: 65°C (150°F).
 - .6 Moisture vapour transmission: 0.05 perm.

- .7 Fastenings:
 - .1 Use solvent weld adhesive compatible with insulation to seal laps and joints.
 - .2 Tacks (not to be used on below-ambient temperature systems)
 - .3 Pressure sensitive vinyl tape of matching colour.
- .2 Aluminum:
 - .1 To ASTM C1729.
 - .2 Thickness: 0.50 mm (0.020") sheet.
 - .3 Finish: Smooth.
 - .4 Joining: Longitudinal and circumferential slip joints with 50 mm (2") laps.
 - .5 Fittings: 0.50 mm (0.020") thick die-shaped fitting covers with factory-attached protective liner.
 - .6 Metal jacket banding and mechanical seals: stainless steel, 20 mm (3/4") wide, 0.50 mm (0.020") thick at 300 mm (12") spacing.
- .3 Canvas:
 - .1 220 g/m² (6oz/sq yd) cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C 921.
 - .2 Lagging adhesive: Compatible with insulation.

2.10 CAULKING FOR JACKETS

- .1 Caulking: Silicone clear caulking.

Part 3 Execution

3.1 PRE-INSTALLATION REQUIREMENT

- .1 Pressure testing of piping systems and adjacent equipment to be complete, witnessed, and certified.
- .2 Surfaces to be clean, dry, free from foreign material.

3.2 INSTALLATION

- .1 Install in accordance with North American Commercial and Industrial Insulation Standards.
- .2 Provide continuous insulation for complete systems including all valves, air separators, fittings, and other equipment.
- .3 Apply materials in accordance with manufacturers' instructions and this specification.
- .4 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
 - .1 Hangers, supports to be outside vapour retarder jacket.

- .5 Supports, Hangers:
 - .1 Apply high compressive strength insulation, suitable for service, at oversized saddles and shoes where insulation saddles have not been provided.
- .6 Use two layers with staggered joints when required nominal wall thickness exceeds 75 mm (3").
- .7 Below ambient/chilled water installation:
 - .1 All pipes, fittings, valves, strainers, flanges, unions, and other pipe system components and specialties must be properly insulated with correctly completed vapor retarded applied.
 - .2 All insulation material must have properly installed and sealed vapor retarding jacket, including circumferential and longitudinal seams.
 - .3 All penetrations, tears, and punctures must be repaired and sealed with a vapor retarding material with a .02 or lower perm rating.
 - .4 Vapor stops must be installed at 18' intervals, at all pipe insulation termination points, including fittings, flanges, and other changes in direction or other types of piping specialties.
 - .5 All fitting insulation must be of the same type, thickness, and density of the pipe insulation, be premoulded insulation covers or fabricated from the same material as the pipe insulation. Full thickness must be factory-applied, vapor-retarder facing is unacceptable.
 - .6 A complete vapor retarder must be installed on insulation over fittings before applying final finish. Vapor retarder must extend onto and be sealed to the vapor retarder or pipe insulation.
 - .7 Additional fitting covers, PVC or metal, must have a vapor retarder seal applied to all longitudinal and circumferential seams in addition to the vapor retarder applied to the fitting insulation.
 - .8 Additional field applied jackets must not use staples, screws, tacks or rivets for attachment, to avoid puncturing vapor retarder underneath.
 - .9 Insulating support inserts are to be high compressive strength insulation with a rigid shield. No calcium silicate is to be used for insulation on below-ambient operation piping.

3.3 REMOVABLE, PREFABRICATED, INSULATION AND ENCLOSURES

- .1 Application: At expansion joints, valves, primary flow measuring elements, flanges, and unions at equipment.
- .2 Flexible removable insulation covers are not acceptable for below-ambient (cold) operation piping systems. Rigid removable insulation jackets that are vapor retarder exterior material that can be vapor sealed at the seams, are acceptable on below-ambient (cold) operation piping systems.
- .3 Insulation:
 - .1 Insulation, fastenings, and finishes: same as system.
 - .2 Jacket: As per adjacent insulation.

3.4 PIPING INSULATION SCHEDULES

- .1 Includes valves, valve bonnets, strainers, flanges, air separators, and fittings unless otherwise specified.
- .2 Install insulator and jackets to applicable TIAC codes.
- .3 Insulate ends of capped piping with type and thickness indicated for capped service.
- .4 Thickness of insulation to be as listed in following table.
 - .1 Do not insulate exposed runouts to plumbing fixtures, chrome plated piping, valves, fittings.

Application	Type	Pipe sizes through (NPS) and insulation thickness mm (")				
		to 25 (1")	32 (1¼") 40 (1½")	50 (2") 80 (3")	105 (4") 150 (6")	200 (8") & over
Hot Water Heating Casings	A-1	40 (1½")	50 (2")	50 (2")	50 (2")	50 (2")
Refrigerant piping	A-3	25 (1")	25 (1")	25 (1")	25 (1")	25 (1")
Cooling Coil cond. Drain	A-1	25 (1")	25 (1")	25 (1")	25 (1")	25 (1")

- .5 Finishes: Conform to the following table:

Application	Piping	Valves & Fittings
Exposed indoors	PVC	PVC
Exposed in mech. rooms	PVC	PVC
Concealed indoors	N/A	PVC
Within 300 mm (12") of boiler	CANVAS	CANVAS
Exterior refrigerant piping	Aluminum	Aluminum

- .6 Connection: To appropriate TIAC code.
- .7 Finish attachments: SS bands, @ 150 mm (6") oc. seals: closed.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ANSI/ASME B16.5, Pipe Flanges and Flanged Fittings: NPS ½ through NPS 24 Metric/Inch.
- .3 ANSI B16.18, Cast Copper Alloy Solder Joint Pressure Fittings.
- .4 ANSI/ASME B16.22, Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
- .5 ANSI B18.2.1, Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series).
- .6 ASTM A47/A47M, Specification for Ferritic Malleable Iron Castings.
- .7 ASTM A53/A53M, and A106, Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded ERW and Seamless.
- .8 ASTM B32, Specification for Solder Metal.
- .9 ASTM B75M, Specification for Seamless Copper Tube [Metric].
- .10 CSA B149.1, Natural Gas and Propane Installation Code.
- .11 CSA W47.1, Certification of Companies for Fusion Welding of Steel.

1.2 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings product data in accordance with general requirements.
- .2 Indicate on manufacturers catalogue literature.

1.3 CLOSEOUT SUBMITTALS

- .1 Provide maintenance data for incorporation into manual specified in general requirements.

Part 2 Products

2.1 GAS SERVICE

- .1 Arrange with the local utility to have the gas service provided from the street to the gas meter where indicated.
- .2 Fees and charges requested by the local utility to provide the gas service and meter.
- .3 Submit all plans as requested by the local utility.
- .4 Utility supplied gas meter shall be complete with pulse signal for connection to BAS system (co-ordinate pulse representation in m³ of gas used on meter specifications.
- .5 Provide approved pulse gas meter in all locations where indicated on the drawings.

2.2 PIPE

- .1 Steel pipe: to ASTM A106, Schedule 40, seamless as follows:
 - .1 NPS 15 mm to 50 mm (1/2" to 2"), screwed.
 - .2 NPS 65 mm (2 1/2") and over, plain end.
- .2 Copper tube: to ASTM B75M.

2.3 JOINTING MATERIAL

- .1 Screwed fittings: pulverized lead paste.
- .2 Welded fittings: to CSA W47.1.
- .3 Flange gaskets: nonmetallic flat.
- .4 Soldered: to ASTM B32, tin antimony 95/5.
- .5 Screwed brass fittings: Teflon Tape.

2.4 FITTINGS

- .1 Steel pipe fittings, screwed, flanged or welded:
 - .1 Malleable iron: screwed, banded, Class 150.
 - .2 Steel pipe flanges and flanged fittings: to ANSI/ASME B16.5.
 - .3 Welding: butt-welding fittings.
 - .4 Unions: malleable iron, brass to iron, ground seat, to ASTM A47/A47M.
 - .5 Bolts and nuts: to ANSI B18.2.1.
 - .6 Nipples: schedule 40, to ASTM A53/A53M/A106.
- .2 Copper pipe fittings, screwed, flanged or soldered:
 - .1 Cast copper fittings: to ANSI B16.18.
- .3 Brass fittings: To ASTM B16.

2.5 LUBRICATED PLUG VALVES

- .1 All sizes
 - .1 Provincial Code approved, lubricated plug type.
 - .2 Body: cast iron to ASTM A 126 Class B semi-steel.
 - .1 Rating: Class 125 psig.
 - .3 Plug: tapered, with regular pattern port – 90 from full open to fully closed.
 - .4 Ends: 50 mm (2") and smaller with hexagon shoulders, ends screwed to ANSI B1.20.1. Flanged to ANSI B16.1.
 - .5 Lubrication system, nickel-plated.
 - .6 Lubricant: to suit type, temperature and pressure of contained fluid.
 - .7 Feeding system: lubricant forced into lubrication grooves between seating surfaces of plug and body to form positive seal, leakproof operation, and corrosion preventing film.
 - .8 Lubricant screw for lubrication.

- .9 O-rings between body and plug.
- .10 Operator: removable manual lever handle.
- .11 Acceptable Manufacturers:
 - .1 Newman Hattersley
 - .2 Crane
 - .3 Jenkins
 - .4 Milwaukee
 - .5 Toya

2.6 CONTRACTOR PROVIDED GAS METERS

- .1 This contractor shall provide a gas meter complete with digital pulse for connection to the BAS system for where indicated on the drawings.
- .2 The gas meter shall be compatible with the requirement of the local utility and BAS contractor.
- .3 Acceptable materials: Badger Meter Inc. (Line Process Controls 1-416-291-8525).

2.7 GAS REGULATOR

- .1 Reduce pressure from 34.5 kPa (5 psi) to 1.74 kPa (7" WC) capacity as indicated.
 - .1 Acceptable Manufacturers:
 - .1 Singer
 - .2 Schlumberger
- .2 Vent interior relief valve to outdoors with gooseneck and stainless steel insect screen. Vent piping shall be sized as per manufacturers' requirements and recommendations.
- .3 Isolate with lubricated plug valve and union connection.

2.8 MANUFACTURED ROOF SUPPORTS

- .1 Single piece injection moulded polypropylene support.
- .2 Type 3-20 psi extruded polystyrene UV protected base glued to the support.
- .3 Minimum base dimension of 300 x 225 (12" x 9") and be 140 mm (5.5") high.
- .4 Pull test of 1.4 kN (315 lbs) using two #14-10 screws on pipe strap.
- .5 Acceptable Manufacturers:
 - .1 Quick Block
 - .2 Erico

Part 3 Execution

3.1 PIPING

- .1 Install in accordance with applicable Provincial/Territorial Codes.
- .2 Install in accordance with CAN/CSA B149.

- .3 Assemble piping using fittings manufactured to ANSI standards.
- .4 Connect to equipment in accordance with manufacturer's instruction unless otherwise indicated.
- .5 Slope piping down in direction of flow to low points.
- .6 Install drip points:
 - .1 At low points in piping system.
 - .2 At each connection to equipment.
- .7 Use eccentric reducers at pipe size change installed to provide positive drainage.
- .8 Provide clearance for access and for maintenance.
- .9 Ream pipes, clean scale and dirt, inside and out.
- .10 Install piping to minimize pipe dismantling for equipment removal.
- .11 Install regulator vents to code. Terminate in open air with Gooseneck fitting complete with stainless steel screen.
- .12 Paint gas piping with two (2) coats yellow paint. Banding of gas will not be accepted.

3.2 PIPING ON ROOF

- .1 Support piping as follows or as per seismic requirements (1.8 M (6' - 0") O.C.) whichever is more stringent:
 - .1 $\leq 40 \text{ mm (1}\frac{1}{2}\text{")}$ 2.4 M (8' - 0") O.C.
 - .2 $\geq 50 \text{ mm (2")}$ 3.0 M (10' - 0") O.C.
- .2 Provide support at each elbow and fitting.
- .3 Provide support at each regular and/or isolating valve.
- .4 Provide support within 600 mm (24") of each piece of equipment.

3.3 VALVES

- .1 Install valves with stems upright or horizontal unless otherwise approved by Consultant.
- .2 Install valves at branch take-offs to isolate each piece of equipment, and as indicated.
- .3 Provide lubricated plug type when gas line is exterior of building or 65 mm (2½") and larger.

3.4 SUPERVISORY SWITCH

- .1 Install on valves as indicated to monitor open/closed position of valve and send signal to fire alarm system. Install to manufacturer's recommendations.

3.5 FIELD QUALITY CONTROL

- .1 Test system in accordance with CAN/CSA B149. Requirements of authorities having jurisdiction.
- .2 Provide copy of TSSA tag to the consultant.

3.6 PURGING

- .1 Purge after pressure test in accordance with CAN/CSA B149.

3.7 GAS SERVICE

- .1 Arrange with local gas distributor to install gas service and gas meter. Pay all fees and charges to provide the gas service and gas meter.
- .2 Install all the gas meters where indicated.

3.8 GAS FIRED EQUIPMENT START-UP

- .1 Start-up of all new and existing gas fired equipment shall be by this contractor to the requirements of the equipment manufacturer.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 Canadian Standards Association (CSA).
 - .1 CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code.
- .3 American Society for Testing and Materials (ASTM).
 - .1 ASTM A47/A47M, Specification for Ferritic Malleable Iron Castings.
 - .2 ASTM A278/A278M, Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 650°F (350°C).
 - .3 ASTM A516/A516M, Specification for Pressure Vessel Plates, Carbon Steel, for Moderate - and Lower - Temperature Service.
 - .4 ASTM A536, Specification for Ductile Iron Castings.
 - .5 ASTM B62, Specification for Composition Bronze or Ounce Metal Castings.
- .4 American Society of Mechanical Engineers (ASME).
 - .1 ANSI/ASME, Boiler and Pressure Vessels Code (BPVC).

1.2 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with general requirements.
- .2 Indicate on manufacturers' catalogue literature the following:
 - .1 Sizes, orientation, capacities, performance, etc.
 - .2 Accessories

1.3 CLOSEOUT SUBMITTALS

- .1 Provide maintenance data for incorporation into manual specified in general requirements.

Part 2 Products

2.1 AIR SEPARATOR IN-LINE

- .1 Application: Provide for each individual hydronic system.
- .2 Inline steel construction air separator c/w flanged connections.
- .3 Maximum operating pressure: 860 kPa (125 psi) with ASME stamp and certification.
- .4 Operating temperature range: 0 – 132°C (32-270°F)
- .5 Complete with:
 - .1 Side drain valve.
 - .2 Bottom drain valve.

- .3 Connection for air vent at top of unit.
- .4 Corrosion resistant internal mesh for air removal.
- .5 Automatic air vent.
- .6 Size: Line size.
- .7 Acceptable Manufacturers:
 - .1 Caleffi
 - .2 Armstrong
 - .3 Bell and Gossett
 - .4 Amtrol

2.2 MAGNETIC DIRT SEPARATORS – IN-LINE

- .1 Application: Provide for each heating water system.
- .2 Inline steel construction magnetic dirt separator c/w flanged connections.
- .3 Dual magnetic system with drywell mounted magnet stack for rapid removal of ferrous impurity in system. Magnets to be high strength neodymium rare earth style.
- .4 Maximum operating pressure: 860 kPa (125 psi) with ASME stamp and certification.
- .5 Operating temperature range: 0 – 132°C (32-270°F)
- .6 Complete with:
 - .1 Bottom drain valve.
 - .2 Top cap.
- .7 Size: Line size.
- .8 Acceptable Manufacturers:
 - .1 Caleffi
 - .2 Armstrong
 - .3 Bell and Gossett
 - .4 Amtrol

2.3 PIPELINE STRAINER

- .1 Pipeline strainer shall provide a means of mechanically removing solids from a flowing fluid. This is accomplished by utilizing a perforated metal mesh.
- .2 Strainers shall be installed in pipelines to protect downstream mechanical equipment such as condensers, heat exchangers, pumps, compressors, meters, spray nozzles, turbines, and steam traps from the detrimental effect of sediment, rust, pipe scale, or other extraneous debris.
- .3 Types of strainers: Provide strainers that are Y strainer and/or basket strainer.

- .4 Strainer end connections shall match the piping specification.
 - .1 NPS 15 mm to 50 mm (1/2" to 2"): bronze body to ASTM B62, screwed connections.
 - .2 NPS 65 mm to 300 mm (2 1/2" to 12"): cast steel body to ASTM A278M, Class 30, flanged connections.
 - .3 NPS 50 mm to 300 mm (2" to 12"): T type with malleable iron body to ASTM A47M, grooved ends.
- .5 Strainer components shall include a cover, perforated plate, mesh, wedge wire, gasket, and cover fasteners.
 - .1 Perforated Plate/Mesh/Wedge Wire: Stainless steel (various grades available).
 - .2 Gaskets: to suite fluid application.
 - .3 Fasteners: to match body material.
- .6 Mesh sizing:
 - .1 An extremely important consideration in the selection of a strainer is the size of the perforations, mesh or wire opening used in the fabrication of the straining element. Select holes that are actually needed for the application and specified by the equipment manufacturer's request that is being protected.
 - .2 The following tables illustrate mesh and their respective straining capability. The main criteria for choosing hole and mesh size is the size and quantity of particles which can pass through downstream equipment without causing damage.

Mesh (Openings/In.)	Wire Diameter (In.)	Opening		Percent Open Area
		Inches	Micron	
10	0.032	0.068	727	56.3
16	0.018	0.045	1130	50.7
18	0.017	0.036	979	48.3
20	0.015	0.035	889.0	49.0
30	0.011	0.0223	566.4	44.8
40	0.009	0.0156	396.2	40.2
50	0.009	0.011	279	30.3
60	0.0065	0.0102	259.1	37.3
80	0.005	0.0075	190.5	36.0
100	0.0045	0.0055	139.7	30.3
120	0.0035	0.0048	123	30.1
150	0.0026	0.0041	103	37.2
170	0.0024	0.0035	79	35.1
200	0.0020	0.0030	76.2	33.6
250	0.0016	0.0024	61	36.0
300	0.0012	0.0021	54.2	29.7
325	0.0012	0.0019	47.7	30.0
400	0.0011	0.0014	35.6	36.0

- .7 Capacity: The capacity ratio or open area ratio (OAR) of a strainer influences such operating characteristics as the length of time it can operate without cleaning and the created pressure loss. The OAR is the relationship between internal cross sectional area (flow area) of the pipe and the open flow area of the material which makes up the straining element.
 - .1 The OAR for wye strainers shall not be less than 2.5:1.
 - .2 The OAR for basket strainers shall not be less than 7:1.
 - .3 When considering the OAR of a straining element, there are two accepted methods of analysis used by various specifying agencies and manufacturers. One method maintains "line of sight" reasoning and uses the multiple of the open areas for elements in series. In this method, a 60% open area material in series with a 40% open area material has a resultant combined open area of 24% (i.e. as in accordance with Military Standards). An alternative method allows the open area of the more restrictive element in series to be used. This would be 40% for the example above (i.e. as in accordance with Underwriter Laboratories' Standards). The method used influences the estimated operating pressure drop, as well as design decisions such as sizing.
- .8 Strainers are made with various dimensions and configurations; manufacturers have tested and published pressure drop results.
 - .1 Provide strainers designed for reasonable velocities that permit approximately 2 psi pressure drop across the strainer.
 - .2 Provide basket strainers designed for reasonable velocities that permit approximately 0.5 psi pressure drop across the strainer.
- .9 To allow the manufacturer to make selection or recommendations for a particular strainer, as much as possible, the following information should be provided by the Contractor to the Supplier:
 - .1 Physical Characteristics
 - .1 Pipe size and schedule.
 - .2 Strainer type required.
 - .3 End connections.
 - .4 Material (body, screen, bolting, gaskets).
 - .5 Pressure rating (design/operating — including shock).
 - .6 Temperature rating (design, operating, minimum).
 - .7 Straining element opening size.
 - .8 Capacity:
 - .1 Net effective open area required.
 - .2 Method of net open area calculation.
 - .9 Special requirements (hinged cover, vent tapping, jacketed, etc.).
 - .10 Applicable specifications (military specifications, special non-destructive tests or other quality control requirements).

- .2 Flow Data
 - .1 Liquid:
 - .1 Description of fluid.
 - .2 Rate of flow – gallons per minute (gpm) or pounds per hour (lbs/hr).
 - .3 Viscosity – SSU.
 - .4 Specific gravity or density.
 - .5 Temperature.
 - .6 Concentration (if acid or other corrosive).
 - .2 Gas:
 - .1 Description of Gas.
 - .2 Rate of flow – standard cubic feet per minute (scfm) or actual cubic feet per minute (cfm).
 - .3 Specific gravity.
 - .4 Temperature and pressure.
 - .5 Molecular weight.
 - .3 Steam:
 - .1 Rate of flow-pounds per hour (lbs/hr).
 - .2 Temperature.
 - .3 Pressure.
 - .4 Density.
 - .5 State of flow.
- .10 Blowdown connection: NPS 25 mm (1").
- .11 Screens at pumps: stainless steel with 1.19 mm (50 mil) perforations (16 mesh).
- .12 Working pressure: 860 kPa (125 psi).

2.4 LOW WATER CUT-OFF

- .1 Packaged low water cut-off with heavy duty construction, 16A relay.
- .2 Operates on 24V AC, or 120V switching capacity: 5.8 FLA, 24.8 LRA, Max load: 16A, switch contacts: SPDT, 250 psi max pressure, 250°F max water temperature.
- .3 Burner circuit locks out, if water remains below probe for 30 s. Manual reset will not trip due to power failure.
- .4 Burner circuit test button.
- .5 Indicator lights for troubleshooting.
- .6 Acceptable Manufacturers:
 - .1 Hydro Level Company Safgard 500 or 550.

Part 3 Execution

3.1 GENERAL

- .1 Install as indicated and to manufacturer's recommendations.
- .2 Run drain lines (and blow off connections) to terminate above nearest drain.
- .3 Maintain proper clearance to permit service and maintenance.
- .4 Should deviations beyond allowable clearances arise, request, and follow Consultant's directive.
- .5 Check shop drawings for conformance of all tappings for ancillaries and for equipment operating weights.

3.2 STRAINERS

- .1 Install in horizontal or down flow lines.
- .2 Ensure clearance for removal of basket.
- .3 Install ahead each of the following components:
 - .1 Pumps
 - .2 Temperature control valves
 - .3 Boilers
 - .4 Additional locations where indicated on the drawings.
- .4 Provide proper mesh strainers for the proper application.
- .5 Provide proper mesh strainers as recommended by the manufacturer's product being protected.
- .6 Provide basket strainers ahead of all plate heat exchanger or equipment with plate heat exchanger when piping is 100 mm (4") and larger.
- .7 The strainer must be installed such that the debris chamber is located at the lowest possible position. A Y strainer in vertical piping must be placed with its screen in the downward position to trap the sediment in the debris collection chamber.
- .8 Provide with a blowdown so the element can be flushed out by opening and closing the blowdown valve. This shall be accomplished without flow stoppage or disassembling any piping.

3.3 PRESSURE SAFETY RELIEF VALVES

- .1 Run discharge pipe to terminate above nearest drain.

3.4 AIR SEPARATOR

- .1 Provide independent support from structure.
- .2 Provide high capacity air vent as indicated.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 Canadian Standards Association (CSA).
 - .1 CSA W47.1, Certification of Companies for Fusion Welding of Steel.
- .3 American National Standards Institute (ANSI).
 - .1 ANSI/ASME B16.1, Gray Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800.
 - .2 ANSI/ASME B16.3, Malleable-Iron Threaded Fittings, Classes 150 and 300.
 - .3 ANSI/ASME B16.5, Pipe Flanges and Flanged Fittings: NPS½ through NPS24 Metric/Inch.
 - .4 ANSI/ASME B16.9, Factory-Made Wrought Steel Buttwelding Fittings.
 - .5 ANSI B18.2.1, Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series).
 - .6 ANSI/ASME B18.2.2, Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series).
 - .7 ANSI/AWWA C111/A21.11, Rubber Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
- .4 American Society for Testing and Materials (ASTM).
 - .1 ASTM A47/A47M, Specification for Ferritic Malleable Iron Castings.
 - .2 ASTM A53/A53M, Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless.
 - .3 ASTM A536, Specification for Ductile Iron Castings.
 - .4 ASTM B61, Specification for Steam or Valve Bronze Castings.
 - .5 ASTM B62, Specification for Composition Bronze or Ounce Metal Castings.
- .5 Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS).
 - .1 MSS-SP-67, Butterfly Valves.
 - .2 MSS-SP-70, Cast Iron Gate Valves, Flanged and Threaded Ends.
 - .3 MSS-SP-71, Cast Iron Swing Check Valves, Flanged and Threaded Ends.
 - .4 MSS-SP-80, Bronze Gate, Globe, Angle and Check Valves.
 - .5 MSS-SP-85, Cast Iron Globe and Angle Valves, Flanged and Threaded Ends.

1.2 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with general requirements.
- .2 Indicate on manufacturers' catalogue literature the following:
 - .1 Piping
 - .2 Valves
 - .3 Accessories

1.3 CLOSEOUT SUBMITTALS

- .1 Provide maintenance data for incorporation into manual specified in general requirements.

Part 2 Products

2.1 STEEL PIPE

- .1 Steel pipe: to ASTM A53/A53M, Grade B, as follows:
 - .1 NPS 150 mm (6") and smaller: Schedule 40.
 - .2 NPS 200 mm (8") and [over,] [10] Schedule 30.
- .2 Final connection to copper heating elements.
 - .1 Type "L" copper with 95/5 solder joints and dielectric couplings. Maximum length 600 mm (24").
- .3 Pipe Joints
 - .1 NPS 50 mm (2") and under: screwed fittings with pulverized lead paste.
 - .2 NPS 65 mm (2½") and over: welding fittings and flanges to CSA W47.1.
 - .3 Flanges: plain or raised face, slip-on.
 - .4 Flange gaskets: suitable for hydronic heating up to 110°C (220°F).
 - .5 Pipe thread: taper.
 - .6 Bolts and nuts: to ANSI B18.2.1 and ANSI/ASME B18.2.2.
- .4 Fittings
 - .1 Screwed fittings: malleable iron, to ANSI/ASME B16.3, Class 150.
 - .2 Pipe flanges and flanged fittings:
 - .1 Cast iron: to ANSI/ASME B16.1, Class 125.
 - .2 Steel: to ANSI/ASME B16.5.
 - .3 Butt-welding fittings: steel, to ANSI/ASME B16.9.
 - .4 Unions: malleable iron, to ASTM A47/A47M and ANSI/ASME B16.3.

2.2 VALVES

- .1 Connections:
 - .1 NPS 32 mm (1 1/4") and smaller: screwed ends.
 - .2 NPS 50 mm (2") and smaller: screwed ends.
 - .3 NPS 65 mm (2 1/2") and larger: flanged ends.
- .2 Butterfly valves: Application: Isolating each cell or section of multiple component equipment and where indicated.
 - .1 NPS 32 mm (1 1/4") and smaller: screwed ends.
 - .2 NPS 50 mm (2") and smaller: screwed ends.
 - .3 NPS 65 mm (2 1/2") and over: Flanged ends.
- .3 Drain valves: Gate, Class 125, non-rising stem, solid wedge disc, with chain and cap.
- .4 Swing check valves:
 - .1 NPS 50 mm (2") and under:
 - .1 Class 150, swing, with PFTE disc, as specified. Bronze. Jenkins 4475TJ.
 - .2 NPS 65 mm (2 1/2") and over:
 - .1 Flanged or Grooved ends, Bronze trim, Cast Iron: Gate, Globe, Check.
- .5 Ball valves:
 - .1 NPS 80 mm (3") and under:
 - .1 Body and cap: cast high tensile bronze to ASTM B62.
 - .2 Pressure rating: Class 125, 860 kPa (125 psi) steam, WP = 1.4 MPa (203 psi) WOG.
 - .3 Connections:
 - .1 NPS 50 mm (2") and under screwed ends to ANSI B1.20.1 and with hex. shoulders.
 - .2 NPS 65 mm (2 1/2") and over flanged or grooved ends.
 - .4 Stem: stainless steel tamperproof ball drive.
 - .5 Ball and seat: replaceable stainless steel solid ball and teflon seats.
 - .6 Operator: removable lever handle.
 - .7 Extended handles on chilled water valves.
 - .8 Full port.
- .6 All valves shall be of commercial grade and of same manufacturer.
- .7 Acceptable Manufacturers:
 - .1 Newman Hattersley Canada Ltd.
 - .2 Jenkins/Crane
 - .3 Milwaukee
 - .4 Toyo
 - .5 Kitz

2.3 BALANCING VALVES

- .1 Size 15 mm (1/2") to 50mm (2"): Bronze body, brass ball, NPT connections and variable orifice.
- .2 Size 65 mm (2 1/2") to larger: Cast iron body, raised flange connections, glove style with brass plug.
- .3 Differential pressure readout ports with internal EPT inserts and check valves, 6 mm (¼") NPT tapped drain/purge ports, memory stop and calibrated nameplate.
- .4 Acceptable Manufacturers:
 - .1 Bell & Gossett Circuit Setters
 - .2 Armstrong
 - .3 Taco
 - .4 Tour & Anderson
 - .5 Oventrop

2.4 TRIPLE DUTY VALVE

- .1 Straight pattern, combination check, throttling shut off and calibrated balancing valve, heavy duty cast iron construction with standard 125 psig ANSI flanged connections rated for maximum working pressure of 175 psig at 250°F.
- .2 Valve shall be fitted with a replaceable bronze disk with EPDM seat insert, stainless steel stem and chatter preventing spring. Valve design shall permit replacing under full system pressure.
- .3 Valve shall be equipped with brass readout valves (with integral check valves).
- .4 Acceptable Manufacturers:
 - .1 Bell & Gossett
 - .2 Armstrong

2.5 AUTOMATIC AIR VENT

- .1 Industrial float vent: cast iron body and NPS 15 mm (1/2") connection and rated at 860 kpa (125 psi) working pressure.
- .2 Float: solid material suitable for 115°C (240°F) working temperature.
- .3 Plastic vents are not acceptable.
- .4 Acceptable Manufacturers:
 - .1 Maid-O-Mist No. 67
 - .2 Spirax Sarco

Part 3 Execution

3.1 PIPING INSTALLATION

- .1 Installation shall be by a licensed pipe fitter.
- .2 Connect to equipment in accordance with manufacturer's instruction unless otherwise indicated.
- .3 Install concealed pipes close to building structure to keep furring space to minimum. Install to conserve headroom and space. Run exposed piping parallel to walls. Group piping wherever practical.
- .4 Slope piping in direction of drainage and for positive venting.
- .5 Use eccentric reducers at pipe size change installed to provide positive drainage or positive venting.
- .6 Provide clearance for installation of insulation and access for maintenance of equipment, valves and fittings.
- .7 Ream pipes, clean scale and dirt, inside and outside, before and after assembly.
- .8 Assemble piping using fittings manufactured to ANSI standards.
- .9 Saddle type branch fittings may be used on mains if branch line is no larger than half the size of main. Hole saw or drill and ream main to maintain full inside diameter of branch line prior to welding saddle.

3.2 VALVE INSTALLATION

- .1 Install rising stem valves in upright position with stem above horizontal.
- .2 Install butterfly valves on chilled water and condenser water lines only.
- .3 Install gate or ball valves at branch take-offs and to isolate each piece of equipment, and as indicated.
- .4 Install globe valves for balancing and in by-pass around control valves as indicated.
- .5 Provide silent check valves on discharge of pumps and in vertical pipes with downward flow and as indicated.
- .6 Provide swing check valves in horizontal lines as indicated.
- .7 Install chain operators on valves NPS 65 mm (2½") and over where installed more than 2400 mm (96") above floor in Boiler Rooms and Mechanical Equipment Rooms.
- .8 Provide ball valves for glycol service.

3.3 AIR VENTS

- .1 Install at high points of systems.
- .2 Install ball valve on automatic air vent inlet.
- .3 Extend vent lines in Mechanical Room with screwdriver stop at 1.8 m AFF.

3.4 CIRCUIT BALANCING VALVES

- .1 Install flow measuring stations and flow balancing valves as indicated.
 - .1 On return side of all heating devices (convectors, panels, force flows, radiation, coils, etc.).
 - .2 On return side of all water or glycol cooling coils.
 - .3 On return side of all reverse return piping loops and/or branch circuits.
- .2 Install to manufacturers requirements.
- .3 Minimum valve size shall be one pipe size smaller than piping or 20 mm ($\frac{3}{4}$ "), whichever is larger.
- .4 Refer to Testing Adjusting and Balancing Section for applicable procedures.

3.5 FILLING OF SYSTEM

- .1 Refill system with clean water adding water treatment as specified.
- .2 Co-ordinate filling of system with HVAC water treatment contractor.

3.6 TESTING

- .1 Test system in accordance with Mechanical General Requirements Section.
- .2 For glycol systems, retest with propylene glycol to ASTM E202, inhibited, for use in building system after cleaning. Repair any leaking joints, fittings or valves.

3.7 FLUSHING AND CLEANING

- .1 Scope:
 - .1 Drain and flush entire existing system and new piping.
- .2 Refer to Water Treatment Section
- .3 Procedure:
 - .1 Flushing and cleaning should only take place after successful piping pressure testing.
 - .2 Terminal device (reheat coils, heat pumps, perimeter radiation, etc.), air handling unit coils and their associated control and balancing valves should be bypassed during the preliminary flushing and cleaning process.
 - .3 Instruments such as flow meters, flow metering valves and orifice plates should only be installed after flushing and cleaning.
- .4 Timing:
 - .1 The overall construction schedule identifies piping flushing and cleaning with realistic time allotments.
 - .2 The mechanical contractor is required to provide a detailed report outlining the processes and procedures for flushing and cleaning per piping system at least 4 to 6 weeks in advance of work.
 - .3 As a minimum, at least one piping flushing and cleaning procedure shall be witnessed, by the consultant and/or commissioning agent.

- .5 The mechanical contractor shall to utilize a qualified water treatment specialist to supervise the flushing and cleaning process and provide the certified water analysis report certifying that the piping systems are clean.
- .6 Coordinate flushing and cleaning of mechanical systems with HVAC water treatment contractor and HVAC systems commissioning contractor.
- .7 Flush and clean new piping system in presence of Consultant.
- .8 Flush after pressure test for a minimum of 4 hrs.
- .9 Fill system with solution of water and non-foaming, phosphate-free detergent 3% solution by weight. Circulate for minimum of 8 hrs.
- .10 Thoroughly flush all new mechanical systems and equipment with approved cleaning chemicals designed to remove deposition from construction such as pipe dope, oils, loose mill scale and other extraneous materials. Chemicals to inhibit corrosion of various system materials and be safe to handle and use.
- .11 During circulation of cleaning solution, periodically examine and clean filters and screens and monitor changes in pressure drop across equipment.
- .12 Refill system with clean water. Circulate for at least 2 hours. Clean out strainer screens/baskets regularly. Then drain.
- .13 Drainage to include drain valves, dirt pockets, strainers, every low point in system.
- .14 Drain and flush systems until alkalinity of rinse water is equal to make-up water. Refill with clean water treated to prevent scale and corrosion during system operation.
- .15 Re-install strainer screens/baskets only after obtaining Consultant's approval and approval from HVAC water treatment contractor.
- .16 Repeat system drain and flush as often as necessary to have a clean system.
- .17 Disposal of cleaning solutions to be approved by authority having jurisdiction.
- .18 Isolate new piping system from existing system as required for system cleaning.
- .19 After hydronic system is cleaned, refill with clean water and chemical as per chemical supplier treatment.

3.8 EXISTING SYSTEM DISPOSAL

- .1 Disposal of existing system shall be to the requirements of the local and/or provincial regulations.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 Canadian Standards Association (CSA).
- .3 CAN/CSA-B214, Installation Code for Hydronic Heating Systems.
- .4 American Society for Testing and Materials (ASTM).
- .5 ASTM A47/A47M, Specification for Ferritic Malleable Iron Castings.
- .6 ASTM A48/A48M, Specification for Gray Iron Castings.
- .7 ASTM A536, Specification for Ductile Iron Castings.
- .8 ASTM B62, Specification for Composition Bronze or Ounce Metal Castings.
- .9 American Society of Mechanical Engineers (ASME).
- .10 ASME B16.1, Specification for Gray Iron Pipe Flanges and Flanged Fittings.
- .11 American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE).
- .12 Standard 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
- .13 National Energy Code of Canada for Buildings (NECB).
- .14 National Electrical Manufacturer's Association (NEMA)
- .15 NEMA MG 1, Motors and Generators.
- .16 American National Standards Institute/Hydraulics Institute (ANSI/HI)
- .17 ANSI/HI 1.3, Rotodynamic (Centrifugal) Pumps for Design and Application.
- .18 Pump manufacturer shall be ISO-9001 certified.
- .19 Each pump shall be factory tested and name-plated before shipment.
- .20 ANSI/HI 9.6.3.1-2012 standard for Preferred Operating Region (POR).

1.2 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with General Requirements.
- .2 Submit manufacturer's detailed composite wiring diagrams for control systems showing factory installed wiring and equipment on packaged equipment or required for controlling devices or ancillaries, accessories, and controllers.
- .3 Submit product data of pump curves for review showing point of operation.
- .4 Indicate piping, valves and fittings shipped loose by packaged equipment supplier, showing their final location in field assembly.

1.3 MAINTENANCE DATA

- .1 Provide maintenance data for incorporation into manual specified in general requirements.

Part 2 Products

2.1 IN-LINE CIRCULATORS

- .1 Close-coupled, inline for vertical or horizontal installation, in cast iron bronze fitted (or all bronze) construction specifically designed for quiet operation.
- .2 Pump internals shall be capable of being serviced without disturbing piping connections.
- .3 Shaft: solid stainless steel that is integral to the motor.
- .4 Motor bearings shall support the shaft via heavy-duty permanently lubricated ball bearings.
- .5 Internally-flushed mechanical seal assembly installed in an enlarged tapered seal chamber. Seal assembly shall be the unitized type with stainless steel drive tabs, EPR bellows and seat gasket, stainless steel spring, and be of a carbon silicon-carbide design with the carbon face rotating against a stationary silicon- carbide face. 300
- .6 Pump shaft shall connect to a brass impeller. Impeller shall be hydraulically and dynamically balanced, threaded onto the motor shaft.
- .7 Pump shall be designed to allow for true back pull-out access to the pump's working components for ease of maintenance.
- .8 Pump volute shall be of a cast iron design for heating systems. The connection style on the cast iron and bronze pumps shall be flanged. Volute shall include gauge ports at nozzles.
- .9 Motors shall meet scheduled horsepower, speed, and voltage. Motors shall have permanently lubricated ball bearings sized to offset the additional bearing loads associated with the closed-coupled pump design. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications.
 - .1 Motors up to 0.375 (½HP) shall be ODP, open drip proof.
 - .2 Motors above 0.375 (½HP) shall be TEFC, totally enclosed fan cooled.
- .10 Pump shall be of a maintainable design and for ease of maintenance should use machine fit parts. Press fit components shall not be permitted.
- .11 Design Pressure & Temperature: Suitable standard operations at 225°F and 175 PSIG working pressure. Working pressures shall not be de-rated at temperatures up to 250°F.
- .12 Capacity: as indicated on schedules.
- .13 Accessories:
 - .1 External mechanical seal flush line.
- .14 Acceptable Manufacturers:
 - .1 Bell & Gossett Series e90
 - .2 Armstrong
 - .3 Grundfos

2.2 VERTICAL IN-LINE CIRCULATORS (SPLIT-COUPLED)

- .1 Split-coupled, inline for vertical installation, in cast iron stainless steel fitted construction specifically designed for quiet operation.
- .2 Pump internals shall be capable of being serviced without disturbing piping connections.
- .3 Shaft: 416 stainless steel shaft that is guided by a carbon graphite lower throttle bushing.
- .4 Pump shall be equipped with a unitized inside mechanical seal assembly with flush line. The seal assembly shall have an EPR elastomer bellows and a positive metal-to-metal drive system to reduce torsional stress on the bellows. The bellows will be pressure supported without creases or folds for long life. The mechanical seal shall have a rotating carbon face against a stationary ceramic face. (As an option, an outside mechanical seal may be used in lieu of the inside mechanical seal design. The outside seal materials shall be EPR elastomer with carbon-ceramic faces.)
- .5 Pump shaft shall connect to a stainless steel impeller. Impeller shall be hydraulically and dynamically balanced to Hydraulic Institute Standards ANSI/HI 9.6.4.-2016. The allowable residual imbalance conforms to ANSI grade G6.3, keyed to the shaft and secured by a stainless steel locking capscrew or nut.
- .6 The pump shall include a spacer coupling of high tensile aluminum, split to allow servicing of the mechanical seal without disturbing the pump or motor. Coupling shall incorporate tapered washer shaft jacking design.
- .7 The combination motor bracket and volute coverplate shall be a one-piece unit to ensure concentric alignment of the motor to the pump casing. A carbon steel coupler guard shall be mounted on the motor bracket for safety.
- .8 Pump volute shall be of a Class 30 cast iron design for heating systems. Volute shall include gauge ports at nozzles, and vent and drain ports. The volute shall be designed with a base ring matching an ANSI 125# flange that can be used for pump support.
- .9 Motors shall meet scheduled horsepower, speed, and voltage. Motors shall have permanently lubricated ball bearings sized to offset the additional bearing loads associated with the closed-coupled pump design. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications.
 - .1 Motors shall be TEFC, totally enclosed fan cooled.
- .10 Pump shall be of a maintainable design and for ease of maintenance should use machine fit parts. Press fit components shall not be permitted.
- .11 Design Pressure & Temperature: Suitable standard operations at 225°F and 175 PSIG working pressure for buildings up to six stories, and 250°F and 250 PSIG working pressures for building over six stories high.

Working pressures shall not be de-rated at temperatures up to 250°F.
- .12 Capacity: as indicated on schedules.

- .13 Accessories:
 - .1 Suction strainer.
 - .2 Triple duty valve.
 - .3 One mechanical seal for each model type of primary pump.
 - .4 Field installed VFDs.
- .14 Acceptable Manufacturers:
 - .1 Bell & Gossett Series e80SC
 - .2 Armstrong
 - .3 Grundfos
- .15 The seismic capability of the pump shall allow it to withstand a horizontal load of 0.5g, excluding piping and/or fasteners used to anchor the pump to mounting pads or to the floor, without adversely affecting pump operation.

2.3 SUCTION DIFFUSER

- .1 Body: cast iron with flanged connections.
- .2 Construction strainer: with built-in disposable construction 1.19 mm (3/64") mesh no. 16, low pressure drop screen (maximum 2 psig) and NPS 25 mm (1") blowdown connection.
- .3 System strainer: Provide permanent 3.0 mm perforated stainless steel strainer (mesh no. 7) with maximum pressure drop of 1 psig.
- .4 Permanent magnet particle trap.
- .5 Full length straightening vanes.
- .6 Pressure gauge tapings.
- .7 Adjustable support leg.
- .8 Angle orientation. Line size inlet and pump suction size outlet.
- .9 Acceptable Manufacturer:
 - .1 To match pump supplier.

2.4 TRIPLE DUTY VALVES

- .1 Body: Cast iron with flanged connections. Straight pattern combination shut off, non slam check and calibrated balance valve.
- .2 Brass seat, bronze disk with EPDM seat insert.
- .3 Brass stem, stainless steel spring, teflon-graphite packing.
- .4 Brass readout valve.
- .5 Straight orientation when installed in discharge piping downstream of pump. Line size inlet and outlet.
- .6 Angle orientation when installed at pump outlet. Pump discharge size inlet and line size outlet.

- .7 Acceptable Manufacturer:
 - .1 To match pump supplier.

2.5 SPARE PARTS

- .1 Refer to Section 23 05 11 General HVAC Work Requirements.
- .2 One spare mechanical seal for each model type for primary pump.
- .3 Two (2) spare filter cartridges for each pump.

Part 3 Execution

3.1 INSTALLATION

- .1 Install equipment in accordance with manufacturer's instructions.
- .2 Reduction from line size to pump connection size shall be made with eccentric reducers attached to the pump with tops flat to allow continuity of flow.
- .3 Circulating pump shall have sufficient capacity to circulate the scheduled GPM against the scheduled external head (feet) with the horsepower and speed as scheduled and/or as denoted on the drawings. Motors shall be of electrical characteristics as scheduled, denoted and/or as indicated on the electrical plans and specifications. Pump characteristics shall be such that the head of the pump under varying conditions shall not exceed the rated horsepower of the drive motor.
- .4 On systems where the final balancing procedure requires the triple duty valve to be throttled more than 25% to attain design flow (on a constant speed pumping system), and no future capacity has been built into the pump, the pump impeller must be trimmed to represent actual system head resistance. The pump provider and engineer of record, based on the balancing contractor's reports, shall determine the final impeller trim diameter.
- .5 All piping shall be brought to equipment and pump connections in such a manner so as to prevent the possibility of any loads or stresses being applied to the connections or piping. All piping shall be fitted to the pumps even though piping adjustments may be required after the pipe is installed.
- .6 On components that require draining, contractor must provide piping to and discharging into appropriate drains.
- .7 Power wiring, as required, shall be the responsibility of the electrical contractor. All wiring shall be performed per manufacturer's instruction and applicable codes.
- .8 Control wiring for remote mounted switches and sensor / transmitters shall be the responsibility of the control's contractor. All wiring shall be performed per manufacturer's instructions and applicable codes.
- .9 In line circulators: install as indicated by flow arrows. Support at inlet and outlet flanges or unions. Install with bearing lubrication points accessible suction discharge in vertical alignment.
- .10 Ensure that pump body does not support piping or equipment. Provide stanchions or hangers for this purpose. Refer to manufacturer's installation instructions for details.

- .11 Pipe drain tapping to floor drain complete with isolating valve.
- .12 Install volute venting pet cock in accessible location.
- .13 Check rotation prior to start-up.
- .14 Install pressure gauge with plug cocks on inlet and outlet on pump.

3.2 SUCTION DIFFUSERS

- .1 Install on inlet to pumps.
- .3 Clean hydronic system with both strainers installed (mesh 16 and mech 17).
- .4 Remove construction screen strainer (mesh 16) from inlet suction guide after system cleaned and before balancing. Mount mesh 16 strainer on wall for future cleaning use

3.3 TRIPLE DUTY VALVES

- .1 Valves shall be straight pattern.
- .2 Provide 4x pipe diameter spool piece between pump discharge and triple duty valve.
- .3 Leave valves open for TAB to set.

3.4 PUMP VIBRATION

- .1 Install pumps isolated from the piping system when larger than 2" piping main.
- .2 Install pumps on vibration isolators and flex connectors when greater than 3.0 HP.
- .3 Install pumps on an inertia pad when on an upper floor level and 3.0 HP or greater. Pumps mounted on slab, on grade, for 3.0 HP or greater can be on spring isolator base.
- .4 All pumps 15 HP and greater shall be installed on inertia base regardless of location in building.

3.5 SENSORED PUMP COMMISSIONING

- .1 This contractor shall arrange for pump manufacturer's representative, BAS contractor, and mechanical contractor to be present for all equipment start-up and commissioning.
- .2 Manufacturer's representative shall complete full start-up of all sensed pumps.
- .3 Submit start-up data as part of pump maintenance manuals.
- .4 Verify in writing pump modulation has been tested and working correctly based on system requirements.

3.6 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.

- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ANSI/ASME B16.22, Wrought Copper Alloy and Copper Alloy Solder - Joint Pressure Fittings: Classes 150, 300, 600, 900, 1500, and 2500.
- .3 ANSI/ASME B16.24, Cast Copper Pipe Flanges and Flanged Fittings.
- .4 ANSI/ASME B16.26, Cast Copper Alloy Fittings for Flared Copper Tubes.
- .5 ANSI/ASME B31.5, Refrigeration Piping and Heating Transfer Components.
- .6 ASTM A307, Specification for Carbon Steel Bolts and Studs, 413.5 mPa (60,000 psi) Tensile Strength.
- .7 ASTM B280, Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
- .8 CSA B52, Mechanical Refrigeration Code.
- .9 EPS 1/RA/2, Environmental Code of Practice for Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems.

Part 2 Products

2.1 TUBING

- .1 Processed for refrigeration installations, deoxidized, dehydrated and sealed.
 - .1 Hard copper: to ASTM B280, Type ACR-B.
 - .2 Soft copper: to ASTM B280, Type ACR
 - .3 Refer to Part 3 for allowed applications.

2.2 FITTINGS

- .1 Service: design pressure 2070 kPa (300 psi) and temperature 121°C (250°F).
- .2 Brazed:
 - .1 Fittings: wrought copper to ANSI/ASME B16.22.
 - .2 Joints: silver solder, 45% Ag-15% Cu or copper-phosphorous, 95% Cu-5%P and non-corrosive flux.
- .3 Flanged:
 - .1 Bronze or brass, to ANSI/ASME B16.24, Class 150 and Class 300.
 - .2 Gaskets: suitable for service.
 - .3 Bolts, nuts and washers: to ASTM A307, heavy series.
- .4 Flared:
 - .1 Bronze or brass, for refrigeration, to ANSI/ASME 16.26.

2.3 PIPE SLEEVES

- .1 Hard copper or steel, sized to provide 6 mm (1/4") clearance all around between sleeve and uninsulated pipe or between sleeve and insulation.

2.4 VALVES

- .1 22 mm (7/8") and under: Class 500, 3.5 MPa (500 psi), globe or angle non-directional type, diaphragm, packless type, with forged brass body and bonnet, moisture proof seal for below freezing applications, brazed connections.
- .2 Over 22 mm (7/8"): Class 375, 2.5 MPa (375 psi), globe or angle type, diaphragm, packless type, back-seating, cap seal, with cast bronze body and bonnet, moisture proof seal for below freezing applications, brazed connections.

2.5 FILTER-DRIER

- .1 On lines 20 mm (3/4") outside diameter and larger, filter-drier shall be replaceable core type with Schraeder type valve.
- .2 On lines smaller than 20 mm (3/4") outside diameter, filter-drier shall be sealed type using flared copper fittings.
- .3 Size shall be full line size.
- .4 Acceptable Manufacturers:
 - .1 Mueller
 - .2 Parker
 - .3 Sporlan
 - .4 Virginia

2.6 SIGHT GLASS

- .1 Combination moisture and liquid indicator with protection cap.
- .2 Sight glass shall be full line size.
- .3 Sight glass connections shall be solid copper or brass, no copper-coated steel sight glasses allowed.
- .4 Acceptable Manufacturers:
 - .1 Mueller
 - .2 Henry
 - .3 Parker
 - .4 Superior

2.7 SUCTION LINE TRAP

- .1 Manufactured standard one-piece traps.

2.8 EXPANSION VALVES

- .1 For pressure type distributors, externally equalized with stainless steel diaphragm, and same refrigerant in thermostatic elements as in system.
- .2 Size valves to provide full rated capacity of cooling coil served. Co-ordinate selection with evaporator coil and condensing unit.
- .3 Acceptable Manufacturers:
 - .1 Henry
 - .2 Mueller
 - .3 Parker
 - .4 Sporlan

2.9 FLEXIBLE CONNECTORS

- .1 Designed for refrigerant service with bronze seamless corrugated hose and bronze braiding.
- .2 Approved Manufacturers:
 - .1 Anaconda "Vibration Eliminators" by Anamet
 - .2 Vibration Absorber Model VAF by Packless Industries
 - .3 Vibration Absorbers by Superior Valve Co
 - .4 Style "BF" Spring-flex freon connectors by Vibration Mountings.

2.10 ROOF FLASHING

- .1 Thaler or equal spun aluminum complete with insulation, cap, and rubber gasket.

2.11 PREFABRICATED PIPE ENTRY DOGHOUSE

- .1 Dog House and cover shall be fabricated from 2mm thick aluminum with UV protected powder coated finish is also acceptable.
- .2 Cover shall be gasketed to ensure air and water tightness.
- .3 Mount in curb shall be full insulated and supplied with Doghouse.
- .4 Curb shall be 610 mm (24") high with 89 mm (3.5") wide flange pre-punched for securement to roof deck.
- .5 Curb shall be insulated with 50 mm (2") thick glass fibre insulation.
- .6 Pipe entry openings shall be provided by the pipe entry chase manufacturer and be specifically made for the application. Minimum acceptable standard:
 - .1 Sigrist Exit Seal
 - .2 Vault Exit Seal
- .7 Cover shall be removable and be fastened to the curb/body with vandal resistant fasteners. Hardware shall be zinc plated or stainless steel.
- .8 Size: To suite required penetrations.

- .9 Acceptable Manufacturers:
 - .1 Sigrist Alta Pipe Chase Housing
 - .2 Vault Roof Penetration Housing
 - .3 Other Acceptable Manufacturers if approved by Consultant prior to tender close.

2.12 PIPING SUPPORT ASSEMBLY

- .1 All channel members shall be fabricated from structural grade steel conforming to one of the following ASTM specifications: A1011/A1011M, A653/A653M.
- .2 All fittings shall be fabricated from steel conforming to one of the following ASTM specifications: A575, A36/A36M or A635/A635M.
- .3 Electro galvanized cush clamps with shoulder bolt and molded thermoplastic cushion, size to suit pipe.
- .4 Acceptable Manufacturers:
 - .1 Unistrut
 - .2 Or equal

Part 3 Execution

3.1 GENERAL

- .1 Install in accordance with CSA B52, EPS 1/RA/2 and ANSI/ASME B31.5.
- .2 Connect to equipment with isolating valves and unions.
- .3 Provide space for servicing, disassemble, and removal of equipment and components all as recommended by manufacturer.
- .4 Protect all openings in piping against entry of foreign material.
- .5 Provide all necessary equipment including thermal expansion valve, sight glass, solenoid valve, filter dryer, etc., for a complete installed system. Pipe system as per manufacturer's recommendation and requirements.
- .6 Provide number of refrigerant circuits and appropriate corresponding piping as per manufacturer's recommendations and requirements.

3.2 APPLICATION

- .1 Soft copper piping is allowed to be used as follows:
 - .1 For all systems under 3 tons in nominal size, except for exterior piping.
- .2 Hard copper shall be used as follows:
 - .1 For all other systems/applications.
 - .2 For all exterior piping.

3.3 BRAZING PROCEDURES

- .1 Bleed inert gas into pipe during brazing.
- .2 Remove valve internal parts, solenoid valve coils, sight glass.
- .3 Do not apply heat near expansion valve and bulb.

3.4 PIPING INSTALLATION

- .1 General:
 - .1 Hard drawn copper tubing: do not bend. Minimize use of fittings.
 - .2 Soft drawn copper: install in a neat manner without excessive bends or twists. Minimize use of fittings.
 - .3 Fittings, joints and other connections to equipment shall be minimized in all inaccessible areas, including but not limited to areas above drywall ceilings, shafts etc.
 - .4 Pitch at least 1:240 down in direction of flow to prevent oil return to compressor during operation.
 - .5 Provide trap at base of risers greater than 2.4m (8') high and at each 7.6m (25'-0") thereafter.
 - .6 Provide inverted deep trap at top of each riser.

3.5 PRESSURE AND LEAK TESTING

- .1 Close valves on factory charged equipment and other equipment not designed for test pressures.
- .2 Leak test to CSA B52 before evacuation to 2 MPa (290 psi) and 1 MPa (145 psi) on high and low sides respectively.
- .3 Test Procedure: Build pressure up to 35 kPa (5 psi) with refrigerant gas on high and low sides. Supplement with nitrogen to required test pressure. Test for leaks with electronic or halide detector. Repair leaks and repeat tests.
- .4 Testing shall be completed to the standards of CSA B52, section 5.10 so that the exemption contained in Annex N (N.1.2) allowing areas (such as those above fully enclosed drywall ceilings) to have joints and connections installed within them is met.

3.6 DEHYDRATION AND CHARGING

- .1 Close service valves on factory charged equipment.
- .2 Ambient temperatures to be at least 13°C (55°F) for at least 12 h before and during dehydration.
- .3 Use copper lines of largest practical size to reduce evacuation time.
- .4 Use 2-stage vacuum pump with gas ballast on 2nd stage capable of pulling 5 Pa (0.02" WC) absolute and filled with dehydrated oil.
- .5 Measure system pressure with vacuum gauge. Take readings with valve between vacuum pump and system closed.

- .6 Triple evacuate all system components containing gases other than correct refrigerant or having lost holding charge as follows:
 - .1 Twice to 14 Pa (0.056" WC) absolute and hold for 4 h.
 - .2 Break vacuum with refrigerant to 14 kPa (0.056" WC).
 - .3 Final to 5 Pa (0.02" WC) absolute and hold for at least 12 h.
 - .4 Isolate pump from system, record vacuum and time readings until stabilization of vacuum.
 - .5 Submit all test results to Consultant.
- .7 Charging:
 - .1 Charge system through filter-drier and charging valve on high side. Low side charging not permitted.
 - .2 With compressors off, charge only amount necessary for proper operation of system. If system pressures equalize before system is fully charged, close charging valve and start up. With unit operating, add remainder of charge to system.
 - .3 Re-purge charging line if refrigerant container is changed during charging process.
- .8 Checks:
 - .1 Make all checks and measurements as per manufacturer's operation and maintenance instructions.
 - .2 Record and report all measurements to Consultant.

3.7 INSTRUCTIONS

- .1 Post instructions in frame with glass cover in accordance with Operation and Maintenance Manual Section and CSA B52.

3.8 PREFABRICATED PIPE CHASE

- .1 Install on prefabricated, insulated roof curb.
- .2 Install pipe chase and pipe entry to manufacturers installation instructions.
- .3 Provide field installed insulation on roof deck to match roof insulation thickness.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 SMACNA HVAC Duct Construction Standards, Metal and Flexible.
- .3 SMACNA HVAC Duct Leakage Test Manual.
- .4 ASTM A480/A480M, Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip.
- .5 ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process. (Metric).
- .6 ANSI/NFPA 90A, Installation of Air Conditioning and Ventilating Systems.
- .7 ANSI/NFPA 90B, Installation of Warm Air Heating and Air Conditioning Systems.
- .8 **ANSI/NFPA 96, Ventilation Control and Fire Protection of Commercial Cooking Operations.**
- .9 **CSA B228.1, Pipe Ducts and Fittings for Residential Type Air Conditioning Systems.**

1.2 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with Section general requirements.
- .2 Indicate following:
 - .1 Sealants
 - .2 Tape
 - .3 Proprietary Joints
 - .4 Fittings

1.3 CERTIFICATION OF RATINGS

- .1 Catalogue or published ratings shall be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.

Part 2 Products

2.1 DUCTWORK

.1 Galvanized Steel:

- .1 Galvanized steel with Z90 designation zinc coating lock forming quality: to ASTM A653/A653M.
- .2 Thickness:

Size Type	Class A Gauge	Class B Gauge	Class C Gauge
Square and Rectangular			
Up to 600 mm (24")	22	24	24
625 mm to 1000 mm (25" to 40")	20	22	24
1025 mm to 1800 mm (41" to 72")	18	20	22
Round and Oval			
Up to 300 mm (12")	24	24	24
325 mm to 600 mm (13" to 24")	22	24	24
625 mm to 900 mm (25" to 36")	20	22	24

*Following SMACNA for low pressure ductwork.

- .3 All ductwork between HVAC unit connections and 3.0 m (10'-0") downstream or to silencers shall be 1.4 mm (18 gauge).

.2 Aluminum

- .1 To ASHRAE and SMACNA. Aluminum type: 3003-H-14.
- .2 Thickness, fabrication and reinforcement: to ASHRAE and SMACNA or as indicated.
- .3 Joints: to ASHRAE and SMACNA.
 - .1 Acceptable Manufacturers:
 - .1 Ductmate Canada Ltd.
- .4 Foil tape all transverse and longitudinal joints.

2.2 DUCT CONSTRUCTION

.1 Round and oval:

- .1 Ducts: factory fabricated, spiral wound, with matching fittings and specials to SMACNA.
- .2 Transverse joints up to 900 mm (36"): slip type with tape and sealants.
- .3 Transverse joints over 900 mm (36"): Ductmate or Exanno Nexus Duct System.

.2 Square and rectangular:

- .1 Ducts: to SMACNA.
- .2 Transverse joints, longest side:
 - up to and including 750 mm (30"): SMACNA proprietary duct joints.

- .3 Ducts with sides over 750 mm (30") to 1200 mm (48"), transverse duct joint system by Ductmate/25, Nexus, or WDCI (Lite) (SMACNA "E" or "G" Type connection). Weld all corners.

- .1 Acceptable Manufacturers:

- .1 Ductmate Canada Ltd.
- .2 Nexus, Exanno Corp.
- .3 WDCI

2.3 FITTINGS

- .1 Fabrication: to SMACNA.
- .2 Radiused elbows:
 - .1 Rectangular: standard radius and or short radius with single thickness turning vanes Centreline radius: 1.5 times width of duct.
 - .2 Round:
 - .1 In exposed areas one-piece smooth radius, 1.5 times diameter.
 - .2 In concealed areas 3-piece adjustable, 1.5 times diameter.
- .3 Mitred elbows, rectangular:
 - .1 To 400 mm (16"): with double thickness turning vanes.
 - .2 Over 400 mm (16"): with double thickness turning vanes.
- .4 Branches:
 - .1 Rectangular main and branch: with 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 splitter damper.
- .5 Diffuser connection to main:
 - .1 90° round spin in collars with balancing damper and locking quadrant.
- .6 Transitions:
 - .1 Diverging: 20° maximum included angle.
 - .2 Converging: 30° maximum included angle.
- .7 Offsets:
 - .1 Full short radiused elbows.
- .8 Obstruction deflectors: maintain full cross-sectional area.

2.4 SEAL CLASSIFICATION

- .1 Classification as follows:

Maximum Pressure Pa (" w.c.)	SMACNA Seal Class	Acceptable Leakage Classification (Rectangular)	Acceptable Leakage Classification (Round)
750 (3")	A	8	4
500 (2")	B	16	8
250 (1")	B	16	8
125 (0.5")	C	16	8

- .2 Seal classification:

- .1 Class A: longitudinal seams, transverse joints, duct wall penetrations and connections made airtight with sealant and tape.
- .2 Class B: longitudinal seams, transverse joints and connections made airtight with sealant.
- .3 Class C: transverse joints and connections made air tight with gaskets, or sealant or combination thereof. Longitudinal seams sealed with foil tape or sealant.

2.5 SEALANT

- .1 Sealant: oil resistant, polymer type flame resistant duct sealant. Temperature range of -30°C (-22°F) to plus 93°C (199°F).
- .2 Flame-spread rating not more than 25.
- .3 Smoke developed classification not more than 50.
- .4 Acceptable Manufacturers:
- .1 Duro Dyne S-2
- .2 Foster

2.6 TAPE

- .1 Tape: polyvinyl treated, open weave fiberglass tape, 50 mm (2") wide.
- .1 Acceptable Manufacturers:
- .1 Duro Dyne FT-2

2.7 DUCT LEAKAGE

- .1 In accordance with SMACNA HVAC Duct Leakage Test Manual.

2.8 FIRESTOPPING

- .1 40 mm x 40 mm x 3 mm (1½" x 1½" x 16ga) retaining angles all around duct, on both sides of fire separation.
- .2 Firestopping material and installation must not distort duct.

- .3 All ductwork passing through partition walls shall be firestopped.

2.9 HANGERS AND SUPPORTS

- .1 Band hangers: use on round and oval ducts only up to 500 mm (20") diameter, of same material as duct but next sheet metal thickness heavier than duct.
- .2 Trapeze hangers: ducts over 500 mm (20") diameter or longest side, to ASHRAE and SMACNA.
- .3 Hangers: galvanized steel angle with black steel rods to ASHRAE and SMACNA following table:

Duct Size mm (")	Angle Size mm (")	Rod Size mm (")
up to 750 (30)	25 x 25 x 3 (1 x 1 x 1/8)	6 (1/4)
>750 to 1050 (>30 to 42)	40 x 40 x 3 (1½ x 1½ x 1/8)	6 (1/4)
>1050 to 1500 (>42 to 60)	40 x 40 x 3 (1½ x 1½ x 1/8)	10 (3/8)

- .4 Upper hanger attachments:
- .1 For concrete: manufactured concrete inserts.
- .1 Acceptable Manufacturers:
- .1 Myatt fig. 485
- .2 For steel joist: manufactured joist clamp or steel plate washer.
- .1 Acceptable Manufacturers:
- .1 Grinnell fig. 61 or 60
- .3 For steel beams: manufactured beam clamps:
- .1 Acceptable Manufacturers:
- .1 Grinnell Fig. 60

Part 3 Execution

3.1 GENERAL

- .1 The following systems shall conform to these requirements:

System	Pressure	Class	Material
VAV Supply	+/-	A	Galvanized steel
Science Room Exhaust	+/-	A	Stainless steel
General Exhaust	+	A	Galvanized Steel/Aluminum
Individual Exhaust	+	A	Galvanized Steel/Aluminum
Dryer Exhaust	+	A	Aluminum
Exhaust Plenum	+/-	A	Galvanized steel
HVAC Supply and Return	+/-	B	Galvanized steel
General Exhaust	-	B	Galvanized steel
Individual Exhaust	-	C	Galvanized steel/Aluminum

- .2 Do work in accordance with ASHRAE and SMACNA.
- .3 Do not break continuity of insulation vapour barrier with hangers or rods.
- .4 Support risers in accordance with ASHRAE and SMACNA.
- .5 Install breakaway joints in ductwork on each side of fire separation.
- .6 Install proprietary manufactured flanged duct joints in accordance with manufacturer's instructions.
- .7 Manufacture duct in lengths to accommodate installation of acoustic duct lining.

3.2 HANGERS

- .1 Strap hangers: install in accordance with SMACNA.
- .2 Angle hangers: complete with locking nuts and washers.
- .3 Hanger spacing: in accordance with ASHRAE, SMACNA and as follows:

Duct Size	Spacing
mm (")	mm (")
to 1500 (60")	3000 (120")
over 1500 (60")	2500 (100")

- .4 Do not support ductwork over 250 mm x 250 mm (10" x 10") from roof deck.

3.3 SEALING

- .1 Apply sealant to outside of joint to manufacturer's recommendations.
- .2 Bed tape in sealant and recoat with minimum of 1 coat of sealant to manufacturers recommendations.

3.4 LEAKAGE TESTS

- .1 Co-ordinate leakage testing with TAB contractor **and commissioning agent**. TAB contractor will be responsible for all duct testing.
- .2 Duct to be tested in accordance with SMACNA HVAC Duct Leakage Test Manual.
- .3 Leakage tests to be done in sections.
- .4 Trial leakage tests to be performed as instructed to demonstrate workmanship.
- .5 Install no additional ductwork until trial test has been passed.
- .6 Test section to be minimum of 15 m (50'-0") long with not less than 3 branch takeoffs and two 90° elbows. Maximum test length and area to be determined by BAS testing equipment. Allow for twelve (12) tests.
- .7 Complete test before insulation or concealment.
- .8 Provide all necessary end caps and fittings as required for the TAB contractor. Remove same after successful completion of duct test.
- .9 Pressure test ductwork to 1½ times operating pressure (minimum pressure 500 Pa (2" wc) all systems).

3.5 CLEANING

- .1 Keep ducts clear from dust and debris
- .2 Keep duct liner clean from dust, debris, and moisture.
- .3 At completion of project vacuum ducts if dirt or dust is present.
- .4 Where new systems connect into existing systems the existing systems shall be cleaned and vacuumed prior to reconnection. **Refer to Section 23 03 31 'HVAC System Cleaning' for more information.**
- .5 Ensure all systems are clean prior to start up.

3.6 INSTALLATION REQUIREMENTS

- .1 All ductwork is to be protected from the weather and precipitation. The top and sides of all ductwork are to be completely covered with 6mil poly to the satisfaction of the consultant. Maintain protection of the ductwork until the building is made watertight and hollow cores drained. Tape all joints.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.
- .3 ASTM C423, Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
- .4 ASTM E90, Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
- .5 ASTM E477, Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.

1.2 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with general requirements.
- .2 Provide separate shop drawings for each piece of attenuation equipment complete with product data.

1.3 PERFORMANCE RATING DATA

- .1 Provide performance rating data, certified by an accredited test laboratory and supported by calculations and verified by test results in accordance with referenced standards as follows:
 - .1 Silencer: insertion loss, pressure drop at design conditions, generated noise level.
 - .2 Acoustic plenums: transmission loss and acoustical absorption.

Part 2 Products

2.1 ABSORPTION AND INSULATING MEDIA

- .1 Acoustical performance measurements to be made in accordance with ASTM E477, ASTM E90 and ASTM C423, except where specified otherwise.
- .2 Acoustic quality, glass fibre, free of shot and odor; bacteria and fungus resistant; free of corrosion causing or accelerating agents; packed to density to meet performance requirements; and meet NBC fire requirements or requirements of authority having jurisdiction for duct lining.

2.2 ACOUSTIC SOUND PLENUMS

- .1 Panels: 50 mm thick tongue and groove connection type, designed for individual panel removal for equipment access without major dismantling of plenum.
 - .1 Outer sheet: 1.3 mm (18 gauge) thick galvanized steel to ASTM A526/A526M, with coating designation Z90.
 - .2 Inner sheet: 0.085 mm (4 mil) thick galvanized steel to ASTM A526/A526M, with coating designation Z90 with 2 mm (79 mil) diameter clean cut perforations on 5 mm (3/16") staggered centres.
 - .3 Fully framed with 1.3 mm (18 gauge) thick galvanized steel channels.
 - .4 Horizontal stiffeners: 0.85 mm (22 gauge) minimum galvanized steel on 800 mm (32") centres to control media settlement.
 - .5 Deflection: not to exceed 1/240 of unsupported panel span at design pressure differential of 2500 Pa (10" w.c.).
 - .6 Connections: as per manufacturers requirements.
- .2 Assembly:
 - .1 Panel and flashing joints externally sealed with 6 mm (1/4") diameter bead of non sag, non hardening sealant. Floor channel to floor connection sealed with 3 mm x 15 mm (1/8" x 1/2") monolastomeric tape.
 - .2 Factory cut and frame openings where greatest dimension exceeds 300 mm (12"). Smaller panel openings, to be site located and cut 50 mm (2") larger in diameter, sleeved with 0.7 mm (22 gauge) minimum galvanized steel.
 - .3 Fill space between pipe or conduit and sleeve with acoustic media, covered and mastic sealed in accordance with manufacturer's instructions.
 - .4 No sensory leakage at design pressure differential of 1000 KPa (145 psi).
 - .5 Assembly RSI not less than 1.2 m²C/W (6.81 ft²F/Btuh) at 10°C (50°F).
- .3 Acceptable Manufacturers:
 - .1 BVA Systems
 - .2 Vibron
 - .3 VAW Systems
 - .4 IAC Acoustics

Part 3 Execution

3.1 INSTALLATION

- .1 Install in accordance with manufacturer's instructions.
- .2 Noise flanking: where indicated, install in wall sleeve with uniform clearance all around to ensure no contact of silencer with wall sleeve. Pack with flexible, non hardening caulking on both sides of sleeves.
- .3 Instrument test ports: install at inlet and outlet to permit measurement of insertion loss and pressure loss.
- .4 Suspension: to manufacturer's instructions.

3.2 SITE VISIT

- .1 Supplier of equipment to visit site to ensure installation is in accordance with manufacturer's instructions and submit report to Consultant
- .2 Make adjustments and corrections in accordance with written report.
- .3 Provide Consultant with notice 48h in advance of visit.

3.3 TESTING

- .1 Experienced and competent sound and vibration testing professional engineer to take sound measurement after start up and testing, adjusting and balancing of systems to Testing Adjusting and Balancing (TAB) of Mechanical Systems section.
- .2 Sound measurements to extend over specified frequency range of 250 to 2000 and to be taken:
 - .1 Upstream and downstream of each silencer and plenum.
 - .2 In areas adjacent to mechanical equipment rooms, duct and pipe shafts.
 - .3 At 1800 mm (72") above floor adjacent to first air terminal.
- .3 Provide Consultant with notice 48 h in advance of commencement of tests.
- .4 Establish adequacy of equipment isolation, acceptability of noise levels in occupied areas, other conditions affecting acoustics and, where appropriate, recommendation for remedial measures and costs.
- .5 Submit complete report of test results including sound curves.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 SMACNA HVAC Duct Construction Standards, Metal and Flexible.
- .3 ANSI/NFPA 90B, Installation of Warm Air Heating and Air Conditioning Systems.
- .4 ANSI/NFPA 96, Ventilation Control and Fire Protection of Commercial Cooking Operations.
- .5 CSA B228.1, Pipes, Ducts and Fittings for Residential Type Air Conditioning.

1.2 PRODUCT DATA

- .1 Submit product data in accordance with general requirements.
- .2 Indicate the following:
 - .1 Flexible connections.
 - .2 Duct access doors.
 - .3 Turning vanes.
 - .4 Instrument test ports.

1.3 CERTIFICATION OF RATINGS

- .1 Catalogue or published ratings shall be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.

Part 2 Products

2.1 GENERAL

- .1 Manufacture in accordance with CSA B228.1.

2.2 FLEXIBLE CONNECTIONS

- .1 Frame: galvanized sheet metal frame with fabric clenched by means of double locked seams.
- .2 Material:
 - .1 Fire resistant, self extinguishing, neoprene coated glass fabric, temperature rated at -40°C (-40°F) to plus 90°C (194°F), density of 1.3 kg/m.

2.3 ACCESS DOORS IN DUCTS

- .1 Non-insulated ducts: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm (25 gauge) thick complete with sheet metal angle frame.

- .2 Insulated ducts: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm (24 gauge) thick complete with sheet metal angle frame and 25 mm (1") thick rigid glass fibre insulation.
- .3 Gaskets: neoprene
- .4 Hardware:
 - .1 Up to 300 mm (12"): 2 sash locks
 - .2 301 mm to 450 mm (13" to 18"): 4 sash locks Complete with safety chain.
 - .3 451 mm to 1000 mm (19" to 40"): piano hinge and minimum 2 sash locks.
 - .4 Doors over 1000 mm (40"): piano hinge and 2 handles operable from both sides.
 - .5 Hold open devices.
- .5 Acceptable Manufacturers:
 - .1 Nailor
 - .2 E. H. Price
 - .3 Titus

2.4 TURNING VANES

- .1 Factory or shop fabricated double thickness, to recommendations of SMACNA and as indicated.
- .2 Acceptable Manufacturers:
 - .1 Duro Dyne
 - .2 Ductmate

2.5 INSTRUMENT TEST PORTS

- .1 1.6 mm (16 gauge) thick steel zinc plated after manufacture.
- .2 Cam lock handles with neoprene expansion plug and handle chain.
- .3 28 mm (1 1/8") minimum inside diameter. Length to suit insulation thickness.
- .4 Neoprene mounting gasket.
- .5 Acceptable Manufacturers:
 - .1 Duro Dyne IP1 or IP2
 - .2 Duct mate

2.6 PREFABRICATED ROOF CURB

- .1 Construction: welded with exposed joints ground flush and smooth.
- .2 Material: 1.3 mm (18 gauge) galvanized steel with raised cant and wood nailer.
- .3 25 mm (1") insulation 3 lb density.
- .4 Acceptable Manufacturers:
 - .1 Greenheck GPR – 600 mm (24") high
 - .2 Penn

2.7 SPIN-IN COLLAR

- .1 Construction: galvanized straight or conical spin-in collar complete with spin-in bead and crimped collar connection.
- .2 Provide balancing damper where indicated.
- .3 Acceptable Manufacturers:
 - .1 Ecco Manufacturing
 - .2 Flex Master

Part 3 Execution

3.1 INSTALLATION

- .1 Flexible connections:
 - .1 Install in following locations:
 - .1 Inlets and outlets to supply air units and fans. (Unless internally isolated)
 - .2 Inlets and outlets of exhaust and return air fans.
 - .3 As indicated.
 - .2 Length of connection: 100 mm (4").
 - .3 Minimum distance between metal parts when system in operation: 75 mm (3").
 - .4 Install in accordance with recommendations of SMACNA.
 - .5 When fan is running:
 - .1 Ducting on each side of flexible connection to be in alignment.
 - .2 Ensure slack material in flexible connection.
- .2 Access doors and viewing panels:
 - .1 Size:
 - .1 600 mm x 600 mm (24" x 24") for person size entry.
 - .2 600 mm x 1000 mm (24" x 40") for servicing entry.
 - .3 300 mm x 300 mm (12" x 12") for viewing.
 - .4 As indicated.
 - .2 Location:
 - .1 At fire and smoke dampers.
 - .2 At control dampers.
 - .3 At devices requiring maintenance.
 - .4 At locations required by code.
 - .5 At inlet and outlet of reheat coils.
 - .6 Elsewhere as indicated.
 - .7 Inlet and outlet of duct mounted coils.

- .3 Instrument test ports.
 - .1 General:
 - .1 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's instructions.
 - .2 Locate to permit easy manipulation of instruments
 - .3 Install insulation port extensions as required.
 - .4 Locations.
 - .1 For traverse readings:
 - .1 At ducted inlets to roof and wall exhausters.
 - .2 At inlets and outlets of other fan systems.
 - .3 At main and sub-main ducts.
 - .4 And as indicated.
 - .2 For temperature readings:
 - .1 At outside air intakes.
 - .2 In mixed air applications in locations as approved by Consultant.
 - .3 At inlet and outlet of coils.
 - .4 Downstream of junctions of two converging air streams of different temperatures.
 - .5 And as indicated.
- .4 Turning vanes:
 - .1 Install in accordance with recommendations of SMACNA and as indicated.
 - .2 Install on supply ducts only.

3.2 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.
- .3 Warranty Coverage:
 - .1 Applies to parts and labour.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 SMACNA HVAC Duct Construction Standards, Metal and Flexible.

1.2 PRODUCT DATA

- .1 Submit product data in accordance with general requirements
- .2 Indicate the following: performance data.

Part 2 Products

2.1 GENERAL

- .1 Manufacture to SMACNA standards.

2.2 SINGLE BLADE DAMPERS

- .1 Of same material as duct, but one sheet metal thickness heavier. V-groove stiffened, minimum 1.6 mm (16 gauge).
- .2 Size and configuration to recommendations of SMACNA, except maximum height 100 mm (4").
- .3 Shaft extension to accommodate insulation thickness and locking quadrant.
- .4 Inside and outside nylon end bearings.
- .5 Channel frame of same material as adjacent duct, complete with angle stop.

2.3 MULTI-BLADED DAMPERS

- .1 Factory manufactured of material compatible with duct.
- .2 Opposed blade: configuration, metal thickness and construction to recommendations of SMACNA.
- .3 Maximum blade height:
 - .1 50 mm (2") up to 375 mm (15") high duct.
 - .2 100 mm (4") max 400 mm (16") high duct and over.
- .4 Bearings: self-lubricating nylon.
- .5 Linkage: shaft extension with locking quadrant.
- .6 Channel frame of same material as adjacent duct, complete with angle stop.
- .7 Shaft extension to accommodate insulation thickness and locking quadrants.

.8 Acceptable Manufacturers:

- .1 Duro Dyne
- .2 E.H. Price
- .3 Nailor
- .4 T.A. Morrison
- .5 Tamco
- .6 Ruskin
- .7 Ventex/Alumavent
- .8 United Enertech

2.4 LOCKING QUADRANTS

- .1 6 mm (1/4") dial regulator with square bearing shaft.
 - .1 18 gauge oval frame, cadmium plated, clearly shows damper position.
 - .2 18 gauge formed handle for easy adjustment.
 - .3 Bolt and wing nut lock damper securely.
 - .4 Offset mounting holes avoid interference with damper movement and mechanical fastening to duct.
- .2 9 mm (3/8") and larger: clamp quadrant with square bearing shaft.
 - .1 Accommodates and securely locks square rod, bearing fitting and adaptor pins.
 - .2 Heavily ribbed 16 gauge steel frame, 3 mm (1/8") thick formed steel handle, cadmium-plated.
 - .3 By tightening nut, bearing is securely locked in handle, preventing slippage and rattle.
 - .4 Neoprene and steel washer assembly seals bearing opening to eliminate air-leakage.
 - .5 Screw holes for mechanically fastening to ductwork.
- .3 High pressure system locking quadrant:
 - .1 Airtight, rattle-proof regulator, designed for ZERO leakage at high pressure. Use for applications up to 500°F constant temperature.
 - .2 Handle design for easy recognition of damper position.
 - .3 Heavy-gauge, zinc-plated steel, 2 high temperature rubber seals and washers, end bearing support, and 2 end bearings. Pressure loss and damper rattle in ductwork has been a constant annoyance for as long as HVAC ductwork has been installed. Now, a truly air-tight, rattle-proof regulator is available. The SPEC-SEAL regulator utilizes a special high-temperature rubber seal to eliminate leakage and rattle even at many times the pressure found in high pressure.
 - .4 Soft, comfortable grip handle with a highly-visible, plastic cover which indicates the damper position.
 - .5 Handle to accommodate 9 mm (3/8") or 12 mm (1/2") to match damper shaft size, square and round bearing shafts.

- .4 Acceptable Manufacturers:
 - .1 Duro Dyne
 - .2 Ductmate
 - .3 Pottorff

Part 3 Execution

3.1 INSTALLATION

- .1 Install where indicated.
- .2 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's instructions.
- .3 For supply, return and exhaust systems, locate balancing dampers in each branch duct.
 - .1 Single blade dampers up to 200 mm (8").
 - .2 Multi-blade dampers over 200 mm (8").
- .4 Runouts to registers and diffusers: install single blade damper located as close as possible to main ducts.
- .5 All dampers to be vibration free.
- .6 Leave all dampers in open position for T.A.B.
- .7 Fasten locking quadrants to ductwork and shaft.
- .8 Place locking quadrants on standoffs where ductwork insulated.
- .9 Lock down quadrant arm in the open position.

3.2 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.
- .3 Warranty Coverage:
 - .1 Applies to parts and labour.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ANSI/NFPA 90A, Installation of Air Conditioning and Ventilating Systems.
- .3 CAN/ULC-S112, Standard Method of Fire Test of Fire Damper Assemblies.
- .4 CAN/ULC-S112.1, Standard Method of Fire Test of Ceiling Firestop Flap Assemblies.
- .5 ULC-S505, Fusible Links for Fire Protection Service.

1.2 PRODUCT DATA

- .1 Submit product data in accordance with general requirements.
- .2 Indicate the following:
 - .1 Fire dampers.
 - .2 Operators.
 - .3 Firestop flaps.
 - .4 Fusible links.

1.3 MAINTENANCE DATA

- .1 Provide maintenance data for incorporation into manual specified in general requirements.

1.4 MAINTENANCE MATERIALS

- .1 Provide the following:
 - .1 Six (6) fusible links of each type.

1.5 CERTIFICATION OF RATINGS

- .1 Catalogue or published ratings shall be those obtained from tests carried out by manufacturer or those ordered by him from independent testing agency signifying adherence to codes and standards.

Part 2 Products

2.1 FIRE DAMPERS (DYNAMIC)

- .1 Multi blade or roll type, fire damper suitable for HVAC system velocities up to 2000 fpm (610 m/mm), dual direction air flow, max 4" wg pressure.
- .2 Mild steel, factory fabricated for fire rating requirement to maintain integrity of fire wall and/or fire separation.
- .3 Top hinged: offset single damper, round or square; multi-blade hinged or interlocking type; guillotine type; sized to maintain full duct cross section.

- .4 Stainless closure spring to positively close damper upon fusible link release, for horizontal or vertical orientations.
- .5 Linkage concealed in frame.
- .6 40 mm x 40 mm x 3 mm (1½" x 1½" x 16ga) retaining angle iron frame, on full perimeter of fire damper, on both sides of fire separation being pierced.
- .7 Fire damper assemblies and type to meet requirements of provincial fire authority and authority having jurisdiction.
- .8 Acceptable Manufacturers:
 - .1 Ruskin
 - .2 Nailor
 - .3 E.H. Price
 - .4 T.A. Morrison
 - .5 Tamco
 - .6 Greenheck
 - .7 Ventex/Alumavent
 - .8 Pottorff

2.2 MULTIBLADE DAMPERS (DYNAMIC OR STATIC)

- .1 Provide and install multiblade dampers where roll type fire dampers do not have a ULC listing for the size of the penetration through the assembly.
- .2 Multi blade type fire dampers shall be suitable for HVAC system velocities up to 2000 fpm (610 m/mm), dual direction air flow, max 4" wg pressure.
- .3 Damper shall be labelled for dynamic or static systems as appropriate for the installed location.
- .4 Frame shall be constructed on 16 ga (1.6) steel hat channel with mitered corners reinforced with die-formed corner gussets for strength.
- .5 Damper blades shall be 14 ga (2.0) equivalent steel formed double skin, airfoil design.
- .6 Damper shall be of opposed blade configuration with an interlocking blade design. Blade seals are not acceptable.
- .7 Blade axels shall be double bolted at each end of the blade to provide positive locking connection.
- .8 Bearings shall be sintered stainless steel type.
- .9 Blade linkage shall be zero-maintenance, concealed in frame and out of the air stream.
- .10 Each damper shall be complete with a UL listed fusible link that will cause the damper to close and lock in closed position by means of an over centre/knee lock linkage for assured closure.
- .11 Each damper shall be provided with an internal manual locking quadrant(s) for setting and locking of blades in desired position.

- .12 Provide a steel sleeve of appropriate gauge and length for the assembly being penetrated.
- .13 Provide a 40 mm x 40 mm x 3 mm (1½" x 1½" x 16ga) retaining angle iron frame, on full perimeter of fire damper, on both sides of fire separation being pierced.
- .14 Fire damper assemblies and type to meet requirements of provincial fire authority and authority having jurisdiction.
- .15 Acceptable Manufacturers:
 - .1 Ruskin
 - .2 Nailor
 - .3 E.H. Price
 - .4 T.A. Morrison
 - .5 Tamco
 - .6 Greenheck
 - .7 Ventex/Alumavent
 - .8 Pottorff

Part 3 Execution

3.1 INSTALLATION

- .1 Provide where indicated and at all fire rated partitions indicated, on architectural drawing.
- .2 Install in accordance with ANSI/NFPA 90A and in accordance with conditions of ULC listing.
- .3 Maintain integrity of fire separation.
- .4 After completion and prior to concealment obtain approvals of complete installation from authority having jurisdiction.
- .5 Install access door adjacent to each damper.
- .6 Coordinate with installer of firestopping.
- .7 Static fire dampers: Only on transfer air ducts where ductwork is not connected to a fan/blower.
- .8 Dynamic fire dampers: In all duct work where air is moved by a fan/blower.

3.2 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.

- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.
- .3 Warranty Coverage:
 - .1 Applies to parts and labour.

END OF SECTION

Part 1 General

1.1 CODES AND STANDARDS

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ANSI/NFPA 90A, Installation of Air Conditioning and Ventilating Systems.
- .3 CAN/ULC-S112, Standard Method of Fire Test of Fire Damper Assemblies.
- .4 CAN/ULC-S112.1, Standard Method of Fire Test of Ceiling Firestop Flap Assemblies.
- .5 ULC-S505, Fusible Links for Fire Protection Service.
- .6 CAN/ULC-S524, Installation of Fire Alarm Systems
- .7 CAN/ULC-S1001.11, Integrated Systems Testing of Fire Protection and Life Safety Systems.

1.2 PRODUCT DATA

- .1 Submit product data in accordance with general requirements indicating the following:
 - .1 Damper type
 - .2 Operators
 - .3 Fusible links
 - .4 Smoke detectors
 - .5 Power requirements
 - .6 Size, orientation, construction

1.3 MAINTENANCE DATA

- .1 Provide maintenance data for incorporation into manual specified in general requirements.

1.4 MAINTENANCE MATERIALS

- .1 Provide the following:
 - .1 Six (6) fusible links of each type.

1.5 CERTIFICATION OF RATINGS

- .1 Catalogue or published ratings shall be those obtained from tests carried out by manufacturer or those ordered by him from independent testing agency signifying adherence to codes and standards.

Part 2 Products

2.1 SMOKE DAMPERS

- .1 Provide a complete system, consisting of the damper, damper actuator, smoke detector with duct sample tube, sleeve and all other components necessary for a complete and operable system. **The assembly shall be factory assembled as a single unit.** Field assembly shall be permitted at contractor discretion provided all listings are maintained and the installation follows all manufacturer installation guidelines.
- .2 Damper
 - .1 Damper shall be ULC listed and labelled
 - .2 Both damper and damper actuator to be ULC listed and labelled.
 - .3 Normally closed smoke/seal: folding blade type. Blade edge seals of flexible stainless steel shall provide required constant sealing pressure. Stainless steel negator springs with locking devices shall ensure positive closure for units.
 - .4 Damper shall have Class I leakage rating.
 - .5 Suitable for horizontal or vertical installations.
 - .6 Damper Material: Damper material shall match ductwork it is installed in (i.e., stainless steel in laboratory). Refer to specification section 23 31 13 Metal Ducts.
- .3 Actuator
 - .1 Actuator shall be ULC listed and labelled
 - .2 Motorized actuator: 2-position, spring return, normally open with power on. When power is interrupted damper shall close automatically. Upon return of power, damper shall automatically reset open. Actuators are to be located outside of airstream, unless otherwise specified or shown on drawings.
 - .3 Exterior visualization of damper position.
 - .4 Damper actuator end switches for monitoring damper position by the BAS.
- .4 Factory sleeve.
 - .1 Type and style: matching application.
- .5 Operating Temperature: 0° Celsius to 99° Celsius ambient temperature rating for 300 fpm to 4000 fpm air velocity.
- .6 Smoke Detector:
 - .1 ULC approved photoelectric duct smoke detector.
 - .2 Operates from 300 to 3000 ft/min air velocity (fan system), -4 to 158°F temperature, and 0 to 95% non-condensing humidity.
 - .3 Operates from 100 to 4000 ft/min air velocity, -4 to 158°F temperature and 0 – 95% non-condensing humidity (transfer ducts).
 - .4 Test/reset button with LED display.
 - .5 The detector housing shall be ULC listed specifically for use in air handling systems; capable of local testing via magnetic switch and test button; duct mounted smoke detector with sampling tube, housing.

- .6 The detector shall incorporate separate 2.0A 30VDC Alarm and Supervisory contacts. Alarm contacts shall be normally open (N.O.) in which closed contacts will indicate an alarm condition to the fire alarm panel. Supervisory contacts shall be normally closed (N.C.) in which open contacts will indicate a trouble condition to the fire alarm panel.
- .7 Damper assembly to operate at 120V with single point power connection.
- .8 Large damper sizes can be provided in multiple sections. Field assembly is acceptable following manufacturer's installation guidelines.
- .9 Size: as indicated on drawings.
- .10 Detectors and electrical components within the airstream shall be classified for use in a Class I, Zone 2 system (as defined by the Electrical Safety Code).
- .11 Acceptable Manufacturers:
 - .1 E H Price
 - .2 NCA Ltd.
 - .3 Nailor Industries Inc.
 - .4 Ruskin
 - .5 Alumavent
 - .6 United Enertech
 - .7 Safeair-Dowco (stainless steel)
 - .8 Pottorff

2.2 COMBINATION FIRE AND SMOKE DAMPERS

- .1 Provide a complete system, consisting of the damper, damper actuator, smoke detector with duct sampling tube, sleeve and all other components necessary for a complete and operable system. The assembly shall be factory assembled as a single unit. Field assembly shall be permitted at contractor discretion provided all listings are maintained and the installation follows all manufacturer installation guidelines.
- .2 Damper
 - .1 Damper shall be ULC listed and labelled
 - .2 Both damper and damper actuator to be ULC listed and labelled.
 - .3 Normally closed smoke/seal: folding blade type. Blade edge seals of flexible stainless steel shall provide required constant sealing pressure. Stainless steel negator springs with locking devices shall ensure positive closure for units.
 - .4 Damper shall have Class I leakage rating.
 - .5 Suitable for horizontal or vertical installations.
 - .6 Damper Material: Damper material shall match ductwork it is installed in (i.e., stainless steel in laboratory). Refer to specification section 23 31 13 Metal Ducts.

- .3 Actuator/Link
 - .1 Actuator shall be ULC listed and labelled
 - .2 Motorized actuator: 2-position, spring return, normally open with power on. When power is interrupted damper shall close automatically. Upon return of power, damper shall automatically reset open. Actuators are to be located outside of airstream, unless otherwise specified or shown on drawings.
 - .3 Exterior visualization of damper position.
 - .4 Damper actuator end switches for monitoring damper position by the BAS.
 - .5 Combined actuator: electrical control system actuated from smoke sensor or smoke detection system and from fusible link.
 - .6 Fusible link, or electric re-settable link (ERL).
 - .7 Electric fire sensor capable of remote openable control is to be provided in place of fusible link where specifically indicated in project documents.
 - .8 Where ERL or electric fire sensor is used in place of fusible link, this device shall fail closed upon power failure.
- .4 Factory sleeve.
 - .1 Type and style: matching application.
- .5 Operating Temperature: 0° Celsius to 99° Celsius ambient temperature rating for 300 fpm to 4000 fpm air velocity.
- .6 Smoke Detector:
 - .1 ULC approved photoelectric duct smoke detector;
 - .2 Operates from 300 to 3000 ft/min air velocity (fan systems), -4 to 158°F temperature, and 0 to 95% non-condensing humidity;
 - .3 Operates from 100 to 4000 ft/min air velocity, -4 to 158°F temperature and 0 – 95% non-condensing humidity (transfer ducts)
 - .4 Test/reset button with LED display;
 - .5 The detector housing shall be ULC listed specifically for use in air handling systems; capable of local testing via magnetic switch and test button; duct mounted smoke detector with sampling tube, housing
 - .6 The detector shall incorporate separate 2.0A 30VDC Alarm and Supervisory contacts. Alarm contacts shall be normally open (N.O.) in which closed contacts will indicate an alarm condition to the fire alarm panel. Supervisory contacts shall be normally closed (N.C.) in which open contacts will indicate a trouble condition to the fire alarm panel.
- .7 Damper assembly to operate at 120V with single point power connection.
- .8 Large damper sizes can be provided in multiple sections. Field assembly is acceptable following manufacturer's installation guidelines.
- .9 Fire rating to match wall assembly i.e. 1 hour/1 ½ hour/2 hour/ 3 hour.
- .10 Size: as indicated on drawings.
- .11 Detectors and electrical components within the airstream shall be classified for use in a Class I, Zone 2 system (as defined by the Electrical Safety Code).

- .12 Acceptable Manufacturers:
 - .1 E H Price
 - .2 NCA Ltd.
 - .3 Nailor Industries Inc.
 - .4 Ruskin
 - .5 Alumavent
 - .6 United Enertech
 - .7 Pottorff
 - .8 Safeair-Dowco (stainless steel)
 - .9 Pottorff

2.3 LOCATION OF SMOKE DETECTORS

- .1 Ontario Building Code Section 3.1.8.11 requires the smoke detector to be installed downstream of the damper.
- .2 Ship units to site to suit supply or return/exhaust configuration.
- .3 The contractor shall be responsible to cover all costs of a qualified Electrician/Fire Alarm Technician should field relocation of the damper components be required.

2.4 TRANSFER DUCTS

- .1 In accordance with OBC 3.1.8.11, provide secondary smoke detector at all transfer ductwork. Smoke detector shall be installed on both sides of rated separation.
- .2 This contractor shall be responsible to cover all costs of a qualified Electrician/Fire alarm Technician to field supply, install, and wire the secondary detectors.
- .3 This contractor shall extend transfer ductwork and acoustic lining to facilitate proper installation and clearance requirements.

2.5 NUMBER OF AIR TYPE SMOKE DETECTORS

- .1 Where air velocities are greater than 1.5 m/s (300 feet per second), one air duct type detector shall be installed for every 1.5 meters square (16 square feet) of cross-sectional duct area.
- .2 Where air velocities are less than 1.5 m/s (300 feet per second), one duct type smoke detector shall be installed for every 0.5 meters square (5.3 square feet) or cross-sectional duct area.

2.6 PRESSURE RELIEF DOORS

- .1 Frames shall be Z-shape, 12 gage (2.8) galvanized steel.
- .2 Door shall be 12 gage (2.8) galvanized steel, hinged on one side.
- .3 Seal shall be around the door perimeter allowing no more than 7 cfm/ft² at 1.0 inch w.g..
- .4 Door shall include stainless steel springs to close door upon pressure relief and system shutdown.

- .5 All release mechanisms, springs and parts shall be completely out of airstream.
- .6 Pressure relief settings available from 2" (0.5 kPa) to 10" (2.49 kPa) increments of 1" w.g. (0.25 kPa). Supplier shall examine plans to provide appropriate pressure relief based on associated air handling system.
- .7 Pressure relief mechanism shall be factory calibrated in an AMCA Registered Laboratory.
- .8 Pressure Relief Doors shall be provided as indicated in the execution section.

Part 3 Execution

3.1 INSTALLATION

- .1 Provide combination fire and smoke dampers where indicated and at all duct penetrations through fire rated smoke barrier partitions indicated on architectural drawings. To provide separated fire dampers and smoke dampers, obtain approval from the consultant for the alternate arrangement.
- .2 Provide pressure relief doors (both positive and negative as applicable) as follows:
 - .1 For all systems with a combination fire smoke or smoke damper in the duct main of the system when:
 - .1 The system operates at static pressure of 1.0 inches w.g. or higher; and
 - .2 More than 50% of the system airflow passes through the combination fire/smoke or smoke damper.
 - .2 Where/as indicated on the plans.
- .3 Install in accordance with ANSI/NFPA 90A, in accordance with conditions of ULC listing and manufacturer's recommendation.
- .4 Maintain integrity of smoke separation and fire rating.
- .5 After completion and prior to concealment obtain approvals of complete installation from authority having jurisdiction.
- .6 Install access door adjacent to each damper and smoke detector.
- .7 Front grille access for through wall dampers that terminate in a grille is acceptable.
- .8 Provide proper firestopping and duct seal to fire barrier wall.
- .9 Confirm proper operation and test sheets.
- .10 Should contractor provide separated devices mount smoke detector downstream of damper and within 1.5 m (5 ft) of damper.
- .11 Ensure access doors/panels, fusible links, damper actuators and sensors are easily observed and accessible.

3.2 LOCATION OF SMOKE DETECTORS

- .1 Ontario Building Code Section 3.1.8.11 requires the smoke detector to be installed downstream of the damper.
- .2 Ship units to site to suit supply or return/exhaust configuration.

- .3 The contractor shall be responsible to cover all costs of a qualified Electrician/Fire Alarm Technician should field relocation of the damper components be required.

3.3 TRANSFER DUCTS

- .1 In accordance with OBC 3.1.8.11, provide secondary smoke detector at all transfer ductwork. Smoke detector shall be installed on both sides of rated separation.
- .2 This contractor shall be responsible to cover all costs of a qualified Electrician/Fire alarm Technician to field supply, install, and wire the secondary detectors.
- .3 This contractor shall extend transfer ductwork and acoustic lining to facilitate proper installation and clearance requirements.

3.4 PROTECTION

- .1 Contractor is to ensure all fire smoke dampers detectors are protected from dust, dirt, humidity, and water at all times during construction. This applies to detectors installed, stored on site or stored in storage containers. Contractor shall seal all open-ended ductwork on site at all times. Failure to properly protect dampers, ductwork and detectors will result in the Contractor cleaning all dampers and ductwork. Any detectors that are damaged or dirty shall be replaced at the contractor's expense.

3.5 WIRING

- .1 All fire alarm wiring shall be 1 hour rated and in conduit or as per electrical fire alarm wiring requirement.
- .2 When the building has a BAS contractor, the BAS contractor can be used to provide the 120V power wiring.

3.6 DAMPER POSITION MONITORING

- .1 In all cases the BAS contractor shall monitor the damper actuator end switches i.e. "closed position and open position".

3.7 CLEANING

- .1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools, and equipment.

3.8 INTEGRATED LIFE SAFETY SYSTEMS TESTING

- .1 Prior to the building Integrated Life Safety Systems Testing the mechanical contractor shall commission/verify the operation of all installed smoke dampers.
- .2 Participate in the Integrated Life Safety Systems Testing to confirm proper operation of all operating smoke dampers and associated Life Safety Systems (i.e. fire alarm).
- .3 This contractor shall work with the Integrated Life Safety Contractor and reset all systems back into proper operation.
- .4 Include all costs associated with participation Integrated Life Safety System Testing in the tender value.

3.9 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.
- .3 Warranty Coverage:
 - .1 Applies to parts and labour.

END OF SECTION

Part 1 General

1.1 GENERAL

- .1 This section applies to operating dampers not specified in Controls Section.

1.2 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

1.3 PRODUCT DATA

- .1 Submit product data in accordance with general requirements.
- .2 Indicate the following:
 - .1 Performance data.

1.4 MAINTENANCE DATA

- .1 Provide maintenance data for incorporation into manual specified in general requirements.

1.5 CERTIFICATION OF RATINGS

- .1 Catalogue or published ratings shall be those obtained from tests carried out by manufacturer or those ordered by him from independent testing agency.

Part 2 Products

2.1 MOTORIZED DAMPERS

- .1 Opposed blade type.
- .2 Extruded aluminum, interlocking blades, complete with extruded vinyl seals, spring stainless steel side seals, extruded aluminum frame.
- .3 Pressure fit self-lubricated bronze bearings.
- .4 Linkage: plated steel tie rods, brass pivots and plated steel brackets, complete with plated steel control rod.
- .5 Operator: Refer to BAS Section.
- .6 Performance:
 - .1 Leakage: in closed position to be less than 2% of rated air flow at 250 Pa (1" w.c.) differential across damper.
 - .2 Pressure drop: at full open position to be less than 10 Pa (0.04" w.c.) differential across damper.

- .7 Insulated aluminum dampers:
 - .1 Frames: insulated with extruded polystyrene foam with R factor of 5.0.
 - .2 Blades: constructed from aluminum extrusions with internal hollows insulated with polyurethane or polystyrene foam, R factor of 5.0.
 - .3 Use on services to the exterior.
 - .4 Acceptable Manufacturers:
 - .1 Honeywell
 - .2 Johnson
 - .3 T. A. Morrison
 - .4 E.H. Price
 - .5 Tamco
 - .6 Ruskin
 - .7 Nailor
 - .8 Henderson Industrial
 - .9 Ventex/Alumavent
 - .10 Pottorff

2.2 DISC TYPE DAMPERS

- .1 Frame: brake formed, welded, 1.6 mm (16 gauge) thick, Type Z90 galvanized steel to ASTM A653/A653M.
- .2 Disc: spin formed, 1.6 mm (16 gauge) thick, Type Z90 galvanized steel to ASTM A653/A653M.
- .3 Gasket: extruded neoprene, field replaceable.
- .4 Bearings: roller self lubricated and sealed.
- .5 Operator: compatible with damper, linear stroke operator, spring loaded actuator, zinc-aluminum foundry alloy casting cam follower.
- .6 Performance:
 - .1 Leakage: in closed position to be less than 0.001% of rated air flow at 100 kPa (15 psi) pressure differential across damper.
 - .2 Pressure drop: at full open position to be less than 100 kPa (15 psi) differential across damper.
- .7 Acceptable Manufacturers:
 - .1 Duro Dyne
 - .2 Henderson Industrial
 - .3 Pottorff

2.3 BACK DRAFT DAMPERS

- .1 Automatic gravity operated, multi leaf, aluminum construction with nylon bearings, centre pivoted or counterweighted, as indicated.

- .2 Acceptable Manufacturers:
 - .1 T.A. Morrison
 - .2 Tamco Series 7000
 - .3 Ruskin
 - .4 Nailor
 - .5 E.H. Price
 - .6 Henderson Industrial
 - .7 Ventex/Alumavent
 - .8 Pottorff

Part 3 Execution

3.1 INSTALLATION

- .1 Install where indicated.
- .2 Install in accordance with recommendations of SMACNA and manufacturer's instructions.
- .3 Seal multiple damper modules with silicon sealant.
- .4 Install access door adjacent to each damper. See Duct Accessories Section.
- .5 Insulated dampers on all outside air intake and exhaust damper.
- .6 Non-insulated dampers on all interior motorized dampers not exposed to outside air.

3.2 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.
 - .2 Disk type dampers gasket: Ten (10) years warranty.
- .3 Warranty Coverage:
 - .1 Applies to parts and labour.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.
- .3 ASTM C423, Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
- .4 ASTM E90, Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
- .5 ASTM E477, Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.

1.2 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with general requirements.
- .2 Provide separate shop drawings for each piece of attenuation equipment complete with product data.

1.3 PERFORMANCE RATING DATA

- .1 Provide performance rating data, certified by an accredited test laboratory and supported by calculations and verified by test results in accordance with referenced standards as follows:
 - .1 Silencer: insertion loss, pressure drop at design conditions, generated noise level.
 - .2 Acoustic plenums: transmission loss and acoustical absorption.

Part 2 Products

2.1 ABSORPTION AND INSULATING MEDIA

- .1 Acoustical performance measurements to be made in accordance with ASTM E477, ASTM E90 and ASTM C423, except where specified otherwise.
- .2 Acoustic quality, glass fibre, free of shot and odor; bacteria and fungus resistant; free of corrosion causing or accelerating agents; packed to density to meet performance requirements; and meet NBC fire requirements or requirements of authority having jurisdiction for duct lining.

2.2 SILENCERS

- .1 Silencer type as indicated.
- .2 Factory manufactured of prime coated or galvanized steel, compatible with ductwork specified elsewhere and to ASHRAE and SMACNA standards.

- .3 Outer casing and galvanized steel inner casing with clean cut circular perforations to enclose acoustic media. Inner casing to have half-splitters running full length of silencer where any cross sectional dimension exceeds 450 mm (18"). Protect media from erosion with glass fibre cloth between media and perforated metal.
- .4 Confirm silencer is proper type for system. Silencer to be sized for 35DB in occupied space.
- .5 Manufacturer shall confirm silencer(s) selection is based on sound power levels of equipment to be silenced. Indicate sound power levels of equipment on silencer shop drawings.
- .6 Acceptable Manufacturers:
 - .1 Vibro – Acoustics
 - .2 BVA Systems
 - .3 Vibron
 - .4 VAW Systems
 - .5 IAC Acoustics
 - .6 EH Price

Part 3 Execution

3.1 INSTALLATION

- .1 Install in accordance with manufacturer's instructions.
- .2 Noise flanking: where indicated, install in wall sleeve with uniform clearance all around to ensure no contact of silencer with wall sleeve. Pack with flexible, non hardening caulking on both sides of sleeves.
- .3 Instrument test ports: install at inlet and outlet to permit measurement of insertion loss and pressure loss.
- .4 Suspension: to manufacturer's instructions.

3.2 SITE VISIT

- .1 Supplier of equipment to visit site to ensure installation is in accordance with manufacturer's instructions and submit report to Consultant
- .2 Make adjustments and corrections in accordance with written report.
- .3 Provide Consultant with notice 48h in advance of visit.

3.3 TESTING

- .1 Experienced and competent sound and vibration testing professional engineer to take sound measurement after start up and testing, adjusting and balancing of systems to Testing Adjusting and Balancing (TAB) of Mechanical Systems section.
- .2 Sound measurements to extend over specified frequency range of 250 to 2000 and to be taken:
 - .1 Upstream and downstream of each silencer and plenum.

- .2 In areas adjacent to mechanical equipment rooms, duct and pipe shafts.
- .3 At 1800 mm (72") above floor adjacent to first air terminal.
- .3 Provide Consultant with notice 48 h in advance of commencement of tests.
- .4 Establish adequacy of equipment isolation, acceptability of noise levels in occupied areas, other conditions affecting acoustics and, where appropriate, recommendation for remedial measures and costs.
- .5 Submit complete report of test results including sound curves.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 CAN/ULC-S110, Standard Methods of Test for Air Ducts.
- .3 UL 181, Factory Made Air Ducts and Air Connectors.
- .4 ANSI/NFPA 90A, Installation of Air Conditioning and Ventilating Systems.
- .5 ANSI/NFPA 90B, Installation of Warm Air Heating and Air Conditioning Systems.
- .6 SMACNA HVAC Duct Construction Standards - Metal and Flexible.

1.2 PRODUCT DATA

- .1 Submit product data in accordance with general requirements.
- .2 Indicate the following:
 - .1 Thermal properties.
 - .2 Friction loss.
 - .3 Acoustical loss.
 - .4 Leakage.
 - .5 Fire rating.

1.3 CERTIFICATION OF RATINGS

- .1 Catalogue or published ratings shall be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.

Part 2 Products

2.1 GENERAL

- .1 Factory fabricated to CAN/ULC S110.
- .2 Pressure drop coefficients listed below are based on relative sheet metal duct pressure drop coefficient of 1.00.
- .3 Flame spread rating not to exceed 25. Smoke developed rating not to exceed 50.

2.2 METALLIC – UNINSULATED

- .1 Spiral wound flexible aluminum, Class 1 duct material.
- .2 Performance:
 - .1 Factory tested to 2.5 kPa (10" w.c.) without leakage.
 - .2 Maximum relative pressure drop coefficient: 3.
 - .3 Operating pressure: 300 mm (12").

.3 Acceptable Manufacturers:

- .1 Flexmaster T/L
- .2 Ductmate

2.3 METALLIC –INSULATED

- .1 Spiral wound flexible aluminum with factory applied, 25 mm (1") thick flexible glass fibre thermal insulation with vapour barrier and vinyl jacket, Class 1 duct material.
- .2 Performance:
 - .1 Factory tested to 2.5 kPa (10" w.c.) without leakage.
 - .2 Maximum relative pressure drop coefficient: 3.
 - .3 Operating pressure: 300 mm (12").
- .3 Acceptable Manufacturers:
 - .1 Flexmaster T/L – VT
 - .2 Ductmate

Part 3 Execution

3.1 DUCT INSTALLATION

- .1 Install in accordance with: SMACNA.
- .2 Maximum length of flexible duct: 1.8 m (6' 0").
- .3 Minimum length of acoustical ductwork; 1.5 m (5' 0") with minimum of 1 bend.
- .4 Provide support at centre of flexible duct with 25 mm (1") wide galvanized hanger.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 SMACNA HVAC Duct Construction Standards, Metal and Flexible.
- .3 ASTM C1071 Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
- .4 ASTM C916 Standard Specification for Adhesive for Duct Thermal Insulation.
- .5 ANSI/NFPA 90A, Installation of Air Conditioning and Ventilating Systems.
- .6 ANSI/NFPA 90B, Installation of Warm Air Heating and Air Conditioning Systems.
- .7 **ASTM C177, Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.**
- .8 **CAN/ULC-S102, Surface Burning Characteristics of Building Materials and Assemblies.**

1.2 PRODUCT DATA

- .1 Submit product data in accordance with general requirements.

Part 2 Products

2.1 RECTANGULAR/SQUARE DUCT LINER

- .1 General:
 - .1 Acoustical duct liner to be fibreglass duct liner meeting or exceeding requirements of ASTM C1071, Type I, Flexible or Type II, Rigid, and NFPA 90A/90B.
 - .2 Bonded with formaldehyde free bio-based binder
 - .3 Mat faced airstream surface
 - .4 Factory applied edge coating
 - .5 Shall not contain formaldehyde, PBDE's, asbestos, mercury, mercury compounds, lead, contain 50% or greater recycled glass content.
 - .6 Thermal conductivity, ASTM C177/C518/C1114 .24BTU (sf•hr•°F) @ 75°F mean temp).
 - .7 Noise Reduction Coefficient (NRC) 1.5 PCF 1" = .70, 1 ½ " = .80, 2" =.95
ASTM C423, Type A mounting.
 - .8 Noise Reduction Coefficient (NRC) 2.0 PCF 1/2" = .50, 1" = .70, 1 ½ " = .85
ASTM C423, Type A mounting
 - .9 Corrosiveness/corrosion, ASTM C665/C1617. Does not accelerate/pass.
 - .10 Mold and mildew growth/fungi resistance, ASTM C1338, ASTM G21/G22, UL2824. Pass/resistant to mold.
 - .11 Maximum service temperature, ASTM C411, 250°F (121°C).

- .12 Maximum rate air velocity, ASTM C1071, 6,000 ft./min. (30.5 m/sec.)
- .13 Water vapor sorption, ASTM C1104, less than 3%.
- .14 Surface burning characteristics, ASTM E84, UL 273, CAN/ULC S102, 20/50 flame spread/smoke development.
- .15 Acceptable Manufacturers:
 - .1 Knauf Atmosphere Duct Liner
 - .2 Manson
 - .3 Johns Manville
 - .4 Owen Corning
- .2 Rigid:
 - .1 Use on flat surfaces.
 - .2 25 mm (1") thick, to CGSB 51-GP-10M, fibrous glass rigid board duct liner.
 - .3 Density: 96 kg/m³ (6 lb/ft³).

2.2 ADHESIVE

- .1 Meet requirements of ASTM C916.
- .2 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50. Temperature range -29°C (-20°F) to 93°C (200°F).
- .3 Acceptable Manufacturers:
 - .1 Duro Dyne 1A-22
 - .2 Ductmate

2.3 FASTENERS

- .1 Weld pins 2.0 mm (14 gauge) diameter, length to suit thickness of insulation. Metal retaining clips, 32 mm (1¼") square.
- .2 Acceptable Manufacturers:
 - .1 Duro Dyne
 - .2 Ductmate

2.4 JOINT TAPE

- .1 Poly-Vinyl treated open weave fiberglass membrane 50 mm (2") wide.
- .2 Acceptable Manufacturers:
 - .1 Duro Dyne FT2
 - .2 Ductmate

2.5 SEALER

- .1 Meet requirements of ANSI/NFPA 90A and ANSI/NFPA 90B.
- .2 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50. Temperature range -68°C (-90°F) to 93°C (200°F).

.3 Acceptable Manufacturers:

- .1 Duro Dyne 1A-94
- .2 Ductmate

Part 3 Execution

3.1 GENERAL

- .1 Do work in accordance with recommendations of MAIMA Fibrous Glass Duct Liner Standards (FGDLS) or SMACNA duct liner standards.
- .2 Line inside of ducts where indicated.
- .3 Duct dimensions, as indicated, are clear inside duct lining.
- .4 Provide an interior of ductwork from fans from minimum distance of 3 m (10'-0").

3.2 DUCT LINER

- .1 Install in accordance with manufacturer's recommendations, and as follows:
 - .1 Fasten to interior sheet metal surface with 100% coverage of adhesive.
 - .2 In addition to adhesive, install weld pins not less than 2 rows per surface and not more than 300 mm (12") on centres.
- .2 Weld pins are to have cupped or beveled heads to prevent damage to lining surface.
- .3 Store foam liners away from sunlight.

3.3 JOINTS

- .1 Seal all butt joints, exposed edges, weld pin and clip penetrations and all damaged areas of liner with joint tape and sealer. Install joint tape in accordance with manufacturer's recommendations, and as follows:
 - .1 Bed tape in sealer.
 - .2 Apply 2 coats of sealer over tape.
- .2 Replace damaged areas of liner at discretion of Consultant.
- .3 Protect leading and trailing edges of each duct section with sheet metal nosing having 15 mm (1/2") overlap and fastened to duct.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 AMCA 99, Standards Handbook.
- .3 ANSI/AMCA 210, Laboratory Methods of Testing Fans for Certified Aerodynamics Performance Rating.
- .4 AMCA 300, Revised 1987, Reverberant Room Method for Sound Testing of Fans.
- .5 AMCA 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
- .6 ANSI/ASHRAE 51, Laboratory Methods of Testing Fans for Certified Aerodynamics Performance Rating.
- .7 ANSI/NFPA 96 – Ventilation Control and Fire Protection of Commercial Cooking Operations.

1.2 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with general requirements.
- .2 Product data to include fan curves and sound rating data.

1.3 OPERATION AND MAINTENANCE DATA

- .1 Provide operation and maintenance data for incorporation into manual specified in general requirements.

1.4 CERTIFICATION OF RATINGS

- .1 Catalogued or published ratings shall be those obtained from tests carried out by manufacturer or those ordered from independent testing agency signifying adherence to codes and standards in force.
- .2 Provide confirmation of testing.

Part 2 Products

2.1 FANS GENERAL

- .1 Capacity: Flow rate, total static pressure Pa, r/min, W (" w.c., r/min, bhp) model and size and sound ratings as indicated on schedule.
- .2 Statically and dynamically balanced. Constructed in conformity with AMCA 99.
- .3 Sound ratings: Comply with AMCA 301, tested to AMCA 300.
- .4 Performance ratings: Based on tests performed in accordance with ANSI/AMCA 210, and ANSI/ASHRAE 51.

- .5 Bearings: Sealed lifetime of self aligning type with oil retaining, dust excluding seals and a certified minimum rated life of 80,000 100,000 h in accordance with AFBMA L10 life standard. Bearings to be rated and selected in accordance with AFBMA 9 and AFBMA 11.
- .6 Provide vibration isolation hangers/pads for all fans.
- .7 Electrical components and motors within the airstream shall be classified for use in a Class I, Zone 2 system (as defined by the Electrical Safety Code) when connected to ductwork systems served by refrigerant containing air handling systems.
- .8 Provide factory mounted speed control for all direct drive motors.
- .9 Acceptable Manufacturers:
 - .1 Greenheck
 - .2 Penn-Barry
 - .3 Cook
 - .4 Jenco (S & P)/Jenn
 - .5 Carnes
 - .6 Acme
 - .7 Zonex
 - .8 Nutone (Range hood)
 - .9 Broan (Range hood)
 - .10 Twin-City
 - .11 Reversomatic
 - .12 Fantech
 - .13 Aerovent

2.2 ROOF EXHAUSTERS

- .1 Centrifugal V belt or direct driven as indicated.
 - .1 Housing: Spun aluminum complete with resilient mounted motor and fan.
 - .2 Impeller: Aluminum non-overloading.
 - .3 Adjustable motor sheave.
 - .4 15 mm (1/2") mesh 2.0 mm (79 mil) diameter aluminum birdscreen.
 - .5 Automatic gasketed aluminum backdraft dampers.
 - .6 Disconnect switch within fan housing.
 - .7 Continuous curb gaskets, cadmium plated securing bolts and screw, and sound insulating.
- .2 Roof curbs: of same manufacturer as fan and built to suit model specified. Roof curbs to be minimum 500 mm (20") high except where indicated otherwise. Roof curbs for NFPA 96 fans are to be vented.
- .3 Size, type, and capacity: As indicated.
- .4 Power feed shall be through roof curb.

2.3 CEILING DISCHARGE FANS

- .1 Centrifugal direct drive, with plug in type electric motor suitable for ceiling installation, zinc coated rectangular metal housing.
- .2 Sizes and capacity: As indicated.
- .3 Toggle switch operated complete with integral electrical outlet box with plug-in type receptacle.
- .4 Side duct outlet with integral backdraft damper, size as indicated.
- .5 Wall cap complete with spring loaded backdraft damper with neoprene gasket.
- .6 Silver anodized aluminum grille paint finish.

2.4 DRYER BOOSTER FAN

- .1 Provide a fully automatic dryer booster fan where indicated.
- .2 Provide a Fantech DBLT or equal 100 mm (4") paintable galvanized lint trap complete with removable filter and 15 mm flange for flush mounting.
- .3 Fan shall be inline complete with low profile, self cleaning backward inclined impeller and high efficiency motor suitable for 120/1/60.
- .4 Provide a current sensing relays in electrical junction box on the power feed to the dryer to operate the dryer booster fan in sequence. Dryer and power relay to be ORTECH Amp Sensor Model as without time delay or equal. Co-ordinate installation with the electrical contractor, providing power to the dryer.
- .5 All wiring shall be by Electrical Division.
- .6 Acceptable Manufacturer:
 - .1 Reversomatic 'TLD' Series with DAS 200 sensor.

2.5 EXISTING EXHAUST AIR FANS

- .1 Refurbish existing exhaust air fans as follows:
 - .1 Vacuum entire unit interior.
 - .2 Lubricate all bearings.
 - .3 Replace fan belt(s).
 - .4 Rebalance to capacity indicated.

Part 3 Execution

3.1 INSTALLATION

- .1 Install in accordance with manufacturer's instructions.
- .2 Provide flexible duct connection for all fans.
- .3 Provide backdraft damper at building exterior penetration.
- .4 Provide and install vibration isolation.

- .5 Provide and install roof curb for all roof mounted fans.
- .6 Provide and install sleepers for utility set style roof mounted fans; provide roof curb for duct penetration.

3.2 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.
- .3 Warranty Coverage:
 - .1 Applies to parts and labour.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

1.2 PRODUCT DATA

- .1 Submit product data in accordance with general requirements.
- .2 Indicate the following:
 - .1 Performance data.
 - .2 Noise data.
 - .3 Physical dimensions.

1.3 MAINTENANCE DATA

- .1 Provide maintenance data for incorporation into manual specified in general requirements.

1.4 CERTIFICATION OF RATINGS

- .1 Catalogue or published ratings shall be those obtained from tests carried out by manufacturer or those ordered by an independent testing agency.

Part 2 Products

2.1 VARIABLE AIR VOLUME BOXES

- .1 Single duct, variable volume air distribution assemblies of the sizes and capacities as shown on the plans.
- .2 The assemblies shall be pressure independent and shall reset to any air flow between zero and the maximum catalogued air volume.
- .3 At an inlet velocity of 610 m/min (2,000 fpm), the differential static pressure for any unit with attenuator section, sizes 4 through 16, shall not exceed 25 Pa (0.10" w.c.).
- .4 Sound ratings of air distribution assemblies, shall not exceed 30 NC at 25 Pa (0.10" w.c.) static pressure.
- .5 Pressure shall be ARI Certified.
- .6 The air flow sensor shall be of a cross configuration located at the inlet of the assembly and shall have multiple pickup points, designed to average the flow across the inlet of the assembly. The air flow sensor shall amplify the sensed air flow signal.
- .7 Provide a discharge air temperature sensor on discharge of VAV box. Temperature sensor shall be capable of display on BAS.

- .8 The assembly casing shall be constructed of 0.7 mm (22 gauge) zinc coated steel, internally lined with 20 mm ($\frac{3}{4}$ ") thick, dual density fiberglass insulation, which complies with UL-181 and NFPA-90A. Any cut edges of fiberglass exposed to the air stream shall be coated with NFPA-90A approved sealant.
- .9 The primary air valve damper shall be heavy gauge metal, with peripheral gasket, pivoted in self-lubricating bearings. In the full closed position, air leakage past the closed damper shall not exceed 2% of the nominal catalogue rating at 750 Pa (3" w.c.) inlet static pressure, as rated by ARI Standard 880.
- .10 Provide 900 mm (36") long discharge sound attenuator for each unit.
- .11 Provide hot water reheat coil mounted in 0.7 mm (22 gauge) galvanized steel housing. Reheat coil to have copper tubes, aluminum fins with O.D. sweat connections, and quick opening cam lock access door. Refer to schedule for reheat coil requirements. Provide minimum 2 row coil.
- .12 DDC controls including controller, flow transducer, electric actuator and protective shroud if required to be provided by controls manufacturer.
- .13 Electrical components and motors within the airstream shall be classified for use in a Class I, Zone 2 system (as defined by the Electrical Safety Code) when connected to ductwork systems served by refrigerant containing air handling systems.
- .14 Terminal unit manufacturer shall factory mount controller and actuator including tubing from cross flow sensor to controls, wiring controller to motor and calibration.
- .15 Size and capacity: as indicated.
- .16 Acceptable Manufacturers:
 - .1 E.H. Price SDV
 - .2 Nailor
 - .3 Titus
 - .4 Krueger
 - .5 Carnes
 - .6 Metalaire

2.2 FAN POWERED BOXES

- .1 General.
 - .1 Primary air assembly, pressure independent with reset to any air flow between minimum and maximum air volume.
 - .2 Field calibration and readjustment of air volume to be as follows:
 - .1 Gauge tops for balancing with standard pressure gauge.
 - .2 Adjustable flow settings.
 - .3 Provide inlet and outlet attenuators.
 - .4 Casing: constructed of 0.7 mm (22 gauge) thick galvanized steel, internally lined with 25 mm (1"), 0.7 kg/m² (0.14 lb/ft²) density fibrous glass, to UL 181 and ANSI/NFPA 90A. Mount control components inside protective metal shroud.

- .5 Damper: galvanized steel with peripheral gasket and self lubricating bearings. Air leakage past closed damper not to exceed 2% of nominal rating at 750 Pa (3" w.c.) inlet static pressure, in accordance with Air Diffusion Council test procedure.
- .6 Provide hot water reheat coil mounted in 0.7 mm (22 gauge) galvanized steel housing. Reheat coil to have copper tubes, aluminum fins with O.D. sweat connections, and quick opening cam lock access door. Refer to schedule for reheat coil requirements. Provide minimum two (2) row coil.
- .7 Provide MERV 8 Filter
- .8 Complete with:
 - .1 Sound attenuator as indicated.
 - .2 Reheat coil as indicated.
- .2 Fan section.
 - .1 CSA certified.
 - .2 Provide ECM motor (multispeed)
 - .3 Forward curved, centrifugal, direct drive, motor, internally suspended and isolated from casing on rubber-in-shear isolators complete with access panel.
 - .4 Fan controls to be sealed from primary air flow.
 - .5 Electrical characteristics: As indicated.
 - .6 Electrical components and motors within the airstream shall be classified for use in a Class I, Zone 2 system (as defined by the Electrical Safety Code) when connected to ductwork systems served by refrigerant containing air handling systems.
- .3 Acceptable Manufacturers:
 - .1 EH Price Model FDCQ2
 - .2 Titus
 - .3 Nailor
 - .4 Barber Colman
 - .5 Carnes
 - .6 Krueger

Part 3 Execution

3.1 INSTALLATION

- .1 Install where indicated.
- .2 Install in accordance with recommendations of SMACNA and manufacturer's instructions.
- .3 Install quick opening access door (with sash locks) adjacent to each damper.
- .4 Install controls as per manufacturer's requirements.
- .5 Install with at least 100 mm (4") of flexible inlet ducting.

- .6 Wire associated HVAC unit's refrigeration detection system alarm to all damper actuators and electric reheat coil input signal connection locations.

3.2 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.
- .1 Warranty Coverage:
 - .1 Applies to parts and labour.

END OF SECTION

Part 1 General

1.1 PRODUCT DATA

- .1 Submit product data in accordance with general requirements.
- .2 Indicate the following:
 - .1 Capacity.
 - .2 Throw and terminal velocity.
 - .3 Noise criteria.
 - .4 Pressure drop.
 - .5 Neck velocity.

1.2 MAINTENANCE MATERIALS

- .1 Include:
 - .1 Keys for volume control adjustment.
 - .2 Keys for air flow pattern adjustment.

1.3 MANUFACTURED ITEMS

- .1 Grilles, registers, and diffusers of same generic type to be product of one manufacturer.

1.4 CERTIFICATION OF RATINGS

- .1 Catalogued or published ratings shall be those obtained from tests carried out by manufacturer or those ordered by them from independent testing agency signifying adherence to codes and standards.

Part 2 Products

2.1 GENERAL

- .1 To meet capacity, pressure drop, terminal velocity, throw, noise level, neck velocity as indicated.
- .2 Frames:
 - .1 Full perimeter gaskets.
 - .2 Plaster frames where set into plaster or gypsum board and as specified.
 - .3 Concealed fasteners.
- .3 Concealed operators.
- .4 Colour and Finish: standard as directed by Consultant.
- .5 Acceptable Manufacturers:
 - .1 E.H. Price
 - .2 Nailor

- .3 Krueger
- .4 Titus
- .5 Carnes
- .6 Seiho
- .7 Metalaire
- .8 Tuttle and Bailey

2.2 RETURN AND EXHAUST GRILLES

- .1 General: with opposed blade dampers as indicated, concealed manual operator and gaskets.
- .2 Type, size, and capacity: Refer to schedule for types

2.3 DIFFUSERS

- .1 General: volume control dampers with flow straightening devices and blank-off quadrants, as indicated and gaskets.
- .2 Type, size, and capacity: Refer to schedule for types

2.4 OPEN MESH SCREEN

- .1 15 mm x 15 mm (½" x ½") open mesh screen fastened on 25 mm (1") border, screw fasten.
- .2 On all open ends of ductwork and where indicated.
- .3 Size: To match ductwork size.

Part 3 Execution

3.1 INSTALLATION

- .1 Install in accordance with manufacturer's instructions.
- .2 Install with flat head screws in countersunk holes where fastenings are visible.
- .3 Bolt grilles, registers and diffusers, in place
- .4 Provide concealed safety chain on each grille, register and diffuser in gymnasium, similar game rooms, and on exposed diffusers, and elsewhere as indicated.
- .5 Clean grilles upon completion.
- .6 Paint ductwork beyond grilles, matte black where visible.
- .7 Ensure all grilles, diffusers, etc. match opening sizes as indicated on the drawings and as fabricated on site by the contractor.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ASTM E90, Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions, and Elements.

1.2 PRODUCT DATA

- .1 Submit product data in accordance with general requirements.
- .2 Indicate the following:
 - .1 Pressure drop.
 - .2 Face area.
 - .3 Free area.
 - .4 Colour and finish.

1.3 CERTIFICATION OF RATINGS

- .1 Catalogued or published ratings shall be those obtained from tests carried out by manufacturer or those ordered by him from independent testing agency signifying adherence to codes and standards.

1.4 TEST REPORTS

- .1 Submit certified data from independent laboratory substantiating acoustic and aerodynamic performance to ASTM E90.

Part 2 Products

2.1 GOOSENECK HOODS

- .1 Thickness: to ASHRAE and SMACNA.
- .2 Fabrication: to ASHRAE and SMACNA.
- .3 Joints: to ASHRAE and SMACNA and or proprietary manufactured duct joint.
 - .1 Acceptable Manufacturers:
 - .1 Ductmate Canada
 - .2 Exanno Nexus
- .4 Supports: as indicated.
- .5 Complete with integral birdscreen of 2.7 mm (12 gauge) diameter aluminum wire. Use 15 mm (1/2") mesh on exhaust 20 mm (3/4") mesh on intake.
- .6 Vertical or Horizontal backdraft dampers as required.
- .7 Prefabricated roof curb through roof complete with insulation and counter flashing.

2.2 FIXED LOUVRES – ALUMINUM

- .1 Acceptable Manufacturers:
 - .1 Greenheck
 - .2 Construction Specialties
 - .3 E.H. Price
 - .4 Krueger
 - .5 Ruskin
 - .6 Ventmaster
 - .7 Ventex
 - .8 Nailor

2.3 BRICK VENTS (FLANGE FRAME)

- .1 Construction: welded with exposed joints ground flush and smooth.
- .2 Material: extruded aluminum alloy 6063-T5.
- .3 Blade: stormproof pattern.
- .4 Perimeter flange frame, head, sill and jamb: 40 mm (1½") deep one piece extruded aluminum, minimum 3 mm (1/8") thick with approved caulking slot, integral to unit.
- .5 Fastenings: stainless steel (Society of Automotive Engineers) SAE-194-8F with SAE-194-SFB nuts and resilient neoprene washers between aluminum and head of bolt, or between nut, ss washer and aluminum body.
- .6 Screen: 15 mm (1/2") exhaust 20 mm (3/4") exhaust mesh, 2 mm (5/64") diameter wire aluminum birdscreen on inside face of louvres in formed U-frame.
- .7 Finish:
 - .1 Powder coated.
 - .2 Colour: to Consultant's approval.
- .8 Options:
 - .1 Straight duct extension.
 - .2 Perimeter flange frame.
- .9 Acceptable Manufacturers:
 - .1 Greenheck Model BVF
 - .2 Construction Specialties
 - .3 E.H. Price
 - .4 Krueger
 - .5 Ruskin
 - .6 Ventmaster
 - .7 Ventex
 - .8 Nailor

2.4 ALUMINUM WALL CAPS (CLOTHES DRYER)

- .1 Application: Clothes dryer or as noted on drawings.
- .2 0.3 mm (16 gauge) aluminum wall sleeve sized as noted on plans.
- .3 0.3 mm (16 gauge) sloping exterior wall cap with integral sides, base plate, and 25 mm (1") perimeter flange with 4-hole screw fasten. Fasteners at each corner.
- .4 Bottom outlet with removable 15 mm x 15 mm (1/2") x (1/2") aluminum screen.
- .5 Neoprene backdraft damper with aluminum crimp on bottom edge.
- .6 Acceptable Manufacturers:
 - .1 Reversomatic
 - .2 Broan
 - .3 Ventex
 - .4 AirVent
 - .5 Shop fabricated (submit sample for approval).

Part 3 Execution

3.1 INSTALLATION

- .1 In accordance with manufacturers and SMACNA recommendations.
- .2 Reinforce and brace air vents, intakes and goosenecks as indicated.
- .3 Anchor securely into opening.
- .4 Seal with caulking all around to ensure weather tightness.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 Canadian Standards Association (CSA).
 - .1 CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code.
- .3 Canadian Gas Association (CGA).
 - .1 CAN1-3.1, Industrial and Commercial Gas-Fired Package Boilers.
 - .2 CSA-B149.1, Natural Gas and Propane Installation Code.
- .4 American National Standards Institute (ANSI).
 - .1 ANSI Z21.13, Gas-Fired Low-Pressure Steam and Hot Water Boilers.
- .5 American National Standards Institute (ANSI)/ American Society of Mechanical Engineers (ASME).
 - .1 ANSI/ASME Boiler and Pressure Vessel Code, Section IV.
- .6 ASHRAE 90.1 – Energy Standard for Building Except Low-Rise Residential Buildings

1.2 BOILER SYSTEM LAYOUT ON FLOOR

- .1 Pre-planning of the boiler room system must be done prior to any new construction in the boiler room beginning. The contractor shall provide a full-scale markup of the boiler system on the floor of the boiler room. The markup shall be in various coloured chalk and shall include all the components/equipment of the boiler system.
 - .1 Housekeeping pad sizes/locations.
 - .2 Floor/hub drain locations.
 - .3 Vent/chimney stack locations and locations thru roof.
 - .4 Boiler positions (including burner & front door swing – depending on type of boiler).
 - .5 Rough locations and routing for heating supply/return headers and branch piping.
 - .6 Location of gas train (compared to boiler access/door swing) so gas can be disconnected from one or two unions.
 - .7 Locations for pumps, air separator, sink, eyewash, expansion tanks, etc.
 - .8 Locations for chemical treatment pot feeder assembly and makeup water assembly.
 - .9 Coordinate with the electrician and include markup locations for starters, panels, VFDs, etc.
 - .10 Location of unistrut supports where needed to route wiring or mount piping or equipment.
 - .11 Location of BAS controls & panels.

- .2 Markup shall be reviewed with the consultant and owner prior to new installations starting. Changes or adjustments of the layout will be made with chalk during the review.
- .3 Contractor to provide multiple photos of the final chalk layout.

1.3 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with general requirements.
- .2 Indicate the following:
 - .1 Capacities of selected model
 - .2 General arrangement showing terminal points, instrumentation test connections.
 - .3 Clearances for operation, maintenance, servicing, cleaning.
 - .4 Piping hook-ups.
 - .5 Equipment electrical drawings.
 - .6 Burners and controls.
 - .7 All miscellaneous equipment.
 - .8 Flame safety control system.
 - .9 Breeching and stack configuration.
 - .10 Warranty information
- .3 Engineering data to include:
 - .1 Boiler efficiency at 100% of design capacity.
 - .2 Radiant heat loss at 100% design capacity.
 - .3 Water side pressure drop curve
 - .4 Certificate of Product Rating: AHRI Certificate indicating Thermal Efficiency, Combustion Efficiency, Materials of Construction, Input and Gross Output

1.4 CLOSEOUT SUBMITTALS

- .1 Submit operation and maintenance data for incorporation into manual specified in general requirements.

1.5 CERTIFICATION

- .1 Manufacturer's Certification: The boiler manufacturer shall certify the following:
 - .1 The products and systems furnished are in strict compliance with the specifications.
 - .2 the boiler, burner and other associated mechanical and electrical equipment have all been properly coordinated and integrated to provide a complete and operable boiler.
 - .3 ASME certification.
 - .4 CSA (AGA/CGA) certification.
 - .5 The specified factory tests have been satisfactorily performed.

- .6 The equipment furnished contains inter-changeable parts with the specified equipment so that all major equipment parts can be obtained from the specified manufacturer.

Part 2 Products

2.1 GENERAL

- .1 Furnish the number of factory "packaged" low pressure hot water boilers indicated on the drawings. Each factory "packaged" boiler shall be complete with all components, accessories, and appurtenances necessary for a complete and operable boiler as hereinafter specified. Each unit shall be furnished factory assembled with required wiring and piping as a self-contained unit. Each unit shall be readily transported and ready for installation.
- .2 Each hot water boiler shall consist of a vertical, stainless steel heat exchanger complete with trim, valve trains, burner, and boiler control system. The boiler manufacturer shall fully coordinate the boiler as to the interaction of its elements with the burner and the boiler control system in order to provide the required capacities, efficiencies, and performance as specified.
- .3 The boiler manufacturer shall provide unit responsibility for the engineering, coordination, workmanship, performance, warranties, and all field services for each factory "packaged" boiler as specified herein. The boiler manufacturer shall be fully responsible for all components assembled and furnished by him whether or not they are of his own manufacture.

2.2 PERFORMANCE CRITERIA

- .1 Refer to schedules for boiler capacities.
- .2 Boiler shall be capable of operating with a minimum outlet water temperature of 20°C (68°F).
- .3 Boiler shall comply with ASME Section IV for 345 kPa (50 psig) (max 98°C/200°F).
- .4 Boiler relief valve setting shall be 345 kPa (50 psig) max.
- .5 Maximum allowable water temperature shall be 210°F
- .6 Fuel shall be natural gas with an assumed higher heating value of 1,030 Btu/Cu Ft and an assumed specific gravity of 0.60 (relative to air). Natural gas shall be supplied at a pressure of no less than 3.5" w.c. to the inlet gas valve. Maximum inlet gas pressure shall not exceed 14" w.c.
- .7 Ambient air temperature shall be assumed to range from 10°C (50°F) to 32°C (90°F) with an average of 21°C (70°F).
- .8 Power voltage shall be 120/208 vac, 1-phase, 60 hertz. Control voltage shall be 24 vac (transformer to be supplied by boiler manufacturer).
- .9 Boiler shall be suitable for use with either water or glycol solutions.

2.3 HEAT EXCHANGER

- .1 Each boiler heat exchanger shall be duplex stainless steel, single or multi-pass, down fire, counter-flow design for maximum heat transfer with the multiple sections arranged in a reverse return configuration to assure balanced flow through each section
- .2 Boiler heat exchanger headers shall be fabricated stainless steel and be completely removable for inspection. Seals shall be EPDM, rated for 400°F service. Push nipples or gaskets between the sections are not permitted.
- .3 Heat exchange capability shall be maximized through the use of a corrugation process or fins.

2.4 PRESSURE VESSEL

- .1 Shall be constructed of carbon stainless steel with welded heads and tube connections.
- .2 Pressure vessel shall be counter-flow design for water flow, with internal water baffling plates if required to meet energy efficiency requirements.
- .3 The water volume of the boiler shall not be less than 42 gallons of water volume/1000 MBH.
- .4 The pressure vessel shall have sufficient water capacity to be flow tolerant without minimum flow requirements or the use of a flow switch.

The allowable pressure drop across the boiler inlet and outlet connections shall not exceed **2.0 psi/4.6 ft H₂O** if the system is piped as a primary flow only. If the system is piped as primary-secondary flow the boiler manufacturer shall supply a boiler circulation pump suitable for the pressure drop across the boiler and all associated pipe isolation valves, strainers, etc.

2.5 FRAME AND ENCLOSURE

- .1 Boiler shall be enclosed with a single wall outer casing. It shall be fabricated from a minimum 16 gauge carbon steel. The complete outer casing shall be finished, inside and out, with a powder coat finish.
- .2 The composite structure of the boiler combustion chamber, insulating air gap and outer casing shall be of such thickness and materials to assure an outer casing temperature of not more than 37°C (100°F) when the boiler is operated at full rated load.
- .3 An observation port shall be located on the boiler to allow for observation of the burner flame.
- .4 Access panels shall be hinged.
- .5 Provide appropriate NEMA 250, Type 1 enclosure for controls components.
- .6 Provide lifting eyes and fork holes accessible for rigging and movement of the boiler.
- .7 Minimum 2" thick insulation surrounding the heat exchanger.

2.6 CONNECTIONS

- .1 Each boiler shall be provided with all necessary inlet and outlet connections. Boiler connections shall be as follows:
 - .1 One (1) water supply outlet, Victaulic
 - .2 One (1) water return inlet, Victaulic
 - .3 One (1) relief valve outlet.
 - .4 One (1) flue gas vent outlet.
 - .5 One (1) fuel gas inlet.
 - .6 A flue gas outlet shall be located on the rear of the boiler. Boiler to be certified for installation with Category IV venting (stack) as defined in NFPA 54 (ANSI Z221), latest edition. Contractor must provide venting (stack) certified for installation on a Category IV appliance.

2.7 MAIN GAS VALVE TRAIN (MODULATING)

- .1 Each boiler shall be provided with an integral main gas valve train. The main gas valve trains shall be factory assembled, piped, and wired. Each gas valve train shall include at least the following:
 - .1 One (1) manual shutoff valve (gas train inlet connection).
 - .2 Two (2) safety shutoff valves. Valves equipped with dual solenoids that can independently energized for leak testing.
 - .3 Modulating Air – Gas ratio control (maximum inlet pressure 14" w.c.).
 - .4 One (1) low gas pressure switch (manual reset).
 - .5 One (1) high gas pressure switch (manual reset).
 - .6 Two (2) pressure test ports.
 - .7 Union connection to permit burner servicing.

2.8 NEUTRALIZING VESSEL

- .1 Rotationally molded low density polyethylene vessel with minimum 3" diameter fill/access openings at each end, 3/4" diameter inlet and outlet pipe connections. Provide all necessary mounting hardware. Unit (or units if more than 1 is required) is to be sized to neutralize capacity of condensate from boiler, before being drained to sewer system. Vessel to be sized to suit condensate produced by the boiler.
- .2 Provide initial charge of limestone and store one (1) additional charge where directed on site.
- .3 Acceptable Manufacturers: From boiler manufacturer.

2.9 IGNITION SYSTEM

- .1 Each boiler shall be equipped for direct spark ignition.

2.10 COMBUSTION AIR CONTROL SYSTEM (DIGITAL)

- .1 Each boiler shall be provided with an integral combustion air control system. The combustion air system shall be factory assembled. Each combustion air control system shall include at least the following:
 - .1 The primary control shall vary the speed of the blower based on load demand. The blower shall apply a varying negative pressure on the gas valve, which will open or close to maintain zero pressure at the valve orifice, thereby increasing or decreasing the firing rate. Both the air and gas shall be premixed in the blower.
 - .2 One (1) low airflow differential pressure switch to insure that combustion air is supplied.
 - .3 High exhaust back pressure switch.

2.11 VENTING

- .1 The boiler shall be capable of operating with a stack effect not exceeding -0.04" W.C. and a combined air intake and exhaust venting pressure drop not exceeding +1.50" W.C.
- .2 It shall be acceptable to either direct vent the boiler using sealed combustion by drawing combustion air in from the outdoors, or by drawing air from the mechanical space itself.
 - .1 Sealed Combustion: Contractor shall supply and install venting to suit manufacturers installation guidelines.
 - .2 Mechanical Space: Manufacturer shall supply and install filter for combustion air intake if required or recommended by manufacturer.
- .3 Flue Gas exhaust stack shall be AL 29-4C, 316L stainless steel or other material as indicated in manufacturer installation manual. Material shall be listed and labelled to UL 1738 / COUL S636 for use with Category IV appliances. Material shall be guaranteed appropriate for the application by the manufacturer of the boiler.
- .4 Condensate drain material must be stainless steel or Schedule 40 CPVC. Copper, carbon steel, or PVC pipe materials are not acceptable.

2.12 CONTROL PANEL

- .1 The boiler manufacturer shall provide each boiler with an integral factory prewired control panel. The control panel shall contain at least the following components, all prewired to a numbered terminal strip:
 - .1 One (1) burner "on-off" switch.
 - .2 One (1) electronic combination temperature control, flame safeguard and system control.
 - .3 Control circuit breaker, 5 amp.
 - .4 All necessary control switches, pushbuttons, relays, timers, terminal strips, etc.

2.13 INTERNAL CONTROL

- .1 Boiler control system shall consist of an integral boiler display and micro-processor control system.
- .2 LED Display Panel to adjust set points and control operating parameters. LED display to indicate burner sequence, all service codes (0-65), fan speed, boiler set point, sensor values such as inlet, outlet, flue gas and outdoor air.
- .3 Control system shall be capable of controlling/staging multiple boiler systems, as well as starting/stopping primary boiler pumps, varying primary pump speed based on boiler firing rate and opening and closing the boiler automatic isolation valve. Boiler shall be able to control minimum two separate heating loops.
- .4 In a multiple boiler system, the control shall stage and modulate the boilers utilizing firing rate threshold staging and parallel modulation to optimize condensing potential while minimizing energy wasting short cycling. The control shall monitor the supply water temperature and return water temperature and communicate between the boilers on a local boiler system control network.
- .5 Boiler controls shall have provisions for outside air reset and night setback. Boiler manufacturer to provide outdoor air temperature sensor.
- .6 All parameters shall be adjustable through the control panel display.
- .7 Boiler control panels shall be mounted and located on the boiler to provide ease of servicing and prevent accidental water damage.
- .8 The integral controller on each boiler shall provide for the following functions:
 - .1 Flame safeguard
 - .2 Burner sequencing, with safe start check, pre-purge, electronic direct spark ignition and post-purge. Combustion shall be proven.
 - .3 Flame Supervision: Maintain a running history of operating hours, number of cycles, and the most recent lockouts. Display information on display screen in clear English text descriptions without the need to look up error codes.
 - .4 Safety Shutdown with display of lockout and hold condition.
 - .5 PID modulating control of the variable speed fan for firing capacity relative to load requirements. i.e. to meet supply water temperature set point.
 - .6 Gas Pressure supervision (high and low)
 - .7 Combustion Air Proving supervision
 - .8 High Air Pressure (Back draft too high) supervision
 - .9 Control relay for operation of the isolation valve.
 - .10 Low Water Cut Off (provide for field installation if not integral to boiler)

2.14 BAS HARDWARE INTEGRATION

- .1 Terminal Strip Integration: Boiler shall communicate with the BAS via a terminal strip integration. Provide the following points for integration:
 - .1 Boiler Enable/Disable
 - .2 Boiler Status

- .3 Boiler Alarm
- .4 Hot Water Supply and Return Water Temperature Set Point
- .5 Boiler modulation rate
- .6 Firing Rate feedback

2.15 BACNET INTEGRATION

- .1 The boiler shall also include for the addition of the BACNet integration.
- .2 Through digital integration the following minimal information shall be controlled and visible:
 - .1 Writeable Points
 - .1 Hot Water Supply Temperature Set Point
 - .2 Hot Water Return Temperature Set Point
 - .3 Fire rate
 - .4 System/Boiler Pump Command
 - .5 Boiler Enable/Disable
 - .6 Lead/Lag Control (enable and settings)
 - .7 Emergency Shut down
 - .2 Readable Points
 - .1 Hot Water Supply Temperature
 - .2 Hot Water Return Temperature
 - .3 Fire Rate Feedback
 - .4 Failure/Alarm
 - .5 Cycle/Run Time totals
 - .6 Flow verification (if equipped with internal flow switch)
 - .7 Pump status
 - .8 Combustion efficiency
 - .9 Various operating status' as available in standard BACNet integration offering
 - .3 Lock out and error codes shall be transmitted to the BAS and be readable at the Operator Workstation so that error codes can be remotely accessed and reviewed prior to site visit. Manufacturer shall provide correct controller to provide this functionality.

2.16 ELECTRICAL CONNECTION

- .1 Provide single point field power connection, factory installed and wired, including all transformers, control/safety devices and other devices as required for a complete and operable system.
- .2 Power shall be 120 V, 60 Hz, single phase. Maximum 20 Amp breaker.

2.17 TRIM

- .1 Boiler shall be provided with all necessary trim. Boiler trim shall be as follows:
 - .1 Safety relief valve shall be provided in compliance with the ASME code. Contractor to pipe to acceptable drain.
 - .2 Water pressure temperature gauge.
 - .3 Primary low water flow fuel cutoff (probe type with manual reset).
 - .4 High limit water temperature controller to stop burner operation at excess water temperature (shall be manual reset).
 - .5 Operating temperature control to control the sequential operation of the burner.
 - .6 Separate inlet and outlet water temperature sensors capable of monitoring flow.
 - .7 Alarm lights and horn
 - .8 LCD Display and Diagnostics
 - .9 Strainer in piping system ahead of each boiler.

2.18 ACCESSORIES

- .1 Condensate neutralizing system
- .2 Drain Valve
- .3 Flow Switch (if required for boiler operation or indicated on plans)
- .4 Boiler Circulating pump (if piped primary/secondary)
- .5 BACNet integration card and any required protocol translators for boiler integration with the Building Management System.

2.19 ACCEPTABLE MANUFACTURERS

- .1 Patterson-Kelly
- .2 Lochinvar

Part 3 Execution

3.1 INSTALLATION

- .1 Contractor shall install boilers in accordance with all manufacturer installation instructions and as indicated on the drawings.
- .2 Meet all local and applicable codes of installation.
- .3 Maintain manufacturer's recommended service clearances on all sides of the equipment.
- .4 Supplying contractor shall install all shipped loose equipment.
- .5 Supplying contractor shall be responsible for all interconnecting electrical control and power wiring, including high voltage wiring between boiler and isolation valve actuator.

- .6 Install boilers on cast-in-place concrete housekeeping pads.
- .7 Provide strainers on the inlet water piping.

3.2 QUALITY CONTROL

- .1 Boiler shall be provided by a firm regularly engaged in the manufacture of condensing hydronic boilers with welded steel pressure vessels, whose products have been in satisfactory use in service for not less than ten (10) years.
- .2 Each factory "packaged" boiler shall be hydrostatically tested and bear the ASME "H" stamp.
- .3 Each factory "packaged" boiler shall be fire tested. The boiler manufacturer shall perform this fire test under simulated operating conditions, with the boiler attached to a working chimney system and with water circulating through the boiler. The manufacturer shall provide a fire test report, including fuel and air settings and combustion test results permanently affixed to the boiler.
- .4 The manufacturer shall have a factory authorized service training program, where boiler technicians can attend a training class and obtain certification to perform start-up, maintenance and basic troubleshooting specific to the product line. There shall be a minimum of 4 trained technicians within 100 km of the job site.
- .5 Provided equipment shall be of the type, design and size that the manufacturer currently offers for sale and must appear in the manufacturer's current catalogue.

3.3 FIELD TESTING

- .1 The boiler manufacturer shall field test the following:
 - .1 Boiler and burner interlocks.
 - .2 Valves.
 - .3 Controllers.
 - .4 Gauges.
 - .5 Thermometers.
 - .6 Alarms
 - .7 Stack Pressure
 - .8 Switches.
 - .9 LCD Screen Functional Test
 - .10 Any malfunctioning component shall be replaced.

3.4 COMMISSIONING

- .1 Manufacturer to:
 - .1 Certify installation.
 - .2 Start up and commission installation.
 - .3 Carry out on-site performance verification tests.
 - .4 Demonstrate operation and maintenance.

- .2 Provide Consultant at least 48h notice prior to inspections, tests, and demonstrations. Submit written report of inspections and test results.

3.5 DEMONSTRATION AND TRAINING

- .1 Provide minimum 2 hours training to owner's representative, including all safety procedures, maintenance procedures, control operations and diagnostic procedures.
- .2 Training shall be provided by a factory trained service technician.
- .3 Training shall occur at the installed location.

3.6 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.
 - .2 Manufacturer's standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within the specified period:
 - .1 Pressure Vessel and Heat Exchanger: The boiler manufacturer shall warranty against failure due to thermal shock, flue gas condensate corrosion, and/or defective material or workmanship for a period of 10 years, non-prorated, from the date of Ready for Takeover provided the boiler is installed, controlled, operated, and maintained in accordance with the Installation, Operation and Maintenance Manual.
 - .2 Burner: The boiler manufacturer shall warranty the burner against defective material or workmanship for a period of five (5) years, non-prorated, from the date of Ready for Takeover.
 - .3 All other Components: The boiler manufacturer will repair or replace any part of the boiler that is found to be defective in workmanship or material within twelve (12) months from the date of Ready for Takeover.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ANSI/ARI 210/240, Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
- .3 ARI 270, Standard for Sound Rating of Outdoor Unitary Equipment.
- .4 CSA B52, Mechanical Refrigeration Code.
- .5 CSA C22.1, Canadian Electrical Code, Part 1.
- .6 ANSI/NFPA 90A, Installation of Air Conditioning and Ventilating Systems.
- .7 ANSI/UL 1995, Central Cooling Air Conditioning.
- .8 C.1 CSA B52-2023, Mechanical Refrigeration Code
- .9 C.2 CAN/CSA-C22.2 No 60335 Safety of Household and similar electrical appliances – Heat Pumps, Air-conditioners and dehumidifiers

1.2 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with general requirements.
- .2 Indicate:
 - .1 Equipment, and connections, together with control assemblies, auxiliaries and hardware, and recommended ancillaries which are mounted, wired and piped ready for final connection to building system, its size and recommended bypass connections.
 - .2 Piping, valves, fitting shipped loose showing final location in assembly.
 - .3 Control equipment shipped loose, showing final location in assembly.
 - .4 Dimensions, internal and external construction details, recommended method of installation with proposed structural steel support, mounting curb details, sizes and location of mounting bolt holes; include mass distribution drawings showing point loads.
 - .5 Detailed composite wiring diagrams for control systems showing factory installed wiring and equipment on packaged equipment or required for controlling devices or ancillaries, accessories, controllers.
 - .6 Details of vibration isolation.
 - .7 Estimate of sound levels to be expected across each individual octave band in dB referred to A rating.
 - .8 Type of refrigerant used (A1 or A2L classification only).

1.3 MAINTENANCE DATA

- .1 Provide maintenance data for incorporation into manual specified in general requirements.

- .2 Indicate:
 - .1 Brief description of unit, indexed, with details of function, operation, control, and service for each component.
- .3 Manufacturer's installation instructions shall govern and unless otherwise noted, operation, maintenance and service of items. Include names and addresses of spare part suppliers.
- .4 Include following:
 - .1 Provide for each unit, manufacturer's name, type, year, number of units, and capacity.

Part 2 Products

2.1 ACCEPTABLE MANUFACTURERS

- .1 Trane
- .2 Carrier
- .3 JCI

2.2 HIGH EFFICIENCY HVAC EQUIPMENT (15 TONS & LESS)

- .1 Efficiency:
 - .1 Units under 5 tons of cooling meet a SEER rating of 14.0.
 - .2 Units 6 tons of cooling and larger meeting a EER rating of 12.0 (9.6 for 12½ ton unit).
 - .3 Electronic controls with data link and diagnostic operation.
 - .4 Energy Star rated.
- .2 General:
 - .1 Roof mounted, self-contained single zone unit with gas burner and DX refrigeration and bear label of CSA, CGA, and ULC.
 - .2 Units to consist of cabinet and frame, supply fan, heat exchanger, burner control, air filter, refrigerant cooling coil, compressor, condenser coil and fans, motorized opposed blade outside air damper, return damper, gravity exhaust damper or power exhaust as indicated.
 - .3 Prefabricated roof curb complete with isolation rails (where indicated) to conform to requirements of National Roofing Contractors Association (NRCA), minimum height as indicated.
 - .4 Conform to ANSI/ARI 210/240, rating for unit larger than 40 kW (136 MBH) nominal.
 - .5 **Dehumidification package, factory installed and tested for identified units.**
 - .6 High efficiency motor suitable for voltage indicated. Provide two-speed motors on units 7½ tons and larger where noted in Schedule.
 - .7 All units shall be of the same manufacturer.

- .3 Cabinet:
 - .1 Cabinets: weatherproofing tested and certified to AGA and soundproofing tested to ARI 270.
 - .2 Framing and supports: 2 mm (14 gauge) thick welded steel, galvanized after manufacture, with lifting lugs.
 - .3 Outer casing: weathertight galvanized steel, bonderized with baked enamel finish, complete with flashing.
 - .4 Access: hinged access doors with lockable quarter turn handles.
 - .5 Insulation: neoprene coated glass fiber on all surfaces where conditioned air is handled, 1.6 mm (16 gauge) thick, 2.2 kg/m (1.5 lb/ft) density.
- .4 Fans:
 - .1 Centrifugal, forward curved impellers, statically and dynamically balanced. V-belt drive with adjustable variable pitch motor pulley, isolated hinge mounted motor. Vibration isolators: 95% efficiency.
- .5 Air Filters:
 - .1 50 mm (2") thick, 30% efficiency, permanent metal framed, replaceable media standard to unit manufacturer.
 - .2 To meet ANSI/NFPA 90A, air filter requirements.
- .6 Heat Exchangers and Burners:
 - .1 Gas fired, multiple flue passes, with primary heating surface of stainless steel; secondary heating surface, stainless steel tubes.
 - .2 Gas burner: factory mounted, wired and fire tested complete with operating and safety controls.
 - .1 Forced type.
 - .2 Spark ignited pilot with pilot flame safety shut-off.
- .7 Refrigeration:
 - .1 Conform to CSA B52 and ANSI/UL 1995 requirements.
 - .2 Compressor/condenser section:
 - .1 Compressors:
 - .1 Unit shall use one fully hermetic, scroll compressor for each independent refrigerant circuit.
 - .2 Provide two (2) stages on units 7.5 tons and larger.
 - .3 Resiliently mount compressors on rubber mounts for vibration isolation.
 - .4 Compressor motors to be cooled by refrigerant gas passing through motor windings.
 - .5 Compressors shall be internally protected from high discharge temperature conditions.
 - .6 Compressors shall have internal current and temperature protection.

- .7 Compressors shall be isolated from condenser and evaporator air streams.
- .8 Crank case heaters shall be used on all models to protect compressors with specific refrigerant charges.
- .2 Fans: propeller type with single piece spun venturi outlets and zinc plated guards. Motors shall be sequenced for head pressure control.
- .3 Electrical system shall have operating controls, oil and refrigerant pressure protection, motor overload protection, weatherproof electrical wiring with weatherproof, rain tight disconnect.
- .4 Include refrigerant piping with automatic hot gas bypass, sight glass, filter and valves.
- .5 Condenser: staggered copper tube aluminum fin coil assembly with sub-cooling rows.
- .6 Capacity reduction: hot gas bypass and or cylinder unloading.
- .7 Refrigerant: A1 or A2L classified.
- .3 Evaporator:
 - .1 Rated to ANSI/ARI 210/240.
 - .2 Thermostatic expansion valve, with adjustable super heat and external equalizer.
 - .3 Coil: staggered seamless copper tubes expanded into aluminum fins, and insulated condensation pan.
 - .4 Cooling coil condensate drain pans: designed to avoid any standing water, to be easily cleaned or removable for cleaning. Drain connection to have deep seal trap and be complete with trap seal primer.
- .8 Controls and Safeties:
 - .1 Electronic controller.
 - .2 Network monitoring.
 - .3 Scrolling Marquee display.
 - .4 Unit control with standard suction pressure transducers and condensing temperature thermistors.
 - .5 Provide a 5 F° temperature difference between cooling and heating set points to meet ASHRAE 90.1 Energy Standard.
 - .6 Display a current alarm list and an alarm history list.
 - .7 Automatic compressor redundancy.
 - .8 Service run test capability.
 - .9 Shall accept input from a CO₂ sensor (both indoor and outdoor).
 - .10 Configurable alarm lights shall be provided which activates when certain types of alarms occur.
 - .11 Compressor minimum run time (3 minutes) and minimum off time (5 minutes).
 - .12 Service diagnostic mode.
 - .13 Economizer with enthalpy control.
 - .14 Self-contained low-voltage control circuit.

- .15 Solid-state compressor lockout which provides optional reset capability at the space thermostat, should any of the following safety devices trip and shut off compressor:
 - .1 Compressor lockout protection provided for either internal or external overload.
 - .2 Low-pressure protection.
 - .3 Freeze protection (evaporator coil).
 - .4 High-pressure protection (high pressure switch or internal).
 - .5 Compressor reverse rotation protection.
 - .6 Loss of charge protection.
- .16 Supply-air sensor located in the unit and detect both heating and cooling operation.
- .17 Induced draft heating section with the following minimum protections:
 - .1 High-temperature limit switch.
 - .2 Induced-draft motor speed sensor.
 - .3 Flame rollout switch.
 - .4 Flame proving controls.
 - .5 Redundant gas valve.
- .18 **All control components shall utilize industry standard input/outputs. (i.e 0-10vDC). Proprietary voltages, communication languages etc. between components is not acceptable.**
- .9 Unit Controls:
 - .1 In addition to combustion safety controls, provide low limit on supply.
 - .2 Zone cooling control:
 - .1 Zone sensor or room thermostat to activate cooling relay in control circuit cycling compressor. Provide safeties and pressure controls. Condenser fans to operate in sequence.
 - .2 When call for cooling is satisfied, relay is de-energized. On two compressor units provide separate circuits to evaporator and condenser and manual double pole double throw switch for lead-lag unit choice.
 - .3 Zone heating control:
 - .1 Adjustable zone sensor or room thermostat controls burner operation, to maintain room temperature setting.
 - .4 Mixed air control:
 - .1 Motorized outside, return and gravity relief dampers with spring return damper operator and control package to automatically vary outside air quantity. Outside air and exhaust air dampers, normally closed.
 - .2 Tight fitting opposed blade dampers with neoprene or suitable gaskets, synthetic bushings and 1% maximum leakage.
 - .3 Damper operation: 24 V, spring return motor with gear train sealed in oil.

- .4 Mixed air controls: maintain 14°F (57°F) mixed air temperature, lock out compressor below 10°C (50°F) ambient, restart 15°C (59°F), revert dampers to provide 25% fresh air above 21°C (70°F) adjustable.

2.3 SYSTEM CONTROL

- .1 Equipment control will be by the unit manufacturer and integral economizer controls.
- .2 System controls will be by Building Automation System Contractor.

2.4 REFRIGERATION DETECTION SYSTEM

- .1 The Refrigerant detection system shall meet the requirements of CSA B52 and have the following functionality:
 - .1 Utilize a set point, nonadjustable in the field, to generate a digital output signal to initiate mitigation actions to both internal safeties and external components in the ductwork (dampers, electric coils etc.). Signal shall be generated in not more than 30 seconds from sensor exposure to refrigerant concentration of 25% LFL (+0%, -1%)
 - .2 Sensor within the equipment, near potential source of leaks.
 - .3 Field calibration of the system is not allowed.
 - .4 Be capable of detecting the refrigerant used in the system.
 - .5 Have self diagnostics
 - .6 Energize fans upon failure of a self-diagnostic check
 - .7 Activate refrigerant safety shut off valves in the event of a leak being detected.

2.5 CAPACITY

- .1 As indicated.

2.6 ACCESSORIES

- .1 600 mm (24") high roof curb.
- .2 Leveling curb on sloped roof.
- .3 Vibration rail.
- .4 Opposed blade economizer dampers.
- .5 Condenser coil hail guard.
- .6 Stainless steel vertical extension on flue gas discharge.
- .7 Stainless steel heat exchanger.

2.7 ELECTRICAL REQUIREMENTS

- .1 As indicated.
- .2 Field installed devices.
 - .1 Provide all field installed wiring required for all units that are equipped with power exhaust. Provide transformers as required.

- .3 Mount all accessories shipped loose onto the units.

2.8 EXISTING ROOFTOP AIR HANDLING UNIT

- .1 Refurbish existing RTU as follows:
 - .1 Vacuum entire unit interior.
 - .2 Steam clean coils.
 - .3 Replace existing filters.
 - .4 Lubricate all damper linkages.
 - .5 Lubricate all bearings.
 - .6 Replace fan belt(s).
 - .7 Rebalance to capacity indicated.

Part 3 Execution

3.1 INSTALLATION

- .1 Install as per manufacturers' instructions on roof curbs provided by manufacturer as indicated. Provide all necessary continuous wolmanized wood blocking to install roof curb level complete with 20 gauge liner to ensure combustible wood blocking is not exposed in the building.
- .2 Manufacturer to certify installation, supervise start-up and commission unit.
- .3 Run drain line from cooling coil condensate drain pan to discharge over roof drain.

3.2 START-UP/COMMISSIONING

- .1 Unit manufacturer shall perform start-up and commissioning.

3.3 REFRIGERANT LEAK DETECTION SYSTEM

- .1 This contractor shall provide all wiring between leak detection systems installed within the provided equipment and system components in the spaces served and ductwork system.
- .2 Specifically, the following shall occur for each independent system on registration of a refrigerant leak:
 - .1 Open all zone dampers in the affected system.
 - .2 Disable all electric reheat coils within the affected system.
 - .3 Activate field installed safety shut off valves within the affected refrigeration system.
 - .4 Energize all fans within the affected ductwork system.
 - .5 Activate and refrigerant leak system specific ventilation systems.
 - .6 De-energize any other potential sources of ignition within the affected system.
- .3 All interlocks between field installed detection systems and associated safety system components shall be tested and verified to operate as per the requirements of CSA B52.

3.4 TRAINING

- .1 Provide 2 hours training to owner's staff on the care, maintenance, and operation of the equipment. Dedicated visit to site is required as it will not be paired with equipment startup.

3.5 SPARE PARTS

- .1 Two (2) complete sets of filters.
- .2 One (1) set of spare belts.

3.6 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .1 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year on parts and labour on all components.
 - .2 Five (5) years on compressor.
 - .3 Ten (10) years on stainless steel heat exchanger.
 - .4 Manufacturer hereby warrants refrigeration compressors in accordance with GC 24, but for five (5) years.
 - .5 Manufacturer hereby warrants the gas heat sections for a minimum of ten (10) years.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ANSI/NFPA-90A, Installation of Air Conditioning and Ventilating Systems.
- .3 AMCA 99 – Standard Handbook.
- .4 AMCA 210 – Laboratory Methods of Testing Fans for Rating Purposes.
- .5 ARI 270, Standard for Sound Rating of Outdoor Unitary Equipment.
- .6 ANSI/AHRI 340/360 – Performance Rating of Commercial and Industrial Unitary Air Conditioning and Heat Pump Equipment.
- .7 AMCA 500 – Test Methods for Louvers, Dampers, and Shutters.
- .8 AHRI 260 – Sound Rating of Ducted Air Moving and Conditioning Equipment.
- .9 NFPA 90A – Installation of Air Conditioning and Ventilation Systems.
- .10 UL-1995 – Standard for Safety for Heating and Cooling Equipment.
- .11 C.1 CSA B52-2023, Mechanical Refrigeration Code.
- .12 C.2 CAN/CSA-C22.2 No 60335 Safety of Household and similar electrical appliances – Heat Pumps, Air-conditioners and dehumidifiers.

1.2 QUALITY ASSURANCE

- .1 Manufacturer shall have a minimum 15 years of experience in designing, manufacturing and servicing large air handling units.
- .2 Units shall be factory tested prior to shipment.

1.3 ALTERNATES CO-ORDINATION

- .1 The design indicated on the schedules and shown on the drawings is based upon the products of the named manufacturer. Alternate equipment manufacturers named in this specification are acceptable if equipment meets scheduled performance requirements.
- .2 If equipment is supplied by a manufacturer other than the one named as the basis of design, coordinate with the General Contractor and affected subcontractors to ensure the specified performance is met. This coordination shall include (but is not limited to) the following:
 - .1 Structural supports for units.
 - .2 Size and location of concrete bases/housekeeping pads.
 - .3 Location of roof curbs, unit supports and roof penetrations.
 - .4 Ductwork sizes and connection locations.
 - .5 Piping size and connection/header locations.

- .6 Interference with existing or planned ductwork, piping and wiring.
- .7 Electrical power requirements and wire/conduit and over current protection sizes.
- .3 The Mechanical Contractor shall be responsible for costs incurred by the General Contractor, Subcontractors, and Consulting Engineers to accommodate units furnished by a manufacturer other than manufacturer named as basis of design.
- .4 Substitution of products from manufacturers not listed in the list of acceptable manufacturers shall not be accepted.

1.4 RATINGS AND CERTIFICATIONS

- .1 Unit shall conform to AMCA 210 for fan performance ratings.
- .2 Unit sound ratings shall be reported in accordance with AHRI 260 for inlet and discharge sound power levels.
- .3 Unit casing radiated sound ratings shall be reported in accordance with ISO 9614 parts 1&2 and ANSI S12.12.
- .4 Unit shall conform to AHRI 410 for capacities, pressure drops, and selection procedures of air coils.
- .5 Unit shall conform to ANSI/AHRI 430 for all fabrication procedures of air handling units.
- .6 Control Wiring comply with NEC codes and all other requirements of the Authority Having Jurisdiction.
- .7 Units shall comply with energy use AHSRAE 90.1 and meet all Government of Canada and Ontario Building Code energy requirements, including SB-10 energy efficiency requirements. Energy Efficiency shall be verified by third party laboratory testing.

1.5 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with Section general requirements. Ensure the following information is included:
- .2 Furnish fan performance ratings and fan curves with specified operating point clearly plotted.
- .3 Furnish drawings indicating unit dimensions, required clearances, field connection locations, wiring diagrams, shipping drawings, and curb drawings.
- .4 Furnish performance report showing unit level performance data including: fan(s), motor(s), coil(s) and other functional components. Performance report shall also include unit casing performance.
- .5 Furnish operation and maintenance data, including instructions for lubrication, filter replacement, motor and drive replacement, and condensate pan cleaning; spare parts lists, and wiring diagrams.
- .6 Adjust and report performance ratings for the proper altitude of operation.
- .7 Report air-handling unit performance ratings in accordance with ANSI/AHRI-430 (static pressure, airflow, fan speed, and fan brake horsepower).
- .8 Report coil ratings in accordance with AHRI-410 (capacities and pressure drops).

- .9 Report unweighted octave band AHU sound power for inlets and outlets rated in accordance with AHRI Standard 260. Provide eight data points, the first for the octave centered at 63 Hz, and the eighth centered at 8,000 Hz. Manufacturer shall not use sound estimates based on bare fan data (AMCA ratings), nor use calculations like the substitution method based on AHRI 260 tests of other AHU products. Provide data for inlets and outlets as scheduled. Report unweighted casing radiated sound power over the same 8 octave bands in accordance with ISO 9614 Parts 1&2 and ANSI S12.12.
- .10 Report weight loads and distributions by component section.
- .11 Report product data for filter media, filter performance data, filter assembly, and filter frames.
- .12 Report electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
- .13 Report motor electrical characteristics.

1.6 MAINTENANCE DATA

- .1 Provide maintenance data for incorporation into manual specified in general requirements.

1.7 MAINTENANCE MATERIALS

- .1 Provide maintenance materials in accordance with general requirements.

1.8 UNIT ASSEMBLY

- .1 Unless stated otherwise, air handling units are to be shipped to the job in one piece, factory assembled. All equipment shall be factory tested prior to shipment.
- .2 Units that are shipped in segments must be re-assembled by manufacturer's factory trained service personnel.

1.9 PERFORMANCE RATINGS

- .1 Unit certification: Units shall conform to CSA-C746-2006 and ARI 340/360-2007, be listed by NRCan as approved for sale in Canada and be compliant with the SB-10 Supplement of the Ontario Building Code. Manufacturers shall have performance certified by an AHRI-sponsored, independent, third party laboratory and be able to provide a Certificate of Product Ratings.

Part 2 Products

2.1 GENERAL

- .1 Field Factory assembled components to form units supplying air at design conditions as indicated and specified.
- .2 Acceptable Manufacturers:
 - .1 Daikin Applied Rebel/Skyline.
 - .2 Engineered Air.

2.2 GENERAL DESCRIPTION

- .1 The air handling unit (AHU) shall consist of the following components:
 - .1 Structural frame, including base. Frame must maintain it's integrity when all wall panels are removed.
 - .2 Wall panels complete with access doors.
 - .3 Filters, motors, motor controls, dampers and other components as specified.
 - .4 A supply air fan.
 - .5 A return air fan RTU-1 OR power exhaust fan RTU-2.
 - .6 A modulating gas burner.
 - .7 Packaged DX cooling.
 - .8 A mixed air section complete with economizer operation.
 - .9 Integral energy recovery wheel complete with bypass damper and purge.
 - .10 Single point power connection.
 - .11 Refrigerant detection and safety system.

2.3 UNIT CONSTRUCTION

- .1 Base Rail:
 - .1 Units shall be provided with a structural steel base rail under the full perimeter of the unit, formed from mill galvanized steel, or welded structural steel if determined to be necessary based on unit size by the manufacturer.
 - .2 Base rail shall allow for clearances for proper trapping of drain pans and condensate.
 - .3 Base rail shall have a lifting lug system that does not require additional support for rigging on site. Alternatively, lifting lugs or forklift openings on cabinet are acceptable if designed for on site rigging.
- .2 Casing:
 - .1 Air handling units shall be weatherproofed and equipped for installation outdoors. This shall include for the prevention of infiltration of rain and snow into the unit, and louvres or hoods on air intakes and exhaust openings with 25 mm (1") galvanized inlet screens. Provide rain gutters over all access doors and caulk all joints with a water-resistant sealant.
 - .2 Casing construction shall not be relied upon to provide structural integrity.
 - .3 Casing panels shall be 2" double-wall construction with thermal break. Thermal break shall be between interior and exterior liner of the panel assembly, and between the panel and casing framework.
 - .4 Unit casing shall be of minimum 1.3 mm (18 gauge) satin coat galvanized sheet metal. Surfaces shall be cleaned with a degreasing solvent to remove oil and metal oxides and primed with a two-part acid based etching primer. Finish coat shall be an electrostatically applied enamel, to all exposed surfaces. All unprotected metal and welds shall be factory coated.

- .5 All walls, roofs and floors shall be of formed construction, with at least two breaks at each joint. Joints shall be secured by sheet metal screws or pop rivets. Wall and floor joints shall be broken in and roof joints broken out (exposed) for rigidity. All joints shall be caulked with a water resistant sealant.
- .6 Provide casing with minimum thermal resistance (R-value) of 13 hr-ft²-°F/BTU. Exposed insulation is not acceptable.
- .7 Casing panel insulation shall be injected polyurethane foam. Rigid foam board panels are acceptable provided the above noted R value is met.
- .8 Insulation system provided shall be resistant to mold growth in accordance with a standardized test method such as UL 181 or ASTM C 1338.
- .9 Encapsulate insulation with sheet metal so that air does not contact insulation. Solid lined double-walled panels insulated with injected foam shall be hermetically sealed at each corner and around their entire perimeter to eliminate airflow through the panel and to eliminate microbial growth potential within the casing wall.
- .10 Unit shall be designed to reduce air leakage and infiltration through the cabinet. Cabinet leakage shall not exceed 1% of total airflow when tested at 3 times the minimum external static pressure provided in AHRI Standard 340/360. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, at a maximum 8 inches of positive or negative static pressure, to reduce air leakage.
- .11 Provide wall panels and access doors that deflect no more than L/240 when subjected to 1.5 times design static pressure up to a maximum of +5 inches w.g. in positive pressure sections and -5 inches w.g. in negative pressure sections. 'L' is the panel-span length and 'L/240' is the deflection at panel midpoint.
- .12 Provide floors and roofs that deflect no more than L/240 when subjected to a 300 lb static load at mid-span. 'L' is the panel-span length and 'L/240' is the deflection at panel midpoint.
- .13 Provide outdoor AHUs with a roof system that deflects no more than L/240 when subjected to a static snow load of 30 lb./ft². 'L' is defined as the panel-span length and 'L/240' is the deflection at the panel midpoint.
- .3 Access Doors
 - .1 Units shall be provided with double wall gasketed access doors that meet the requirements of the AHU casing.
 - .2 Access doors shall be provided to the following components: fans and motors; filters; dampers and operators; and access plenums. Access doors shall be large enough for easy access. Removal of screwed wall panels will not be acceptable.
 - .3 Provide hinged access doors, fully lined, with hinges, with a minimum of two camlock fasteners for all units over 1200 mm (48") high.
 - .4 Whenever possible, hinged access doors to areas of negative pressure shall open out, and to areas of positive pressure shall open in. Where space constrictions require the use of outward opening doors to an area of positive pressure, a clear warning label must be affixed.
 - .5 Hinged access doors shall be provided with tie back clips.
 - .6 Doors shall have a drip guard above the door frame, extending 50 mm (2") beyond door surface.

2.4 DX COOLING COILS

.1 General

- .1 Coils shall meet or exceed performance scheduled on drawings.
- .2 Coils shall be provided with performance certified in accordance with AHRI Standard 410 for coil capacity and pressure drop, wherever applicable. Coils circuits shall be designed such that the fluid velocity is within the range of certified rating conditions at design flow.
- .3 Cooling coils shall be provided with a maximum face velocity of 500 feet per minute. Face velocity calculations shall be based on the finned area of the coil.
- .4 Cooling coil shall be provided with drain pan that is sufficient to contain coil condensate. Drain pan shall extend a minimum of 10" downstream of the face of the coil.
- .5 Coil segment casing shall accommodate full-face or reduced-face coils as scheduled. Face and bypass coil shall only be allowed when specifically specified. Where specified segments shall be provided with factory installed bypass damper.
- .6 Access shall be provided of at least 24" between coils. Access panel or door shall be easily operable and are easily removable with no special tools, as shown on drawings.
- .7 Access doors shall be located to provide clearance for pipe insulation, connectors, and accessories. Space shall allow a minimum of 90 degrees of door swing.
- .8 Coils shall be built in their own full perimeter frame. Tube sheets on each end shall have fully drawn collars to support and protect tubes. Horizontal coil casing and support members shall allow moisture to drain. Casing and support members shall not block finned area.
- .9 Individual coils shall be removable from the side of the AHU.
- .10 Continuous aluminum or copper fins shall be provided for coils with die-formed fins. Fins shall have fully drawn collars to accurately space fins and protect tubes. Fins shall be 0.006" or 0.008 or 0.01" thick.
- .11 DX Cooling Coils
 - .1 The coil shall be installed in a blow through configuration, upstream of the supply air fan.
 - .2 The coil shall be multirow, with a minimum of 3 rows. All coils shall have interlaced coil circuiting that keeps the full coil face active at all load conditions.
 - .3 Direct expansion (DX) coils shall conform to UL-207, "Standard for Safety: Refrigerant - Containing Components and Accessories, Nonelectrical," when operating with a maximum refrigerant pressure of 325 psig. Factory shall test DX coils with 325 psig compressed air under water. DX coils shall be dehydrated and sealed prior to installation.
 - .4 Coils shall be provided with a tube OD of 1/2" or 5/8". Mechanically expand tubes shall form fin bond and provide burnished, work-hardened interior surface.

- .5 DX coils shall be provided with brass distributor and solder-type connections. Suction and discharge connections shall be on the same end regardless of coil depth.
- .6 Refrigeration Circuits:
 - .1 The system shall be equipped with minimum four compressors for RTU1, two compressors for RTU-2 and independent refrigeration circuits to limit the volume of refrigerant that may be released in the event of a leak.
 - .2 Refrigerant coils with multiple compressors shall be alternate tube circuited in order to distribute the cooling effect over the entire coil face at reduced load conditions. (split face coils are not acceptable). Provision for use of thermal expansion valves must be included for variable air volume applications.

2.5 PRIMARY DRAIN PANS

- .1 Unit(s) shall be provided with a drain pans under each cooling coil and where applicable, humidifier.
- .2 Provide drain pan under the complete width and length of cooling coil and humidifier sections. Drain pan shall be full width, and extend a minimum of 6" downstream of cooling coil.
- .3 Drain pans for cooling coils and humidifiers shall meet the requirements of ASHRAE 62.
- .4 Drain connection shall be made of same material as drain pan. Dissimilar metals shall not be used to mitigate risk of galvanic corrosion. Drain connection shall be welded to the drain pan.
- .5 Drain pan shall allow visual inspection and physical cleaning on 100% of the pan surface without removal of the coil or humidifier.
- .6 Provide a minimum of 1" clearance between the drain pan and any coil casing, coil support or any other obstruction.
- .7 Provide drain pan that allows the design rate of condensate drainage regardless of fan status.
- .8 Provide drain pan sloped in at least two planes by at least 1/8" per foot toward a single drain. Locate drain connection at the lowest point of the pan. Pan shall have no horizontal surfaces.
- .9 Drain pans shall be stainless steel or fibre reinforced plastic.

2.6 FANS

- .1 General Description
 - .1 Units shall be provided with fans as shown on equipment schedule and drawings.
 - .2 Fans shall be rated in accordance with AMCA Standard Test Code, Bulletin 210. Fan manufacturer shall be a member of AMCA.
 - .3 The fan section shall be provided with an access door on the drive side of the fan.

- .4 Mount the fan and motor assembly on a common adjustable base. This common base shall attach to vibration isolators, which mount to structural support channels. These channels shall span the AHU floor and mount directly to the AHU frame.
 - .1 Provide vibration isolation, as follows:
 - .1 Over 1 ½ hp: Internal Spring Isolation
 - .2 Rubber isolation is acceptable for direct drive plenum fans.
- .5 DWDI fans shall be connected to the unit casing or bulkheads with canvas flexible connection.
- .6 All fan assemblies shall be statically and dynamically balanced at the factory, including a final trim balance prior to shipment.
- .7 The supply fan shall be capable of airflow modulation from 30% to 100% of the scheduled design airflow. The fan shall not operate in a state of surge at any point within the modulation range.
- .2 Belt Drive Fan, Bearings, and Drives
 - .1 Fans shall be provided with polished steel shafts with first critical shaft speed at least 125% of the maximum operating speed for the fan pressure class. Shaft shall have an anti-corrosion coating.
 - .2 Fan wheels shall be keyed to the fan shaft to prevent slipping.
 - .3 Fan shall be provided with an OSHA-approved belt guard to deter incidental contact with rotating sheaves and belts.
 - .4 Airfoil (AF) Fan
 - .1 Provide airfoil fans with blades formed of extruded aluminum, as scheduled. Bent sheet metal blades are not acceptable.
 - .2 Airfoil fans shall comply with AMCA standard 99 2408 69 and 99 2401 82. Provide an AMCA Seal on airfoil fans. Airfoil fan performance shall be based on tests made in accordance with AMCA standards 210 and comply with the requirements of the AMCA certified ratings program for air performance.
 - .5 Plenum (SWSI) Fan
 - .1 Fan shall be a single-width, single-inlet, multi-blade-type, plenum fan.
 - .2 Fan blades shall be backward-inclined airfoil.
 - .3 Fans shall be equipped with self-aligning, anti-friction, pillow-block bearings.
- .3 Direct Drive Fans
 - .1 Plenum (SWSI) Fan
 - .1 Plenum fan wheel shall be single-width, single-inlet.
 - .2 Plenum fan blades shall be aluminum backward-inclined airfoil.
 - .3 Plenum fan shall be direct-driven.
 - .4 Provide VFD with all direct drive fans.

- .4 Fan Motors
 - .1 Fan motors shall be built in accordance and comply with the latest standards of the NEMA and IEEE.
 - .2 Fan motors shall be provided with the following characteristics:
 - .1 Voltage, Frequency and Phase, as scheduled.
 - .2 Motor RPM, maximum 1800 rpm.
 - .3 Minimum service factor of 1.15.
 - .4 Premium efficiency, or as required to meet ASHRAE 90.1.
 - .5 NEMA design ball bearing type.
 - .6 Rated for continuous duty at full load in a 104°F (40°C) ambient.
 - .7 Open drip proof (ODP), totally enclosed, fan cooled (TEFC) or Electronically Commutated (EC).
 - .8 Suitable for use in variable frequency application, per NEMA MG-1 Part 30.
 - .9 Premium Efficiency Inverter ready per NEMA STD MG1 PART 31.4.4.2.
- .5 Fan Motor Disconnects
 - .1 Manufacturer shall provide UL or ETL listed fan-motor disconnects and associated components. Disconnects shall comply with applicable provisions of the National Electric Code.
 - .2 Fused or non-fused fan-motor disconnects shall be provided in NEMA 3R enclosures.
 - .3 Provide single dead front disconnect.
 - .4 Disconnect shall be suitable for use as an OSHA lockout/tagout disconnect.
 - .5 Disconnect handles shall be lockable in the "off" position with up to three padlocks. Switch mechanism shall be directly lockable in the "off" position via padlock when door is open.
 - .6 Disconnects shall be provided with integral ground lug sized to be industry standard.

2.7 GAS HEAT SECTION

- .1 The rooftop unit shall include a natural gas heating section. The assembly shall be an indirect fired type, having 80% minimum thermal efficiency.
- .2 The gas furnace shall be factory installed downstream of the supply air fan in the heat section.
- .3 The gas furnace shall be tubular in design with in-shot gas burners. It shall be of a floating stress relief design and be provided with a condensate drain connection.
- .4 The heat exchanger shall be constructed of stainless steel.
- .5 The heating section shall have modulating control with minimum 8:1 turn down.
- .6 The heating section shall have an induced draft fan that will maintain a negative pressure in the heat exchanger tubes for the removal of the flue gases.

- .7 Each burner module shall have two flame roll-out safety protection switches and a high temperature limit switch that will shut the gas valve off upon detection of improper burner manifold operation. The induced draft fan shall have an airflow safety switch that will prevent the heating module from turning on in the event of no airflow in the flue chamber. The burner controller shall control pre-purge and post-purge fan operation.
- .8 The ignition system, consisting of an electronic ignitor and pilot light will operate continuously with the furnace. The pilot light must extinguish when heating is not required.
- .9 The factory-installed DDC unit control system shall control the gas heat module. The manufacturer's unit certification shall cover the complete unit including the gas heating modules.
- .10 All operating controls and functions shall be factory tested prior to shipment.
- .11 Operating natural gas pressure shall be 7" (1750 Pa) W.C. The burner shall be capable of operating on propane systems with field conversion of orifices and other components as necessary.

2.8 PACKAGED MECHANICAL COOLING

- .1 General
 - .1 Provide an electronic controlled expansion valve. The unit controller shall control the expansion valve to maintain liquid subcooling and the superheat of the refrigerant system.
 - .2 The refrigerant suction lines shall be fully insulated from the expansion valve to the compressors.
 - .3 Refrigerant shall be A1 or A2L classification.
- .2 Condensing Section
 - .1 Outdoor coils shall be cast aluminum, micro-channel coils. Plate fins shall be protected and brazed between adjoining flat tubes such that they shall not extend outside the tubes. A sub-cooling coil shall be an integral part of the main outdoor air coil. Each outdoor air coil shall be factory leak tested with high-pressure air under water.
 - .2 Fan motors shall be an ECM type motor for proportional control. The unit controller shall proportionally control the speed of the condenser fan motors to maintain the head pressure of the refrigerant circuit from ambient condition of 0-120°F. Mechanical cooling shall be provided to 0° F. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase.
 - .3 The condenser fan shall be low noise blade design. Fan blade design shall be a dynamic profile for low tip speed. Fan blade shall be of a composite material.

- .4 The unit shall have scroll compressors. One of the compressors shall be an inverter compressor providing proportional control. The unit controller shall control the speed of the compressor to maintain the discharge air temperature. The inverter compressor shall have a separate oil pump and low oil safety protection.
 - .5 Pressure transducers shall be provided for the suction pressure and head pressure. Temperature sensor shall be provided for the suction temperature and the refrigerant discharge temperature of the compressors. All of the above devices shall be an input to the unit controller and the values be displayed at the unit controller.
 - .6 Each circuit shall be dehydrated and factory charged with Refrigerant and oil.
 - .7 Compressors shall be set on neoprene pads.
 - .8 Compressors shall be located on the side of the unit in a service enclosure complete with hinged access doors c/w lever lock handles for ease of service.
 - .9 Compressors shall have inbuilt overload and temperature protection.
 - .10 Compressors shall be supplied with vibration isolation pads and acoustic blankets.
- .3 Hot Gas Reheat
- .1 Unit shall be equipped with a fully modulating hot gas reheat coil with hot gas coming from the unit condenser.
 - .2 Hot gas reheat coil shall be a copper tube/aluminum fin design. Fins shall be brazed to the tubing for a direct bond. The capacity of the reheat coil shall allow for a 20°F temperature rise at all operating conditions.
 - .3 The modulating hot gas reheat systems shall allow for independent control of the cooling coil leaving air temperature and the reheat coil leaving air temperature. The cooling coil and reheat coil leaving air temperature setpoints shall be adjustable through the unit controller. During the dehumidification cycle the unit shall be capable of 100% of the cooling capacity. The hot gas reheat coil shall provide discharge temperature control within +/- 2°F.
 - .4 Each coil shall be factory leak tested with high- pressure air under water.

2.9 REFRIGERANT LEAK DETECTION

- .1 The refrigerant detection system shall meet the requirements of CSA B52 and have the following functionality:
 - .1 Utilize a set point nonadjustable in the field to generate a digital output signal to initiate mitigation actions to both internal safeties and external components in the ductwork (dampers, electric coils etc.). Signal shall be generated in not more than 30 seconds from sensor exposure to refrigerant concentration of 25% LFL (+0\$, -1%)
 - .2 Sensor within the equipment, near potential source of leaks.
 - .3 Field calibration of the system is not allowed.
 - .4 Be capable of detecting the refrigerant used in the system.
 - .5 Have self diagnostics.

- .6 Energize fans upon failure of a self-diagnostic check.
- .7 Activate refrigerant safety shut off valves in the event of a leak being detected.

2.10 ENERGY RECOVERY WHEEL SECTION

- .1 The rooftop unit shall be provided with an AHRI certified rotary wheel air-to-air heat exchanger in a cassette frame complete with seals, drive motor and drive belt. The energy recovery wheel shall be an integral part of the rooftop unit with unitary construction and does not require field assembly. Bolt-on energy recovery units that require field assembly and section to section gasketing and sealing are not acceptable.
- .2 The wheel capacity, air pressure drop and effectiveness shall be AHRI certified per AHRI Standard 1060. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Heat Exchangers For Energy Recovery Ventilation Equipment.
- .3 The unit shall be designed with a track so the entire energy recovery wheel cassette can slide out from the rooftop unit to facilitate cleaning.
- .4 The unit shall have 2" Merv 7 filters for the outdoor air before the wheel to help keep the wheel clean and reduce maintenance. Filter access shall be by a hinged access door.
- .5 The matrix design shall have channels to reduce cross contamination between the outdoor air and the exhaust air. The layers shall be effectively captured in aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belt(s) of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.
- .6 The total energy recovery wheel shall be coated with silica gel desiccant permanently bonded without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer and shall not degrade. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.
- .7 Wheels shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Where segments are provided, segments shall be removable without the use of tools to facilitate maintenance and cleaning.
- .8 Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel. Wheels shall be connected to the shaft by means of taper lock hubs.
- .9 Wheel seals shall be contact brush seal on both the periphery of the wheel and the face. Seals shall be easily adjustable.

- .10 The control of the energy recovery wheel shall be an integral part of the rooftop unit's DDC controller. The DDC controller shall have visibility of the outdoor air temperature, leaving wheel temperature, return air temperature, and exhaust air temperature. These temperatures shall be displayed at the rooftop units DDC controller LCD display. All of these temperatures shall be made available through the BACnet interface if a BACNet interface has been specified.
- .11 The rooftop unit DDC controller shall provide frost control for the energy recovery wheel. When a frost condition is encountered the unit controller shall (stop, slow down) the wheel. When in the frost control mode the wheel shall be jogged periodically and not be allowed to stay in the stationary position.
- .12 A mechanical purge shall be available and be field adjustable. Purge shall be capable of limiting Exhaust Air Transfer Ratio (EATR) values to 0.4% through proper fan and purge adjustment.
- .13 The energy recovery wheels shall have bypass dampers that allow for 100% outdoor air economizer operation of the unit.

2.11 FILTERS

- .1 Filter sections shall be provided with adequately sized access doors to allow easy removal of filters. Filter removal shall be from one side as noted on the drawings.
- .2 Provide 2" filter rack on outdoor air intake for all units with energy recovery. (MERV 8)
- .3 Provide 2" filter rack on return air (MERV 8)
- .4 Provide final rack for MERV 8 or 13.
- .5 Two sets of filters, as well as a construction set of filters shall be provided.
- .6 For units with filter banks 1825 mm (72") high or less, the filter modules shall be designed to slide out of the unit. Side removal filters shall slide into a formed metal track, sealing against metal spacers at each end of the track.

2.12 ECONOMIZER SECTION

- .1 Unit shall be provided with an outdoor air economizer section.
- .2 The economizer section shall include outdoor, return, and exhaust air dampers.
 - .1 Dampers provided shall be tested in accordance with AMCA 500.
 - .2 Dampers shall be formed damper blades or airfoil blades, extruded vinyl edge seals, and flexible metal compressible jamb seals.
 - .3 Dampers shall have a maximum leakage rate of 4 CFM/square foot at 1" w.g., and shall comply with ASHRAE 90.1.
 - .4 Damper frames shall be u-shaped galvanized metal sections securely screwed or welded to the air handling unit chassis. Pivot rods of 15 mm (1/2") aluminium, shall turn in bronze bushings, fabricated from self-oiling bronze. Rods shall be secured to the blade by means of straps and set screws.

- .5 Blades shall be 1.3 mm (18 gauge) galvanized metal with two breaks on each edge and three breaks on centreline for rigidity. The pivot rod shall "nest" in the centreline break. Damper edges shall interlock. Maximum length of damper between supports shall be 1067 mm (42"). Damper linkage brackets shall be constructed of galvanized metal.
- .6 Two position inlet dampers shall be parallel blade type complete with actuator.
- .7 The outside and return air dampers shall be sized to handle 100% of the supply air volume.
- .3 The economizer operation shall be fully integral to the mechanical cooling and allow up to 100% of mechanical cooling if needed to maintain the cooling discharge air temperature.
- .4 An outdoor air hood shall be factory installed and constructed from galvanized steel finished with the same durable paint finish as the main unit. The hood shall include moisture eliminator filters to drain water away from the entering air stream. The hood shall also include a bird screen to prevent infiltration of foreign materials and a rain lip to drain water away from the entering air stream.
- .5 A barometric exhaust damper shall be provided to exhaust air out of the unit. A bird screen shall be provided to prevent infiltration of rain and foreign materials. Exhaust damper blades shall be lined with vinyl gasketing on contact edges.
- .6 Damper Control
 - .1 Control of the dampers shall be by a factory installed direct coupled actuator. Damper actuator shall be of the modulating, spring return type. A comparative enthalpy control shall be provided to sense and compare enthalpy in both the outdoor and return air streams to determine if outdoor air is suitable for "free" cooling. If outdoor air is suitable for "free" cooling, the outdoor air dampers shall modulate in response to the unit's temperature control system.

2.13 POWER EXHAUST

- .1 Units without a return fan shall be equipped with a power exhaust fan.
- .2 Exhaust fan shall be a single width, single inlet (SWSI) airfoil centrifugal fan. The fan wheel shall be Class II construction with aluminum fan blades that are continuously welded to the hub plate and end rim. The exhaust fan shall be a direct drive fan mounted to the motor shaft. Belts and sheaves are not acceptable due to the additional maintenance.
- .3 The fan motor shall be a totally enclosed EC motor that is speed controlled by the rooftop unit controller. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase. Motors shall be premium efficiency.

- .4 Fan Control:
 - .1 The unit DDC controller shall provide building static pressure control. The unit controller shall provide proportional control of the exhaust fans from 25% to 100% of the supply air fan designed airflow to maintain the adjustable building pressure setpoint. The field installer shall mount the required sensing tubing from the building to the factory mounted building static pressure sensor.
 - .2 The unit's internal controller shall modulate the power exhaust fan based on OA damper position.

2.14 FAN MOTOR VARIABLE FREQUENCY DRIVES (VFDS)

- .1 Manufacturer shall provide UL or ETL listed VFDs and associated components, as scheduled and shown on drawings. VFDs shall comply with applicable provisions of the National Electric Code.
- .2 VFDs shall be mounted in a dedicated NEMA 3R compartment located on the primary access side of its associated fan section and wire VFD to motor, unless otherwise indicated on drawings.
- .3 After unit installation, VFD shall be started and programmed by a factory trained and employed service technician.
- .4 Unit(s) shall be provided with VFD disconnect and bypass.
- .5 Unit(s) shall be provided with harmonic distortion feedback protection:
 - .1 Equivalent 5% impedance input line reactor.
 - .2 Integral RFI/EMI filtering to meet EMC EN61800-3 for First Environment.
- .6 Unit(s) shall be provided with a user interface consisting of following features:
 - .1 30 Character multi-lingual alphanumeric display.
 - .2 Parameter set-up and operating data.
 - .3 Display data shall include:
 - .1 Output frequency (Hz).
 - .2 Speed (RPM)
 - .3 Motor current
 - .4 Calculated % motor torque
 - .5 Calculated motor power (kw)
 - .6 DC bus voltage
 - .7 Output voltage
 - .8 Heat sink temperature
 - .9 Elapsed time meter (re-settable)
 - .10 Kwh (re-settable)
 - .11 Input / output terminal monitor
 - .12 PID actual value (feedback) & error
 - .13 Fault text
 - .14 Warning text
 - .15 Scalable process variable display

- .7 VFD shall be provided with the following protection circuits:
 - .1 Over current
 - .2 Ground fault
 - .3 Over voltage
 - .4 Under voltage
 - .5 Over temperature
 - .6 Input power loss of phase
 - .7 Loss of reference/feedback
 - .8 Adjustable current limit regulator
- .8 VFD shall be UL 508C approved for electronic motor overload.
- .9 VFD shall be provided with features for high input transient protection and surge suppression, such as
 - .1 4 MOVs ahead of diode bridge.
 - .2 120 Joule rated 1600V diode module.
 - .3 Compliant with UL 1449 / ANSI 61.4.
- .10 VFD shall be provided with the following communication features:
 - .1 Two programmable analog inputs.
 - .2 Six programmable digital inputs.
 - .3 Two programmable analog output.
 - .4 Three programmable digital relay outputs.
 - .5 BACNET Communications protocol.
 - .6 Adjustable filters on analog inputs and outputs.
 - .7 Input speed signals, including 4-20 mA and 0-10 VDC.
 - .8 Accel/Decel contacts [floating point control].
 - .9 Auto restart [customer selectable and adjustable].
 - .10 Integrated control interface for Siemens FLN, Johnson N2, Modbus RTU, BACnet MS/TP or LONWorks over RS-485.
- .11 VFD shall consist of the following functions:
 - .1 Pre-magnetization on start.
 - .2 DC braking/hold at stop.
 - .3 Ramp or coast to stop.
 - .4 Seven preset speeds.
 - .5 Three critical frequency lockout bands.
 - .6 Start function shall include ramp, flying start, automatic torque boost, and automatic torque boost with flying start.

2.15 ELECTRICAL WIRING

- .1 Each unit shall be wired and tested at the factory before shipment. Wiring shall comply with CSA standards. All wiring shall be number coded per the electrical wiring diagrams. All electrical components shall be labeled according to the electrical diagram and be CSA recognized.
- .2 A terminal block shall be provided for the main single point power connection. Knockouts shall be provided in the bottom of the main control panel for field wiring entrance. Branch short circuit protection, 115-volt control circuit transformer and fuse, system switches, and a high temperature sensor shall also be provided with the unit.
- .3 Each compressor and condenser fan motor shall be furnished with contactors and internal thermal overload protection. Supply fan motors shall be supplied with external overload protection.

2.16 KAIC RATING

- .1 **Kilo Ampere Interrupting Capacity (kAIC) Rating**
 - .1 **Equipment shall be rated an interrupting capacity rating of 25 kAIC.**
 - .2 **All products supplied to the site shall meet or exceed this kAIC rating.**
 - .3 **The kAIC rating may be lowered to match or exceed the available fault current indicated on the Short Circuit Co-ordination Study completed by the electrical trade.**

2.17 UNIT CONTROLS

- .1 The unit shall be equipped with a microprocessor based control system. The unit's control system shall include all required temperature and pressure sensors, input/output boards, main microprocessor and operator interfaces required for the operation of the unit.
- .2 The unit control system shall be able to perform all unit control functions, including scheduling, unit diagnostics and safeties with and without connection to a building automation system.
- .3 The controller shall have a 4 line x 20 character display with all information and instructions shown in plain English. A keypad shall allow information and controls to be accessed. The microprocessor shall have a programmable time clock, store current and past alarm conditions.
- .4 All factory wiring shall be internal to the unit to maintain product standards for less than 1% air leakage.
- .5 All wiring at unit splits shall be connected with quick-connects - no field splicing of wiring is allowed.
- .6 Control panels shall be factory mounted and all end devices shall be terminated either directly to the controller or to a terminal block.
- .7 Control panels shall include integral 24VAC transformers with circuit breaker overloads.
- .8 No low voltage controls or communication wiring shall be running in the same tray, conduit or proximity as any high voltage wiring.

- .9 Averaging temperature sensors shall be mounted to cover as much cross-sectional area of the interior unit as possible. End and support brackets shall be provided to support sensing element and eliminate strain.
- .10 For mounting probe temperature sensing elements at discharge and air inlet openings, support brackets shall be provided a solid mounting location to minimize vibration effects.
- .11 All actuators for control dampers shall be mounted within the frame of the damper. Actuators shall be mounted on the access side of the damper to facilitate commissioning and servicing.
- .12 Low temperature cut out sensors shall be mounted on downstream face of first water coil within the coil housing frame.
- .13 High temperature cut out sensors shall be mounted, so that the manual reset switch is accessible from the fan section access door. The temperature sensor shall be mounted in the discharge air stream.
- .14 High and low pressure cutout devices shall be mounted so that the manual reset switch is accessible from the fan section access door without putting operator at risk.
- .15 Factory mounted control panels shall be mounted to the exterior wall of the supply fan section. Internal unit wiring is brought into the panel through a single rear knockout. The penetration shall be sealed to prevent air and leakage moisture leakage. Power shall be provided from the single point power connection on the unit.
- .16 Factory packaged controls shall be factory tested using a functional test method. All inputs [AI, BI, DI] and outputs [AO, BO, DO] shall be tested. All sensors and switches shall be cycled through a change of state. All actuators shall be stroked to verify correct operation and rotation through the full operating range. The factory test data results shall be fully documented including all operational conditions. A factory test report document shall be available for each unit. The factory test report shall be provided to the commissioning agent.

2.18 BAS INTEGRATION

- .1 Provide BACNet integration card.
- .2 Provide internal wiring to terminal strip in NEMA 1 enclosure, with space for future DDC controller by BAS contractor. Provide the following points.
 - .1 Supply Fan Start/Stop/Status.
 - .2 Return Fan Start/Stop/Status.
 - .3 Mixed Air Damper Modulation.
 - .4 Mixed Air Temperature.
 - .5 Supply Air Temperature Reset.
 - .6 Heating Enable/Disable/Status.
 - .7 Cooling Enable/Disable/Status.
 - .8 Alarm Status.

2.19 ACCESSORIES

- .1 Roof Curb
 - .1 Provide full perimeter roof mounting curb of heavy gauge sheet metal, minimum of **500 mm (24") high** and complete with wood nailer, neoprene sealing strip, and fully welded "Z" bar with 25 mm (1") upturn on inner perimeter, to provide a complete seal against the elements. Provide on the interior of the roof curb 100 mm (4") thick rigid foil faced insulation over entire surface. Foil tape all joints including joints at curb. External insulation of the roof mounting curb shall be provided by the Roofing Subcontractor.
 - .2 Roof curb shall be matched to the roof slope, and be level in both axes.

2.20 CAPACITY

- .1 Provide unit capacity indicated on schedules.

Part 3 Execution

3.1 INSTALLATION

- .1 Fabricate to provide smooth air flow through all components. Limit air leakage to 1% of rated air flow at 2.5 kPa (10" w.c.) suction pressure.
- .2 Apply sealer into all seams prior to assembly. Secure toe angles continuous along entire length of assembly.
- .3 Install to manufacturers requirements.

3.2 FANS

- .1 Install flexible connections at fan outlets. Ensure metal bands of connectors are parallel and not touching when fan is running and when fan is stopped. Ensure that fan outlet and duct are aligned when fan is running.

3.3 START-UP/COMMISSIONING

- .1 Unit manufacturer shall perform start-up and commissioning.

3.4 SPARE PARTS

- .1 Two (2) complete sets of filters.
- .2 One (1) set of spare belts.

3.5 REFRIGERATION LEAK DETECTION SYSTEM

- .1 This contractor shall provide all wiring between leak detection systems installed within the provided equipment and system components in the spaces served and ductwork system.
- .2 Specifically, the following shall occur for each independent system on registration of a refrigerant leak:
 - .1 Open all zone dampers in the affected system.
 - .2 Disable all electric reheat coils within the affected system.

- .3 Activate field installed safety shut off valves within the affected refrigeration system.
- .4 Energize all fans within the affected ductwork system.
- .5 Activate and refrigerant leak system specific ventilation systems.
- .6 De-energize any other potential sources of ignition within the affected system.
- .3 All interlocks between field installed detection systems and associated safety system components shall be tested and verified to operate as per the requirements of CSA B52.

3.6 TRAINING

- .1 Provide 2 hours training to owner's staff on the care, maintenance, and operation of the equipment. Dedicated visit to site is required as it will not be paired with equipment startup.

3.7 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year on parts on all components.
 - .2 Five (5) years on Energy Recovery Wheel media.
 - .3 Ten (10) years on heat exchanger.
- .3 Warranty Coverage:
 - .1 Applies to parts and labour.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ASTM C553, Mineral Fiber Blanket, Thermal Insulation for Commercial and Industrial Applications.
- .3 EPS 1/RA/2, Environmental Code of Practice for Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems.
- .4 C.1 CSA B52-2023, Mechanical Refrigeration Code.
- .5 C.2 CAN/CSA-C22.2 No 60335 Safety of Household and similar electrical appliances – Heat Pumps, Air-conditioners and dehumidifiers.

1.2 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with general conditions.
- .2 Indicate major components and accessories including sound power levels of units.
- .3 Type of refrigerant used.

1.3 OPERATION AND MAINTENANCE DATA

- .1 Provide operation and maintenance data for incorporation into manual specified in general conditions.

Part 2 Products

2.1 GENERAL

- .1 System type:
 - .1 Air flow arrangement: horizontal
 - .2 Cooling: direct expansion
 - .3 Condensing: air cooled

2.2 OUTDOOR CONDENSING UNITS

- .1 General: Factory-assembled, single piece, air-cooled condensing unit. Contained within the unit enclosure shall be all factory wiring, piping, controls, compressor, refrigerant holding charge, and special features required prior to field start-up. Unit shall be rated in accordance with ARI Standard and be CSA approved.
- .2 Unit Cabinet:
 - .1 Unit cabinet shall be constructed of galvanized steel, bonderized and coated with a prepainted baked enamel finish.
 - .2 A heavy gage roll-formed perimeter base rail with forklift slots and lifting holes shall be provided to facilitate rigging.

- .3 Fans:
 - .1 Condenser fans shall be direct driven, propeller-type, discharging air horizontally.
 - .2 Fan blades shall be balanced.
 - .3 Condenser fan discharge openings shall be equipped with PVC coated steel wire safety guards.
 - .4 Condenser fan and motor shaft shall be corrosion resistant.
- .4 Compressor:
 - .1 Compressor shall be mounted on vibration isolators.
 - .2 Compressors shall include overload protection.
- .5 Condenser Coil:
 - .1 Condenser coil shall be air-cooled and circuited for integral subcooler.
 - .2 Coil shall be constructed of aluminum fins (copper fins optional) mechanically bonded to internally grooved seamless copper tubes which are then cleaned, dehydrated, and sealed.
- .6 Controls and Safeties:
 - .1 Minimum control functions shall include:
 - .1 Control wire terminal blocks.
 - .2 Five-minute recycle protection to prevent compressor short-cycling.
 - .3 Compressor lockout on auto-reset safety until reset from thermostat.
 - .2 Minimum Safety devices which are equipped with automatic reset (after resetting first at thermostat), shall include:
 - .1 High discharge pressure cutout.
 - .2 Loss-of-charge cutout.
- .7 Electrical Requirements:
 - .1 Refer to schedule for voltage.
 - .2 Unit electrical power shall be single-point connection.
 - .3 Unit control circuit shall contain a 24-v transformer for unit control.
- .8 Capacity: Refer to schedule.
- .9 Provide the following:
 - .1 Hail Guard Package.
 - .2 Winter Start Package.
- .10 Acceptable Manufacturers:
 - .1 LG
 - .2 Carrier
 - .3 Trane
 - .4 Lennox.

2.3 WALL HUNG AC UNIT

- .1 Indoor, direct-expansion, wall mounted fan coil, complete with cooling coil, fan, fan motor, piping connectors, electrical controls, microprocessor control system, and integral temperature sensing. Unit shall be furnished with integral wall-mounting bracket and mounting hardware.
- .2 Cabinet discharge and inlet grilles shall be attractively styled, high-impact polystyrene. Cabinet shall be fully insulated for improved thermal and acoustic performance.
- .3 Fan shall be tangential direct-drive blower type with air intake at the upper front face of the unit and discharge at the bottom front. Automatic, motor-driven vertical air sweep shall be provided.
- .4 Coil shall be copper tube with aluminum fins and galvanized steel tube sheets. Fins shall be bonded to the tubes by mechanical expansion. A drip pan under the coil shall have a drain connection for hose attachment to remove condensate. Condensate pan shall have internal trap and auxiliary drip pan under coil header.
- .5 Motors shall be open drip-proof, permanently lubricated ball bearing with inherent overload protection. Fan motors shall be 3-speed.
- .6 Controls shall consist of a microprocessor based control system which shall control space temperature, determine optimum fan speed, and run self diagnostics. The temperature control range shall be from 18°C to 29°C (64°F to 84°F). The unit shall have the following functions:
 - .1 An automatic restart after power failure at the same operating conditions as at failure.
 - .2 A timer function to provide a minimum 24-hour timer cycle for system Auto. Start/Stop.
 - .3 Temperature-sensing controls shall sense return-air temperature. Indoor-air high discharge temperature shutdown shall be provided.
 - .4 Indoor coil freeze protection.
 - .5 Wall mounted thermostat to enter set points and operating conditions.
 - .6 Auto Stop features shall have integral setback control.
 - .7 Automatic airsweep control to provide on or off activation of airsweep louvers.
 - .8 Diagnostics shall provide continuous checks of unit operation and warn of possible malfunctions. Error messages shall be displayed at the unit.
 - .9 Fan speed control shall be user-selectable: high, medium, low, or microprocessor automatic operation during all operating modes.
 - .10 A time delay shall prevent compressor restart in less than three minutes.
- .7 Filter track with factory-supplied cleanable filters.
- .8 Capacity:
 - .1 Refer to schedule.

.9 Acceptable Manufacturers:

- .1 LG
- .2 Carrier
- .3 Trane
- .4 Lennox

2.4 REFRIGERANT

- .1 Refrigerant shall be A1 or A2L Classified.
- .2 Refrigerant holding charge shall be applied at factory.
- .3 Refrigeration circuit components shall include liquid line service valve, suction line service valve, liquid filter drier, a full charge of compressor oil, a holding charge of refrigerant and leak mitigation solenoid valves.
- .4 The system shall be equipped with minimum **2** compressors and independent refrigeration circuits to limit the volume of refrigerant that may be released in the event of a leak.
- .5 The maximum charge allowed per circuit is **5** lbs. Provide additional compressors/circuits if required to keep charge below this value.
- .6 The maximum allowed releasable refrigerant volume is **5** lbs. Provide leak detection and solenoid valves to limit release volume from each circuit.
- .7 Refrigerant coils with multiple compressors shall be alternate tube circuited in order to distribute the cooling effect over the entire coil face at reduced load conditions. (split face coils are not acceptable). Provision for use of thermal expansion valves must be included for variable air volume applications.
- .8 Provide refrigerant leak detectors for installation in served space. Detector shall close refrigeration leak safety valve to limit charge released into space/atmosphere.
- .9 The Refrigerant detection system shall meet the requirements of CSA B52 and have the following functionality:
 - .1 Utilize a set point, nonadjustable in the field, to generate a digital output signal to initiate mitigation actions to both internal safeties and external components in the ductwork (dampers, electric coils etc.). Signal shall be generated in not more than 30 seconds from sensor exposure to refrigerant concentration of 25% LFL (+0%, -1%)
 - .2 Field calibration of the system is not allowed.
 - .3 Be capable of detecting the refrigerant used in the system.
 - .4 Have self diagnostics
 - .5 Energize circulation fans in the event of a leak detection or failed self-diagnostics.
 - .6 Have a digital output signal for monitoring by other systems
 - .7 Activate refrigerant safety shut off valves in the event of a leak being detected.

Part 3 Execution

3.1 GENERAL

- .1 Install as indicated, to manufacturers' recommendations.
- .2 Manufacturer to certify installation.
- .3 Run drain line from cooling coil condensate drain pan to terminate over nearest floor drain.
- .4 Provide concrete pad complete with 100 mm x 100 mm x 20 mm (4" x 4" x 3/4") neoprene type vibration isolation.

3.2 EQUIPMENT

- .1 Preparation and Start-Up
 - .1 Provide services of manufacturer's authorized factory trained mechanic to set and adjust equipment for operation as specified.
 - .2 Provide results in operation and maintenance manuals

3.3 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.
 - .2 Contractor hereby warrants refrigeration compressors for five (5) years.
- .3 Warranty Coverage:
 - .1 Applies to parts and labour.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 All codes, standards, etc. as referenced shall be the latest edition.
- .2 ARI 210/240, Standard for Unitary Air Conditioning and Air-Source Heat Pump Equipment.
- .3 ANSI/ARI 320, Standard for Water-Source Heat Pumps.
- .4 ARI 325, Standard for Ground Water - Source Heat Pumps.
- .5 CAN/CSA-C656, Performance Standard for Split-System and Single Package Central Air Conditioners and Heat Pumps.
- .6 CAN/CSA-C13256-1, Water Source Heat Pumps – Testing and Rating for Performance – Part 1: Water-to-Air and Brine-to-Air Heat Pumps.
- .7 CAN/CSA-C13256-2, Water-source Heat Pumps – Testing and Rating for Performance – Part 2: Water-to-Water and Brine-to-Water Heat Pumps.
- .8 EPS 1/RA/2, Environmental Code of Practice for Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems.
- .9 ANSI/NFPA 90A, Installation of Air Conditioning and Ventilating Systems.
- .10 C.1 CSA B52-2023, Mechanical Refrigeration Code
- .11 C.2 CAN/CSA-C22.2 No 60335 Safety of Household and similar electrical appliances – Heat Pumps, Air-conditioners and dehumidifiers

1.2 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings in accordance with general requirements.
- .2 Indicate:
 - .1 Capacities.
 - .2 ARI Ratings.
 - .3 Sound Power levels.
 - .4 Installation instructions.
 - .5 Start-up Instructions.
 - .6 O&M Instructions.

Part 2 Products

2.1 GENERAL

- .1 Heat pumps to be EPS 1/RA/2, CSA approved and carry ARI or CSA certification seal.

2.2 REFRIGERANTS

- .1 Refrigerant shall be an A1 or an A2L classified refrigerant.
- .2 Refrigerant charge shall not exceed 3 kg (6.6 lbs)
- .3 For all units with refrigerant charge in excess of 3kg provide a leak detection system as follows:
 - .1 The Refrigerant detection system shall meet the requirements of CSA B52 and have the following functionality:
 - .1 Utilize a set point, nonadjustable in the field, to generate a digital output signal to initiate mitigation actions to both internal safeties and external components in the ductwork (dampers, electric coils etc.). Signal shall be generated in not more than 30 seconds from sensor exposure to refrigerant concentration of 25% LFL (+0\$, -1%)
 - .2 Sensor within the equipment, near potential source of leaks.
 - .3 Field calibration of the system is not allowed.
 - .4 Be capable of detecting the refrigerant used in the system.
 - .5 Have self diagnostics
 - .6 Energize fans upon failure of a self-diagnostic check
 - .7 Activate refrigerant safety shut off valves in the event of a leak being detected.

2.3 DRAIN PANS

- .1 Design and construct condensate drain pans under indoor coils so that no water can accumulate and install to allow for easy cleaning.

2.4 INCREMENTAL WATER SOURCE HEAT PUMP

- .1 General:
 - .1 Horizontal type, as indicated, consisting of factory-assembled package containing fan, air-to-refrigerant coil, compressor, 4-way reversing valve, water-to-refrigerant heat exchanger and controls.
- .2 Performance:
 - .1 Certified in accordance with CAN/CSA-C655.
 - .2 As indicated on the drawings.
 - .3 Ratings in accordance with CAN/CSA-C655.
- .3 Basic unit:
 - .1 Compressor: welded hermetic type with internal vibration isolation. Controls to prevent compressor short cycling.
 - .2 Air-to-refrigerant coil: aluminum plate fins mechanically bonded to copper tubing with all joints brazed and with all controls factory installed.
 - .3 Water-to-refrigerant heat exchanger: copper integral finned inner tube tested for maximum working pressure of 2 MPa (290 psi).

- .4 Refrigerant piping: factory assembled, tested charged with refrigerant sealed, with thermal expansion valve, pilot operated refrigerant reversing valve, high pressure and low temperature safety cut-outs.
- .5 Water piping within unit: factory assembled and tested to 1.4 MPa (203 psi).
- .6 NPT connections: ball valve tested to 1.4 MPa (203 psi) WOG (on supply line) and ball valve tested to 2.8 MPa (406 psi) WOG (on return line), flexible hose with threaded swivel connections on supply and return lines to heat exchanger.
- .7 Piping connections: arranged so that only one supply and return connections to hydronic system is required on site.
- .8 Fan: centrifugal forward curved with double inlet, statically and dynamically balanced direct or belt driven from multi-speed, factory lubricated motor. Provide fan speed controller if direct drive. Provide ECM motor.
- .9 Filters: 25 mm (1") thick replaceable media in Merv 8 Filter. Provide spare filter for each unit.
- .10 Unit cabinet: constructed of heavy gauge die-formed galvanized steel with welded corner bracing, complete with provision for connection to return ductwork, hanger brackets and vibration isolators.
 - .1 Console cabinet to be acoustically insulated.
 - .2 Finish: oven baked enamel.
- .11 Provide for field connection of water and electrical services.
- .12 Condensate drain: pan and piping designed to ensure complete removal of all water. Drain connections: minimum NPS 20 mm (3/4").
- .13 Provide the following minimum hose kit, isolating valves, manual circuit balancing valves and strainers: (all items to be provided separately)
 - .1 up to and including 2½ ton unit: 20 mm (3/4").
 - .2 3 ton unit: 25 mm (1").
 - .3 3½ ton unit and over: 32 mm (1¼").
- .4 Controls:
 - .1 Units shall consist of a factory installed microprocessor-based control system, wired and piped, which shall optimize operation, and run self-diagnostics.
 - .2 Manufacturer to provide any special tools like a hand held terminal for any configuration **2 of such tool** with all associate wiring and licensing to be provided as part of the project. (The tool to be new and not to be used for commissioning purpose). Software tool is not preferred. If only software tool is available. Ensure that all upgrade and licensing provision for next 5 years is factored in and all associate interface cables are provided. (2such tool)
Factory certified vendor training and documentation to be provided.
 - .3 O.E.M. furnished controller must use the following inputs for control:
 - .1 Binary input from Building Automation System to command / enable / disable Mechanical Cooling
 - .2 Binary input from Building Automation System to command / enable / disable Heating.

- .3 Binary input from Building Automation System to command / enable / disable Supply Air Fan(s)
- .4 O.E.M. furnished controller must provide a binary output or dry contact set for indication of unit fault.
- .5 Unit shall be equipped to accept signal from end switch on 2-way control valve provided by others. Upon activation, the unit shall turn off the compressor.
- .6 Unit shall be equipped with a condensate overflow switch. Upon activation, the unit shall turn off the compressor.
- .7 Unit Control will be by the Building Automation contractor in accordance with Section 25 20 11.
- .5 Noise and vibration requirements:
 - .1 Sound ratings: measured from unit casing at unit inlet while in cooling mode.
 - .2 Maximum permissible outlet Sound Power Levels (DB re 10 to -12 Watts).
 - .3 Where manufacturer cannot meet specified Sound Power Levels, provide downstream or upstream silencer. Where radiated noise level exceeds specified PWL, provide special enclosure around entire unit, designed to fit in allotted space and still allow full access to unit for O&M.
- .6 Acceptable Manufacturers:
 - .1 Daikin
 - .2 Johnson/Water Furnace
 - .3 Carrier
 - .4 Trane

Part 3 Execution

3.1 INSTALLATION

- .1 Install where indicated and in accordance with manufacturers instructions.
- .2 Secure with hold-down bolts.
- .3 Make all duct connections through flexible connections.
- .4 Level unit with fans running. Align ductwork. flexible connections. Misalignment with fan stopped not to strain or damage flexible connection.
- .5 Make all piping connections with isolation valves, strainers, temperature control valves, balancing valves, and flex connections.
- .6 Nothing to obstruct ready access to all components or to prevent removal of components for servicing.

3.2 CLEANING

- .1 Clean the hydronic piping system with a single hose between the supply and return main. Do NOT clean the hydronic piping system with the heat pump in the piping system. The heat pump is already clean from the manufacturer.

3.3 DRAIN PANS

- .1 Install so that no water can accumulate and arrange so as to be easily accessible for cleaning.

3.3 REFRIGERANT LEAK DETECTION SYSTEM

- .1 This contractor shall provide all wiring between leak detection systems installed within the provided equipment and system components in the spaces served and ductwork system.
- .2 Specifically, the following shall occur for each independent system on registration of a refrigerant leak:
 - .1 Open all zone dampers in the affected system.
 - .2 Disable all electric reheat coils within the affected system.
 - .3 Activate field installed safety shut off valves within the affected refrigeration system.
 - .4 Energize all fans within the affected ductwork system.
 - .5 Activate and refrigerant leak system specific ventilation systems.
 - .6 De-energize any other potential sources of ignition within the affected system.
- .3 All interlocks between field installed detection systems and associated safety system components shall be tested and verified to operate as per the requirements of CSA B52.

3.4 TRAINING

- .1 Provide 2 hours training to owner's staff on the care, maintenance, and operation of the equipment. Dedicated visit to site is required as it will not be paired with equipment startup.

3.4 START-UP AND COMMISSIONING

- .1 Manufacturer to certify installation.
- .2 Manufacturer to be present during start-up, and test and start up units, and certify.
- .3 Manufacturer to provide verbal and written instructions to operating personnel.
- .4 Submit written report to Consultant.

3.5 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.
 - .2 Contractor hereby warrants heat pumps in accordance with general requirements, but for five (5) years.

- .3 Warranty Coverage:
 - .1 Applies to parts and labour.

END OF SECTION

Part 1 General

1.1 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with general requirements.
- .2 Indicate:
 - .1 Equipment, capacity, piping, and connections.
 - .2 Dimensions, internal and external construction details, recommended method of installation with proposed structural steel support, sizes and location of mounting bolt holes.
 - .3 Special enclosures.
- .3 Primer coat to be off white.
- .4 All hydronic heating shall be by a single manufacturer.

1.2 MAINTENANCE DATA

- .1 Provide maintenance data for incorporation into manual specified in general requirements.

Part 2 Products

2.1 DAMPERS

- .1 Factory built, internal damper, complete with operator, at enclosure air outlet grille for each convection type heating unit not thermostatically controlled. Refer to schedules on drawings.

2.2 CAPACITY

- .1 As indicated.

2.3 FINNED TUBE RADIATION (H-3)

- .1 Heating elements: NPS 32 mm (1 1/4") seamless copper tubing, 1.2 mm (18 gauge) minimum wall thickness, mechanically expanded into flanged collars of evenly spaced aluminum fins, 100 mm x 100 mm (4" x 4") nominal, 164 fins per meter (50 fins/ft) suitable for sweat fittings.
- .2 Element hangers: cradle type providing unrestricted longitudinal movement on enclosure brackets. Space brackets 900 mm (36") centres maximum.

- .3 Standard enclosures: 450 mm (18") high, 1.6 mm (16 gauge) thick steel complete with stamped grille, components for wall-to-wall or complete with die formed end caps having no knock-outs, with inside corners, outside corners, as indicated. Provide full length channel and sealer strip at top of wall edge. Height as indicated. Joints and filler pieces to be flush with cabinet. Support rigidly top and bottom, on wall mounted brackets. Joints and filler pieces to be clear of grilles located to provide easy access to valves and vents. Provide access doors for valves. Finish cabinet with factory applied baked primer coat. Enclosure height as indicated. Sloping (flat) top open (sloping) bottom.
- .4 Special enclosures: as indicated.
- .5 Dimensions for enclosures: measure site conditions. Do not scale from drawing.
- .6 Provide for noiseless expansion of all components.
- .7 Expansion compensators: Flexonics at each section by mechanical contractor as specified elsewhere.
- .8 Acceptable Manufacturers:
 - .1 Engineered Air WF-1A Series
 - .2 Slant Fin
 - .3 Sigma

2.4 FINNED TUBE RADIATION (H-5)

- .1 Heating elements: NPS 32 mm (1 1/4") seamless copper tubing, 1.2 mm (18 gauge) minimum wall thickness, mechanically expanded into flanged collars of evenly spaced aluminum fins, 100 mm x 100 mm (4" x 4") nominal, 164 fins per meter (50 fins/ft) suitable for sweat fittings.
- .2 Element hangers: cradle type providing unrestricted longitudinal movement on enclosure brackets. Space brackets 900 mm (36") centres maximum.
- .3 Standard enclosures: 450 mm (18") high, 1.6 mm (16 gauge) thick steel complete with stamped grille, components for wall-to-wall or complete with die formed end caps having no knock-outs, with inside corners, outside corners, as indicated. Provide full length channel and sealer strip at top of wall edge. Height as indicated. Joints and filler pieces to be flush with cabinet. Support rigidly top and bottom, on wall mounted brackets. Joints and filler pieces to be clear of grilles located to provide easy access to valves and vents. Provide access doors for valves. Finish cabinet with factory applied baked primer coat. Enclosure height as indicated. Sloping top, sloping bottom.
- .4 Special enclosures: as indicated.
- .5 Dimensions for enclosures: measure site conditions. Do not scale from drawing.
- .6 Provide for noiseless expansion of all components.
- .7 Expansion compensators: Flexonics at each section by mechanical contractor as specified elsewhere.
- .8 Acceptable Manufacturers:
 - .1 Engineered Air WF-1B Series
 - .2 Slant Fin

2.5 CABINET CONVECTORS (H-4)

- .1 Heating element: seamless copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins and cast iron headers, steel side plates and supports.
- .2 Cabinet: type as indicated, 1.6 mm (16 gauge) thick steel back and ends, manual damper, exposed corners rounded, secured removable front panel, braced and reinforced for stiffness. Provide stamped grill in sloping top, open bottom. Provide damper and operator and access doors for valves. Finish cabinet with factory applied baked primer coat.
- .3 Catalogue rating: certified IBR ratings.
- .4 Capacity: as indicated.
- .5 Acceptable Manufacturers:
 - .1 Engineered Air C-1W
 - .2 Slant Fin
 - .3 Sigma

2.6 CABINET UNIT HEATERS (H-1 & H-2)

- .1 Cabinet: semi-recessed or recessed installation as indicated, 1.6 mm (16 gauge) thick steel with rounded exposed corners and edges, removable panels, glass fiber insulation and integral air outlet and inlet, Arrangement 19 or 24 as indicated.
- .2 Finish with factory applied primer coat.
- .3 Coils: aluminum fins mechanically bonded to copper tubes. Hydrostatically tested to 1 MPa (145 psi).
- .4 Fans: centrifugal double width wheels, statically and dynamically balanced, direct driven, sleeve bearings, resilient mounted.
- .5 Motor: multi-speed, tapped wound permanent split capacitor type with sleeve bearings, built-in thermal overload protection and resilient rubber isolation mounting.
- .6 Filters: removable permanent washable type.
- .7 Capacity and orientation as indicated.
- .8 Control:
 - .1 3 speed switch with integral overloads in cabinet.
 - .2 Low limit aquastat strapped on to hot water heating supply set to prevent fan operating below 27°C (81°F).
 - .3 Control thermostat: electric, rated to suit cabinet heater, with setpoint locking device and concealed adjustment.
 - .1 Remote thermostat and locking guard cover on downflow units.
 - .2 Integral thermostat with access door on upflow units.
 - .3 Remote thermostat and guard by BAS contractor.

- .9 Acceptable Manufacturers:
 - .1 Engineered Air CUH Series
 - .2 Slant Fin
 - .3 Sigma
 - .4 Dunham-Bush

Part 3 Execution

3.1 INSTALLATION

- .1 Install in accordance with manufacturer's instructions.
- .2 Install in accordance with piping layout and reviewed shop drawings.
- .3 Provide for pipe movement during normal operation.
- .4 Maintain sufficient clearance to permit performance of service maintenance.
- .5 Check final location with Consultant if different from that indicated prior to installation. Should deviations beyond allowable clearances arise, request and follow Consultant's directive.
- .6 Valves
 - .1 Install valves with stems upright or horizontal unless approved otherwise.
 - .2 Install isolating gate valves on inlet and balancing valves on outlet of each unit.
- .7 Venting:
 - .1 Install screwdriver vent on cabinet convector, terminating flush with surface of cabinet.
 - .2 Install standard air vent with cock on continuous finned tube radiation.
- .8 Clean finned tubes and comb straight.
- .9 Install flexible expansion compensators as indicated.
- .10 Mount wall mounted convectors at 200 mm (8") above finish floor.
- .11 Mount wall mounted radiation at 200 mm (8") above finish floor unless otherwise indicated.
- .12 On units fed from below floor provide factory manufactured piping shrouds on the exposed piping between base of the radiation cabinet and finished floor. Shroud shall be manufactured by the radiation manufacturer. Shroud shall match finish of the radiation cabinet.
- .13 On fan forced units set discharge patterns and fan speeds to suit requirements prior to acceptance.
- .14 Provide new filter media.

3.2 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.
- .3 Warranty Coverage:
 - .1 Applies to parts and labour.

END OF SECTION

Part 1 General

1.1 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with general requirements.
- .2 Indicate:
 - .1 Equipment, capacity, piping, and connections.
 - .2 Dimensions, construction details, recommended method of installation with proposed steel support.

1.2 MAINTENANCE DATA

- .1 Provide maintenance data for incorporation into manual specified in general requirements.

1.3 SAMPLES

- .1 Submit samples in accordance with general requirements.

1.4 QUALITY ASSURANCE

- .1 Panels shall be manufactured by a company regularly engaged in the manufacture of radiant panels and having catalogue performance data and certified test data.

Part 2 Products

2.1 LINEAR RADIANT CEILING PANELS

- .1 Contractor shall refer to architectural reflected ceiling plans and room finish schedule in addition to mechanical drawings to determine location, quantity and finish of radiant panels.
- .2 This panel specification is based on the AIRTEX HEF-2 Linear radiant ceiling panel design. Refer to the contract drawings for details and dimensions. Panels shall run continuously from wall to wall or as indicated and specified widths are minimum allowable.
- .3 Radiant ceiling extrusions shall consist of extruded aluminum with copper tubing of 15 mm (1/2") I.D. mechanically attached to the aluminum faceplate. The copper tube shall be held in place by an aluminum saddle, which extends more than half way around the diameter of the tube. A non-hardening heat conductive paste shall be placed between the copper tubing and the aluminum faceplate. Panels shall weigh no more than 10.5 kg/m² (2.15 lb/ft²) when operating. The use of adhesive and/or clips to attach the copper tube to the extrusion will not be acceptable.
- .4 Panels shall be finished in the manufacturer's standard white colour.
- .5 Acceptable Manufacturers:
 - .1 Airtex HEF-2
 - .2 Epsilon

- .3 Frenger
- .4 SUN-EL ELF-2 Series
- .5 Sigma
- .6 Armstrong Airtite

2.2 CAPACITY

- .1 As indicated, based on 60°C (140°F) average water temperature, 11C° (20F°) temperature drop and 18.3C (65°F) E.A.T.

Part 3 Execution

3.1 INSTALLATION

- .1 Install in accordance with manufacturer's instructions and as indicated.
- .2 Install in accordance with piping layout and reviewed shop drawings.
- .3 Provide for pipe movement during normal operation.
- .4 Maintain sufficient clearance to permit performance of service maintenance.
- .5 Check final location with Consultant if different from that indicated prior to installation. Should deviations beyond allowable clearances arise, request and follow Consultant's directive.
- .6 The Mechanical Contractor shall co-operate with other trades working in the ceiling to achieve a neat, well co-ordinated overall installation. Refer to Architectural and Mechanical Details for installation requirements.
- .7 All interconnecting of radiant panels by the mechanical contractor shall consist of 0.500" O.D. soft copper tubing or accessories as recommended by the manufacturer, i.e. factory supplied 360 deg. Inter-connecting loops and 180 deg. Return U-bends. Multiple panels shall be circuited to ensure serpentine flow over complete length of zone. Individual serpentine panel coils connected in series are unacceptable for multiple panel zones.
- .8 All radiant panels shall be field trimmed to length ensuring adequate expansion allowance while maintaining panel end coverage by architectural mouldings. Inactive filler panels will be permitted only where indicated on drawings.
- .9 Ceiling support mouldings for Radiant Panels to be supplied and installed by general trades. Ensure ceiling openings and wall mouldings are installed as per radiant panel shop drawings.
- .10 All radiant panels shall be installed by personnel wearing clean white gloves, to avoid spoiling of panel face.
- .11 Provide hanger wires for safety and/or seismic restraint at 1.2 m (4'-0") o.c.
- .12 All active panels shall be covered with a minimum of 50 mm (2") foil backed thick batt non-combustible insulation. Seal edges/entire of perimeter of insulation to radiant panel with foil tape.

3.2 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.
- .3 Warranty Coverage:
 - .1 Applies to parts and labour.

END OF SECTION

Part 1 General

1.1 GENERAL NOTES

- .1 This section is to be read in conjunction with Division 1, the General Conditions, the Common Requirements of the Mechanical Trades, all of Division 23, the remainder of the Division 25 specifications/drawings and the documents required by the BIDDING REQUIREMENTS and CONDITION OF THE CONTRACT SECTIONS.
- .2 This contractor shall bid and work for the mechanical contractor as a sub-contractor.
- .3 When the work is covered as a Cash Allowance in the tender form, the successful Building Automation Contractor must accept the above terms of contract.

1.2 BACNET INTEGRATION AND CONTROL POINTS

- .1 The BAS contractor is responsible to provide a full and operable system that meets all required specifications and sequences.
- .2 The BAS contractor shall provide hard wired control points, sensors and all other components of the system as required to either supplement available BACNet points, or in the absence of a BACNet card make the system completely operable.
- .3 Sequences of operation may or may not be achievable through BACNet integration, as not all points required may be available from the unit manufacturer.
- .4 Not all equipment in the project has been specified with BACNet cards. The BAS contractor is responsible to review the entirety of the mechanical specification to confirm which equipment is being specified with BACNet integration cards and which equipment will not be provided with BACNet integration.
- .5 Quoting or pricing work as BACNet integration only is not acceptable.

1.3 RELATED SECTIONS

- .1 This contractor shall review work specified elsewhere in the mechanical specifications to confirm integration methodology:
 - .1 Sections Plumbing and Drainage
 - .2 Sections Ventilation and Air Conditioning
 - .3 Sections Testing and Balancing
 - .4 Sections Integrated Automation Systems
 - .5 Division 26 Electrical

1.4 PRODUCTS FURNISHED BUT NOT INSTALLED BY BAS CONTRACTOR

- .1 Hydronic Piping:
 - .1 Control Valves
 - .2 Flow Switches
 - .3 Temperature Sensor Wells and Sockets
 - .4 Flow meters.

- .2 Refrigerant Piping:
 - .1 Pressure and Temperature Sensor Wells and Sockets.
- .3 Ductwork Accessories:
 - .1 Automatic Dampers
 - .2 Airflow Stations
- .4 Variable Frequency Drives

1.5 PRODUCTS INSTALLED BUT NOT FURNISHED BY THE BAS CONTRACTOR

- .1 Refrigerant Leak Detection System
- .2 Rooftop Air-Handling Equipment:
 - .1 Thermostats
 - .2 Duct Static Pressure Sensors
- .3 Gas Detection Systems.
- .4 Security System.

1.6 PRODUCTS NOT FURNISHED OR INSTALLED BUT INTEGRATED WITH THE WORK OF THE BAS CONTRACTOR

- .1 Heat Generation Equipment:
 - .1 Boiler Controls.
- .2 Refrigeration Equipment:
 - .1 Chiller Controls.
- .3 Air-Handling Equipment:
 - .1 Discharge Air Temperature Control.
 - .2 Economizer Control.
 - .3 Volume Control.
- .4 Unit Ventilators and Fan Coil Units:
 - .1 Set Point Reset.
 - .2 Day/Night Indexing.
- .5 VAV Terminal Units:
 - .1 Cross-Flow Velocity Sensor.
 - .2 Damper Control.
- .6 Heat Pump Units.
- .7 Domestic Water Plant.

1.7 WORK INCLUDED

- .1 Provide all labour, materials, products, equipment and services to supply, install and commission the Building Management System, utilizing Direct Digital Control (DDC) and monitoring system with electronic actuation.

- .2 Provide all computer hardware and software, operator input/output communication devices, communication units, communication interface to digital system controllers, field sensors and controls as required to meet the specified performance.
- .3 Provide all labour, materials, products, equipment and services to supply, install and commission the electronic control and monitoring system to interface with the Owner's Operations Centre under Terminal Service Option communication protocol.
- .4 Provide all calibration, commissioning, software programming and data base generation of colour graphics and additional work necessary to provide a complete and fully operating system.
- .5 Provide all control wiring in accordance with Electrical Division as necessary to provide a complete and fully operating system as specified in this Section of the Specification.
- .6 120 Volt Wiring
 - .1 New Construction: BAS contractor is responsible to provide and install all 120 volt wiring required for the BAS system from designated junction boxes above electrical panels that have had breakers assigned to "BAS Power." BAS contractor shall review electrical drawings prior to tender. **Any additional breakers or power requirements shall be provided and installed by the electrical contractor at the BAS contractors cost to ensure warranty of the panels.**
 - .2 Existing Buildings: Provide and install 120 Volt, 20 amp circuits in existing electrical panels as required to power field panels and other devices requiring a main supply from electrical panels. Provide updated, type written panel directories to indicate new breakers.
 - .3 All wiring shall be to the standards of Division 26.
- .7 Obtain Ontario Hydro Permits for work specified in this Section of the Specification and submit final certificates in manual.
- .8 Surge transient protection shall be incorporated in design of system to protect electrical components.
- .9 Testing, debugging, confirmation of total system operation and owner training on the complete operation of the system and the computer software shall also be provided in this section.

1.8 EXISTING SYSTEM

- .1 The existing facility is controlled by SIEMENS Automation System. The scope of work for this project involves expanding the existing system to accommodate the newly required points.
- .2 The successful contractor shall locate the communication line and identify its entire length with yellow caution tape. The successful contractor shall maintain it during construction and verify proper operation after construction. Educate other trades and repair all damages that may have occurred.
- .3 Relocate controls and wiring to accommodate new services being installed i.e. ductwork, piping, etc.

- .4 Non compatible manufacturers shall provide their own communication loop in the building for their new services. Wherever possible both communication loops shall be beside each other.
- .5 Non compatible manufacturers shall be required to provide integrated graphics. Provide for a monolithic programming so the operator does not have to alter between software programs. All systems shall be graphically shown on the same floor plan of the building.

1.9 QUALITY ASSURANCE

- .1 Materials and equipment shall be the catalogue products of a single manufacturer regularly engaged in production and Installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.
- .2 Install system using competent workmen who are fully trained in the installation of temperature control equipment. Single source responsibility of the supplier shall be the complete installation and proper operation of the DDC control system and BAS shall include debugging and proper calibration of each component in the entire system.

1.10 SHOP DRAWINGS

- .1 Product Data and Shop Drawings: Meet requirements of Section 15001 on Shop Drawings, Product Data, and Samples. In addition, Contractor shall provide shop drawings or other submittals on all hardware, and installation to be provided. No work may begin on any segment of this project until submittals have been successfully reviewed for conformity with the design intent.
- .2 Submittals shall be provided within 2 weeks of contract award. Submittals shall include:
 - .1 Direct Digital Control System Hardware:
 - .1 A complete bill of materials of equipment to be used indicating quantity, manufacturer, model number, and other relevant technical data.
 - .2 Manufacturer's description and technical data, such as performance curves, product specification sheets, and installation/maintenance instructions for the items listed below and other relevant items not listed below:
 - .1 Direct Digital Controller (controller panels)
 - .2 Transducers/Transmitters
 - .3 Sensors (including accuracy data)
 - .4 Actuators
 - .5 Valves
 - .6 Relays/Switches
 - .7 Control Panels
 - .8 Power Supply
 - .9 Batteries

- .10 Operator Interface Equipment
 - .11 Wiring
 - .3 Wiring diagrams and layouts for each control panel. Show all termination numbers.
 - .4 Schematic diagrams for all field sensors and controllers. Provide floor plans of all sensor locations and control hardware.
- .2 Central System Hardware and Software:
 - .1 A complete bill of material of equipment used, indicating quantity, manufacturer, model number, and other relevant technical data.
 - .2 Manufacturer's description and technical data, such as product specification sheets and installation/maintenance instructions for the items listed below and other relevant items not listed below:
 - .1 Central Processing Unit
 - .2 Power Supply
 - .3 Battery Backup
 - .4 Interface Equipment Between CPU and Control Panels
 - .5 Operating System Software
 - .6 Operator Interface Software
 - .7 Color Graphic Software
 - .8 Third-Party Software
 - .9 Software License
 - .3 Schematic diagrams for all control, communication, and power wiring.
 - .4 Riser diagrams of wiring between central control unit and all control panels.
 - .5 A list of the color graphic screens to be provided. For each screen, provide a conceptual layout of pictures and data and show or explain which other screens can be directly accessed.
- .3 Controlled Systems:
 - .1 A schematic diagram of each controlled system. The schematics shall have all control points labeled with point names shown or listed. The schematics shall graphically show the location of all control elements in the system.
 - .2 A schematic wiring diagram for each controlled system. Each schematic shall have all elements labeled. Where a control element is the same as that shown on the control system schematic, it shall be labeled with the same name. All terminals shall be labeled.
 - .3 An instrumentation list for each controlled system. Each element of the controlled system shall be listed in table format. The table shall show element name, type of device, manufacturer, model number, and product data sheet number.
 - .4 A complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system.

- .5 A point list for each system controller including both inputs and outputs (I/O), point number, the controlled device associated with the I/O point, and the location of the I/O device. Software flag points, alarm points, etc.
- .6 A list of trended points and alarms.
- .4 Provide a riser diagram showing the physical location of building control system equipment and the system architecture. DDC controller trunk conductors shall also be shown on a floor plan.
- .5 Testing and commissioning plan.
- .6 Provide 24 VAC power layout and load calculation for each transformer.

1.11 REFERENCE STANDARDS

- .1 Provide electrical material and installation in accordance with the appropriate sections of the current edition of the applicable local codes for signaling systems. Install wiring in conduit or approved totally enclosed raceways. Do not use cable raceways or troughs.
- .2 Provide materials and equipment, which are standard components regularly manufactured and guaranteed to be available as regular inventory as replacement parts.
- .3 Provide electrical and electronic equipment which is CSA or Ontario Hydro approved where such approvals are required by the regulatory authorities.
- .4 Provide ASCII American Standard for Communication and Information Interchange code input/output devices with standard EIA Electronic Industry Association interface.

1.12 DOCUMENTATION – GENERAL

- .1 Provide documentation for the BAS before the commencement of acceptance testing.
- .2 Provide two (2) sets of operator and programmer manuals to serve the diverse needs of personnel concerned with the operation, and maintenance of the facility.
- .3 Provide prior to project completion three (3) sets of maintenance documentation of a standard, which would enable the Owner to undertake planned maintenance, repair, calibration and other adjustments as may be necessary from time to time, on any component provided under this Contract without additional documentation being required and without assistance from others.

1.13 AS BUILT DRAWINGS AND INFORMATION

- .1 Upon completion of the work, the BMS Contractor shall submit three (3) copies of all Operating and Maintenance Manuals for equipment and materials supplied, and one set of "As- Built" plans showing reasonably exact routes of all cabling, specifications marked "As-Built", plans and specifications marked "As-Built".
- .2 Provide a manual divided into 3 sections describing the following functions:
 - .1 System Hardware Specification Manual, which provides a functional description of all hardware component installation/configuration with detailed instructions.
 - .2 System Operator's Manual, which provides concise instructions for operation of each system an explanation recovery route for all system alarms.

- .3 System Data Manual, which provides the applications data, programmed into the system including a list of virtual points and a print out of the programs and point labels.
 - .4 A complete English language description of each control program for each system shall be provided. Clearly identify the function of each point reference used in the program for each system and/or equipment.
 - .5 Calibrate these points and establish units, limits and alarms;
 - .6 Incorporate these points in screen displays and reports;
 - .7 Incorporate these points in software sequences and control loops.
 - .8 Incorporate these points dynamically in graphic displays.
 - .9 Modify designation of control and virtual points.
- .3 A description of all maintenance procedures for each system's components, including inspection, periodic preventive maintenance, fault diagnosis and repair or replacement of defective module shall be provided. This shall include calibration, maintenance and repair of sensors, transmitters, transducers and panels plus diagnostics and repair or replacement of all system hardware.
 - .4 Control damper schedules with construction details and dimensions. Identify dampers in accordance with specification and drawings. Dampers shall be identified as parallel or opposed blade, c/w frame style and actuator position.
 - .5 Valve schedules with construction details calculated, CVs, selected valve CV pressure drops and flows.
 - .6 Specifications and data sheets for all control system components including relays, switches, thermostats, controllers, dampers, indicators, flow switches, sensors and similar components.
 - .7 Two (2) copies of all software programs for controlled systems on disk
 - .8 Revised points list, panel schedule and sequences of operations and all other information submitted with the original shop drawings, reflecting the "as built" condition.
- .1 The point list shall consist of the following information:

PHYSICAL POINT IDENTIFIER ON THE DDC	SIGNAL TYPE
POINT TYPE (AI, AO, BI, BO)	TREND / TANTALIZATION
POINT NAME	ALARM
POINT DESCRIPTOR	CALIBRATED
PERIPHERAL DEVICE PART NUMBER	COMMISSIONED
WIRE NUMBER	
COMMENT	

- .2 The as-built drawings shall consist of a single page showing the system architecture with BACnet (MSTP & I/P)network numbers, instance and MAC address.

1.14 UNITS

- .1 All equipment and instrumentation shall be graduated in System International (SI) units.

1.15 OWNERSHIP OF PROPRIETARY MATERIALS

- .1 All project developed software and documentation shall become property of the owner. These include, but are not limited to:"
 - .1 Project graphic images
 - .2 As-built drawings
 - .3 Project database
 - .4 Project specific application programming code
 - .5 All documentation

1.16 TRIAL USAGE

- .1 Consultant or owner may use equipment and systems for test purposes prior to acceptance. Supply labour, material, and instruments required for testing.
- .2 Trial usage to apply to following equipment and systems:
 - .1 HVAC
 - .2 Exhaust air
 - .3 Domestic water
 - .4 Plumbing and drainage.

1.17 DEFICIENCIES

- .1 During the course of construction, the consultants will monitor construction and provide written reports of work progress, discussions, and instruction to correct work.
- .2 Instruction to correct work shall be done within the work period before the next review.
- .3 The contractor shall not conceal any work until inspected.
- .4 The contractor shall expedite 100% complete rough-in work and have inspected prior to concealing services and equipment especially above ceiling.
- .5 Upon completion of the project the consultant will do a final review. Upon receiving the final inspection report, the contractor must correct and sign back the inspection report indicating the deficiencies are completed. A re-inspection will only be done once consultant receives this in writing.

1.18 READY FOR TAKEOVER

- .1 Complete the following to the satisfaction of the consultant prior to request for ready for takeover.
 - .1 As-Built Drawings.
 - .2 Maintenance Manuals
 - .3 System Start up
 - .4 HVAC System Commissioning
 - .5 Instructions to Owners

1.19 REVISION TO CONTRACT

- .1 Provide the following:
 - .1 Itemized list of material with associated costs.
 - .2 Labour rate and itemized list of labour for each item.
 - .3 Copy of manufacturers/supplier's invoice if requested.

1.20 DESIGNATED SUBSTANCES AND HAZARDOUS MATERIALS

- .1 If designated substances and/or hazardous materials are suspected or identified cease all work in the immediate area in accordance with OHSA and notify consultant.
- .2 Each contractor and on site employee of the contractor shall have "asbestos awareness training".
- .3 It is the responsibility of the contractor to review the designated substances and/or hazardous materials book in the building prior to starting any work.
- .4 Existing occupied buildings (depending upon their age) may contain designated substances and/or hazardous materials in thermal insulating materials and some manufactured products, such as vinyl asbestos floor tile. Any insulating materials, on pipes, fittings, boilers, tanks, ductwork, etc. may contain designated substances and/or hazardous materials and shall not be disturbed.
- .5 A survey of each building documenting the location and condition of designated substances and/or hazardous materials -containing materials is available for your mandatory review prior to commencing any work on premises.

1.21 REQUEST FOR INFORMATION (RFI) PROCEDURES

- .1 RFIs shall be submitted to the consultant minimum two (2) weeks prior to answer being required. Failure to submit an RFI in a timely manner will forfeit delay claims and schedule extension requests by the contractor.
- .2 All RFIs will be submitted with the following information:
 - .1 RFI number
 - .2 Name of project
 - .3 Date of initiation
 - .4 Date response required by (minimum two (2) weeks)
 - .5 Subject
 - .6 Submitter's name
 - .7 Drawing/specification reference
 - .8 Photograph of the issue (if applicable)
 - .9 Description of the issue
 - .10 Contractor's proposed resolution

1.22 REGULATIONS, PERMITS, AND FEES

- .1 All materials and quality of work shall meet all current and latest Provincial, Municipal and Fire Marshall requirements, regulations, codes, and by-laws in force in the area of the project.
- .2 Each contractor shall give all necessary notices, obtain all necessary permits, and pay all fees in order that the work shown or specified may be carried out. Each contractor shall furnish any certificates necessary as evidence that the work installed conforms with the laws and regulations of all authorities having jurisdiction.
- .3 In the event that changes, or alterations are required on completed work by authorized inspectors, these changes shall be made at the contractor's expense.
- .4 Special equipment which does not have a standard CSA label shall be inspected by the local electrical authority having jurisdiction and the Approval Certificate shall be submitted to the Consultant as soon as possible. All costs and fees for inspections shall be borne by this contractor.

Part 2 Products

2.1 ACCEPTABLE MANUFACTURERS

- .1 The following are the approved Control System Contractors and Manufacturers

Company Name	Product Line	Location	Contact
Siemens	Apogee	Stoney Creek	Jake Rendulic

- .2 Notes
 - .1 The contractor shall use only products from the corresponding manufacturer and product line listed.
 - .2 The above list of manufacturers applies to operator workstation software, controller software, the custom application program language and controllers.
 - .3 All other products specified in the Building Automation specifications need not be manufactured by the above manufacturers (i.e. sensors, valves, dampers and actuators)

2.2 DESCRIPTION OF SYSTEM

- .1 The BAS shall include control of the following systems as detailed in this Section of the Specification under Sequence of Operation:
 - .1 CENTRAL PLANT
 - .1 Heating Water Plant consisting of
 - .1 Boilers.
 - .2 Heating System Pumps and loop.

- .2 Chilled Water Plant consisting of:
 - .1 Cooling Tower.
- .3 Heat Pump Loop consisting of:
 - .1 Circulation Pumps.
- .4 Domestic Hot Water Circulation Pump and Boilers
- .2 FAN PLANT
 - .1 Air Handling Units.
 - .2 HVAC Equipment.
 - .3 Energy or Heat Recovery Units.
- .3 FLOOR LEVEL CONTROL
 - .1 VAV Terminal.
 - .2 Heat Pumps.
 - .3 Vestibule Heaters.
 - .4 Dx Split Systems.
 - .5 Supply, Return and Exhaust Fans.
 - .6 Perimeter Radiation.
 - .7 Reheat Coils.
 - .8 Unit Heaters.
 - .9 Misc. Mechanical and Electrical Room Temperature Control.
- .4 OUTDOOR LIGHTING
- .5 INDOOR LIGHTING CONTROL
- .6 FIRE PANEL MONITORING
- .7 SECURITY MONITORING
- .8 UTILITY MONITORING
 - .1 Switchboard electrical meter monitoring.
 - .2 Gas meter monitoring.
 - .3 Domestic water meter monitoring.
- .2 Refer to sequences of operation section for full description of systems.

2.3 LICENSE

- .1 The system shall be licensed to the owner.
- .2 Provide license for minimum of three years.

2.4 GENERAL SYSTEM REQUIREMENTS

- .1 All applications programs shall be pre-engineered and pre-tested.
 - .1 All the controllers used on the project must use the same programming language, and programs developed for one model of controller must be cross platform transferable to any other model of controller that has sufficient RAM and suitable input/output points.

- .2 Temperature control system shall be completely microprocessor based Direct Digital Control (DDC) electrically and /or electronically operated except where otherwise stated. System shall be installed by competent mechanics and electricians regularly employed by the BMS Company. Energy management system shall be an integral part of BMS.
- .3 In event of power or system failure, equipment shall fail safe, and heating valves open, dampers closed, cooling off. Provide spring return feature on all valves to ensure this condition. (Exception: valve and damper actuators on radiation, reheat valves, etc.) Floating point valves shall not be accepted. Wax valves shall not be acceptable
- .4 All system hardware and associated equipment shall be standard OEM items regularly manufactured for this and/or other systems and not custom designed especially for this project. All components shall have been thoroughly tested and proven in actual use. All electronic circuits shall be self-diagnostic.
- .5 Design scope documents establish minimum acceptable system and component capability. They are not all inclusive. All additional construction, equipment, interfaces and software required for a complete and operating systems providing the specified functions are required.
- .6 The fire/life safety system (F/LS) shall have priority with respect to control of equipment that is subject to control by both the F/LS and BMS. The BMS Contractor shall coordinate installation of the BMS to ensure that interfacing and connection of BMS to such equipment and H-O-A switches shall not pass or interfere with F/LS operation under either normal mode or failure mode operation of the BMS.
- .7 Freeze stats and other safety controls shall have priority with respect to control of equipment that is also controlled by the BMS. Contractor shall co-ordinate installation of the BMS to ensure that interfacing and connections of the BMS and H-O-A switches to such equipment shall not by-pass or interfere with freeze stats or other safety controls.
- .8 System shall be fully modular, permitting point expansion by adding computer memory, remote terminal units, or applications software without obsolescence of existing communication or processing equipment.
- .1 Provide licences for the software packages normally used by the BMS contractor to create, modify and add programming and graphics to the system. The software shall enable owner to add points to system and to program complex routines. Owner shall be able to add and modify all point information. Owner accessible software shall include:
 - .1 Direct Digital Control Library.
 - .2 Report Generation Library.
 - .3 Energy Management Library.
 - .4 Graphics Library.
 - .5 Programming Tool.
 - .6 Engineering Graphics Tool.
- .2 Once programmed, the results may be used to start/stop points, and readjust set points, sequence equipment, report abnormal conditions, etc.

- .9 Set points and values given are for initial set-up only. All points shall be adjustable from the operator workstation.
- .10 All electrical and electronic components shall be CSA; ULC, UL or Ontario Hydro approved where such approvals are required by the regulatory authorities.
- .11 Failure of any Direct Digital Controller Unit (DDC) or its communication link in the system shall not affect the proper operation of the operator workstation or any other Direct Digital Controllers.
- .12 If the Host Computer (CPU) or transmission network fails but power to the DDC does not, the DDC shall continue to monitor all changes of state and/or values and shall retain the most recent values. The DDC shall also maintain all analog set points and command positions.
- .13 Components shall not require any customizing other than setting of jumpers and switches, adding of firmware modules or software modules or any software programming to perform required functions. System shall be a true distributed processing system without any form of network management device used. All software control functions shall be performed by intelligent field panels and by intelligent unit controllers as appropriate.

2.5 GENERAL MATERIALS REQUIREMENTS

- .1 The CPU and peripheral equipment shall operate in the following conditions:
 - .1 Temperature 15 C to 27 C
 - .2 Humidity 20% to 80% (non condensing)
 - .3 Power 120 VAC +/-10%
 - .4 Frequency 60HZ +/-3HZ
 - .5 Power factor 0.6 to 1.0
- .2 Local field panels and peripheral equipment shall be rated to operate in following conditions:
 - .1 Temperature 0° C to 50° C
 - .2 Humidity 10% to 90% RH (non condensing)
 - .3 Power 120 VAC + 10% on primary side of control transformers and plus or minus 25% of nominal voltage on the secondary side.
 - .4 Frequency 60 Hz + 3 Hz
 - .5 Power Factor 0.6 to 1
- .3 Controls shall be D.D.C. solid state type as noted elsewhere, and with exception of actuators, contain no moving parts.
- .4 Sensor accuracy shall be within 0.6% of maximum range, maximum $\pm 0.25^{\circ}\text{C}$. Mixed air sensors must give a true average across duct cross section.

2.6 GENERAL SYSTEM PERFORMANCE REQUIREMENTS

- .1 Comply with the following performance requirements:
 - .1 Graphic Display: Display graphic with minimum 20 dynamic points with current data within 5 seconds.
 - .2 Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 5 seconds.
 - .3 Object Command: Reaction time of less than 5 seconds between operator command of a binary object and device reaction.
 - .4 Object Scan: Transmit change of state and change of analogue values to control units or workstation within 5 seconds.
 - .5 Alarm Response Time: Annunciate alarm at workstation within 2 seconds. Multiple workstations must receive alarms within five seconds of each other.
 - .6 Program Execution Frequency: Programmable controllers shall execute DDC PI control loops, and scan and update process values and outputs at least once per second.
- .2 Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
 - .1 Water Temperature: Plus or minus 0.25°C.
 - .2 Water Flow: Plus or minus 5% of full scale.
 - .3 Water Pressure: Plus or minus 2% of full scale.
 - .4 Space Temperature: Plus or minus 0.25°C.
 - .5 Ducted Air Temperature: Plus or minus 0.25°C.
 - .6 Outside Air Temperature: Plus or minus 0.5°C.
 - .7 Dew Point Temperature: Plus or minus 0.75°C.
 - .8 Temperature Differential: Plus or minus 0.25°C.
 - .9 Relative Humidity: Plus or minus 2%.
 - .10 Airflow (Pressurized Spaces): Plus or minus 3% of full scale.
 - .11 Airflow (Measuring Stations): Plus or minus 5% of full scale.
 - .12 Airflow (Terminal): Plus or minus 10% of full scale.
 - .13 Air Pressure (Space): Plus or minus 0.01-inch wg.
 - .14 Air Pressure (Ducts): Plus or minus 0.1-inch wg.
 - .15 Carbon Monoxide: Plus or minus 5% of reading.
 - .16 Carbon Dioxide: Plus or minus 50 ppm.
 - .17 Electrical: Plus or minus 5% of reading.

2.1 INTEGRATED LIFE SAFETY SYSTEMS TESTING

- .1 Systems in this building, including but not limited to smoke control dampers, smoke control fans, high speed low velocity ceiling fans, makeup air units, heat tracing for fire protection systems and fire protection system components may be subject to Integrated Life Safety Systems testing.

- .2 This contractor shall co-ordinate with the Integrated Life Safety Systems Testing Agent as follows:
 - .1 Confirm which mechanical systems are to be included as part of the testing process.
 - .2 Verify in writing to the Integrated Life Safety Systems Testing Agent that mechanical commissioning of the affected systems/devices is complete prior to the scheduled testing date(s).
 - .3 Participate in the Integrated Life Safety Systems Testing to confirm proper operation of all associated systems.
 - .4 This contractor shall work with the Integrated Life Safety Systems Testing Agent to reset all systems back to normal operating mode after the testing is complete.
- .3 Include all costs associated with Integrated Life Safety System Testing in the tender value.
- .4 Refer to Division 1/Division 26 Integrated Life Safety Systems Testing specifications for additional information/requirements.

Part 3 Execution

3.1 EXAMINATION

- .1 The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the architect/consultant for resolution before rough-in work is started.
- .2 The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the consultant for resolution before rough-in work is started.
- .3 The contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate-or if any discrepancies occur between the plans and the contractor's work and the plans and the work of others-the contractor shall report these discrepancies to the consultant and shall obtain written instructions for any changes necessary to accommodate the contractor's work with the work of others. Any changes in the work covered by this specification made necessary by the failure or neglect of the contractor to report such discrepancies shall be made by-and at the expense of-this contractor.

3.2 A2L REFRIGERANT CONTAINING EQUIPMENT

- .1 A2L refrigerants are classified as mildly flammable. CSA B52-2023 has specific safety clauses related to the use of refrigerants with this classification within buildings.
- .2 This contractor shall be responsible to ensure that the installation requirements of CSA B52-2023 are met.

- .3 Throughout this specification various pieces of equipment have been specified with refrigerant leak detection systems. Field wiring of the alarm status of this system to various downstream system components is required under Annex P of the standard and is the responsibility of this contractor. These devices include the following:
 - .1 Open all zone dampers connected to the affected system.
 - .2 Disable electric reheat coils within the affected system.
 - .3 Activate field installed safety shut off valves on the affected refrigeration systems
 - .4 De-energize any potential sources of ignition with the ductwork system of the affected system.
 - .5 Energize fans within the ductwork system.
 - .6 Activate any designated refrigeration leak ventilation systems.

3.3 VERIFICATION OF REFRIGERATION LEAK DETECTION SYSTEM OPERATION

- .1 The commissioning process shall include the verification of the refrigeration leak detection system.
- .2 All interlocks between leak detection systems installed and system components, as well as interlocks between field installed detection systems and associated safety system components shall be tested and verified to operate as per the requirements of CSA B52. Specifically, the following shall occur for each independent system on registration of a refrigerant leak:
 - .1 Open all zone dampers in the affected system.
 - .2 Disable all electric reheat coils within the affected system.
 - .3 Activate field installed safety shut off valves within the affected refrigeration system.
 - .4 Energize all fans within the affected ductwork system.
 - .5 Activate and refrigerant leak system specific ventilation systems.
 - .6 De-energize any other potential sources of ignition within the affected system.

3.4 PROTECTION

- .1 The contractor shall protect all work and material from damage by his/her work or employees and shall be liable for all damage thus caused.
- .2 The contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The contractor shall protect any material that is not immediately installed. The contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.5 INSTALLATION

- .1 Install all equipment, accessories, conduit and interconnecting wiring in a neat and protected manner by skilled and qualified work persons using the latest standard practices of the industry.
- .2 Meet Owner's requirements.

- .3 Cooperate with the air and water balance technicians during the balancing of the system.
- .4 Trip test high and low temperature protection devices to ensure satisfactory operation, in the presence of the Owner.
- .5 Unless otherwise specified, meet manufacturer's latest printed instructions for materials, planned maintenance and installation methods.
- .6 Notify Consultant in writing of any conflict between these Specifications and manufacturer's instructions.
- .7 Install equipment so as to allow for easy maintenance access and such that it does not interfere in any way with access to adjacent equipment and personnel traffic in the surrounding space.
- .8 Shield and ground communication trunk wiring at a single end.
- .9 Do not splice trunk line.
- .10 Provide complete installation, testing, debugging and interfacing of specified software.

3.6 LABELLING

- .1 Provide engraved black and white Lamicoid plastic nameplates, 25 x 65 mm minimum at all duct mounted instruments, reset controls, thermometers and panels so as to clearly indicate service of particular device. All manual switches unless they come with standard nameplate shall be similarly labeled.

3.7 NAMING

- .1 Object and Point Naming
 - .1 All BACnet objects and points programmed under these specifications, shall conform to the following case sensitive convention:
 - .1 First group of characters = Building Unique Identifier (Enterprise systems only)
 - .2 Second group of characters = Network number
 - .3 Third group of characters = Device number
 - .4 Fourth group of characters = Controller / Equipment Identifier
 - .5 Last segment = Point name abbreviation
 - .2 Example: S1156_2_15_HP10_RmTemp
 - .3 Object name segment shall be delimited by () character, however, must be consistent by Vendor across all owner sites
- .2 Controller and Device Addressing and Naming
 - .1 Each device or network installed and programmed under these specifications, shall be addressed and/or named as follows:
 - .2 Device Instance
 - .1 First group of characters = Building Unique Identifier (Enterprise systems only)
 - .2 Second group of characters = Network number

- .3 Third group of characters = Device number
 - .4 Fourth group of characters = Controller / Equipment Identifier
 - .5 Example: S1156_2_15_HP1
- .3 BACnet Network Number
 - .1 First group of characters = Building Unique Identifier (Enterprise systems only)
 - .2 Second group of characters = Network number
 - .3 Third group of characters = Network and Type
 - .4 Example: S1156_2_1 (S1156 = Forest Trail, 2 = Network 2, 1 = 1st MS/TP network)
- .4 MAC Addresses
 - .1 B-BC
 - .2 Maintenance Connection
 - .3 Reserved
 - .4 -127. Master Range
 - .5 128.– 254. Slave Range
 - .6 255. Broadcast
- .5 Object name segment shall be delimited by () character, however, must be consistent by Vendor across all owner sites
- .3 Controller and Equipment identifiers shall match the standard adopted within the owner's enterprise level network. In the case of no enterprise level network or owner standard identifiers shall match the drawings.

3.8 COORDINATION

- .1 Site
 - .1 Where the mechanical work will be installed in close proximity to, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment. If the contractor installs his/her work before coordinating with other trades, so as to cause any interference with work of other trades, the contractor shall make the necessary changes in his/her work to correct the condition without extra charge.
 - .2 Coordinate and schedule work with all other work in the same area, or with work that is dependent upon other work, to facilitate mutual progress.
- .2 Submittals. Refer to the "Submittals" article in Part 1 of this specification for requirements.
- .3 Test and Balance
 - .1 The contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.
 - .2 The contractor shall provide training in the use of these tools. This training will be planned for a minimum of 4 hours.
 - .3 In addition, the contractor shall provide a qualified technician to assist in the test and balance process.

- .4 The tools used during the test and balance process will be returned at the completion of the testing and balancing.
- .5 During the system testing and balancing by an independent agency fully demonstrate the operation of all sensors, dampers, actuators, controls, valves, etc. This contractor shall be present during the testing and balancing and make adjustments as often as necessary to satisfy the testing and balancing agency.
- .4 Commissioning**
 - .1 This contractor shall work with the commissioning agent to demonstrate the operation of all systems.**
- .5 Life Safety
 - .1 Duct smoke detectors required for air handler shutdown are supplied under the mechanical section of this specification. The contractor shall interlock smoke detectors to air handlers for shutdown as described in Part 3, "Sequences of Operation."
 - .2 Smoke dampers and actuators required for duct smoke isolation are provided under mechanical section. The contractor shall interlock these dampers to the air handlers as described in Part 3, "Sequences of Operation."
 - .3 Fire/smoke dampers and actuators required for fire rated walls are provided under another Section of mechanical section. Control of these dampers shall be by electrical. The contractor shall monitor the position of these dampers.
- .6 Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:
 - .1 All communication media and equipment shall be provided as specified in Part 2, "Communication" of this specification.
 - .2 Each supplier of a controls product is responsible for the configuration, programming, startup, and testing of that product to meet the sequences of operation described in this section.
 - .3 The Contractor shall coordinate and resolve any incompatibility issues that arise between the control products provided under this section and those provided under other sections or divisions of this specification.
 - .4 The contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
 - .5 The contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

3.9 ACCEPTANCE TESTING

- .1 Upon completion of the system control contractor will request, in writing, to the Engineer and Owner that the acceptance procedures can commence.
- .2 After installation forward submittal data relevant to point index, functions, limits, sequences, interlocks, software routines and associated parameters and other pertinent information for the operating system and data base to the Owners authorized representative. Enter software into the central computer and debug.
- .3 Prior to on-line operation perform a complete demonstration and readout of the computer real-time responsibilities of surveillance and command in the presence of the Owner's authorized representative.
- .4 Adjust all devices and components to ensure that the operations are performed correctly and that all analog values are displays to the accuracy specified. Check all alarms, start/stop and status conditions to ensure proper operation.
- .5 Upon successful completion of on-line operation provide the Owner's authorized representative with written confirmation, inspection and approval of the satisfactory operation of the building automation system.
- .6 Complete all outstanding deficiencies as determined by the Owner's representative in his inspection report, after which a resubmission of formal acceptance shall be made. Repeat this procedure, if necessary, until acceptable performance has been established.

3.10 CONTROL SYSTEM CHECKOUT AND TESTING BY BAS CONTRACTOR

- .1 Start-up Testing: All testing listed in this article shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. Submit test worksheets to the consultant. This testing shall be completed before the owner's representative is notified of the system demonstration.
 - .1 The contractor shall furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.
 - .2 Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
 - .3 Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturers' recommendations.
 - .4 Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are rect.
 - .5 Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The contractor shall check all control valves and automatic dampers to ensure proper action and closure. The contractor shall make any necessary adjustments to valve stem and damper blade travel.
 - .6 Verify that the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops and optimum start/stop routines.
 - .7 Alarms and Interlocks:

- .1 Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
 - .2 Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
 - .3 Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.
- .2 Submit copies of test sheets to the consultant and include in as-built information.

3.11 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

- .1 Verify to the Owner's Representative and Architect/Engineer in letter form that supplier has in place support facility. Letter shall show location of support facility, name and titles of technical staff, engineers, supervisors, fitters, electricians, managers and all other personnel responsible for the completion of the work on this project.
- .2 Demonstration
 - .1 Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests.
 - .2 The tests described in this section are to be performed in addition to the tests that the contractor performs as a necessary part of the installation, start-up, and debugging process and as specified in the "Control System Checkout and Testing" article in Part 3 of this specification. The consultant will be present to observe and review these tests. The consultant shall be notified at least 10 days in advance of the start of the testing procedures.
 - .3 The demonstration process shall follow that approved in Part 1, "Submittals." The approved checklists and forms shall be completed for all systems as part of the demonstration.
 - .4 The contractor shall provide at least two persons equipped with two-way communication and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point and system. Any test equipment required to prove the proper operation shall be provided by and operated by the contractor.
 - .5 As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.
 - .6 Demonstrate compliance with Part 1, "System Performance."
 - .7 Demonstrate compliance with sequences of operation through all modes of operation.
 - .8 Manually generate an alarm at a remote DDC Controller as selected by the Architect/Engineer to demonstrate the capability of the workstation and alarm printer to receive alarms within 5 seconds.

- .9 Disconnect an operator workstation in the central control room and manually generate an alarm at a remote DDC Controller to demonstrate the capability of the system printer to receive alarms when the workstation is disconnected from the system.
- .10 Disconnect one DDC Controller from the network to demonstrate that a single device failure shall not disrupt or halt peer to peer communication. Panel to be disconnected shall be selected by the Architect/Engineer.
- .11 At an ASC of the Architect/Engineer's choice, disconnect the LAN connection to demonstrate its lack of reliance on a DDC Controller to maintain full control functionality.
- .12 Demonstrate complete operation of operator interface.
- .13 Additionally, the following items shall be demonstrated:
 - .1 DDC loop response. The contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in set point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.
 - .2 Demand limiting. The contractor shall supply a trend data output showing the action of the demand limiting algorithm. The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting set point, and the status of sheddable equipment outputs.
 - .3 Optimum start/stop. The contractor shall supply a trend data output showing the capability of the algorithm. The change-of-value or change-of-state trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.
 - .4 Interface to the building fire alarm system.
 - .5 Operational logs for each system that indicate all set points, operating points, valve positions, mode, and equipment status shall be submitted to the architect/consultant. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats.
- .14 Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

.3 Acceptance

- .1 All tests described in this specification shall have been performed to the satisfaction of both the consultant and owner prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the consultant. Such tests shall then be performed as part of the warranty.

3.12 TRAINING

- .1 The Contractor shall provide a competent instructor to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed, rather than a general training course.
- .2 Provide 16 hours of training for Owner's operating personnel. Training shall include:
- .1 Explanation of drawings, operations and maintenance manuals
- .2 Walk-through of the job to locate control components
- .3 DDC Controller
- .4 Explanation of adjustment, calibration and replacement procedures
- .5 Review of Operator Work Station Functions (set point adjustment, scheduling etc.)
- .3 Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If such training is required by the Owner, it will be contracted at a later date. Provide description of available local and factory customer training.

3.13 WARRANTY AND SERVICE

- .1 Warranty Start Date:
- .1 Warranty period starts as of the date of Ready for Takeover.
- .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
- .1 One (1) year warranty period applies.
- .3 Warrant in writing, all provided equipment, accessories, installations, software, and firmware against defects in workmanship and materials for a period of one year commencing from the date of issue of the Certificate of Substantial Performance.
- .4 Maintain the affected parts operational during repair of defective equipment covered by the warranty.
- .5 Provide warranty service at no cost to the owner for the guarantee period, this shall include, but not limited to the following:
- .1 Repair service on hour basis during warranty. Provide emergency service where malfunction would result in property damage. If not emergency, respond to site within 24 hours and resolve issue within three (3) days.

- .2 Replacing defective parts and components as required.
- .3 Servicing by factory trained and employed service representatives of system manufacture.
- .6 Supplier shall have an in-place support facility within 100 km of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.
- .7 Provide all labour, associated travel and expenses, materials, and equipment necessary for the successful operation of this system for a period of 12 months from the date of Ready for Takeover.
- .8 **In addition, provide three (3) visits for testing and evaluating the performance of the hardware and software installed per this specification, to be coordinated with the owner's Building Automation Manager. One visit shall be during the cooling season, one visit shall be during the heating season, and one visit shall be during a shoulder season, either spring or fall. Provide a written report after each visit is complete. This service visit shall include, but not be limited to, the following:**
 - .1 **Check calibration and re-calibrate if needed instrumentation sensors for air flow, liquid flow, pressure, humidity, temperature, and transducers. Written records shall be kept indicating the performance of such calibrations along with pertinent data.**
 - .2 **Check the operation of dampers and damper actuators to assure no lock up has occurred and stroke is proper. Written records shall be kept indicating the performance of such calibrations along with pertinent data.**
 - .3 **Check the overall system field operations by performing a review of all points. Verify that all monitoring and command points are valid and active. Written records shall be kept indicating the performance of such exercises.**
- .9 If a problem develops at any time during the warranty/service period, the affected BAS point/object shall be monitored and logged for the remainder of the warranty/service period. "A problem" in the above statement will refer to an incident in which any of the following occur:
 - .1 An alarm occurs due to a defective control system component(s), improper installation or programming.
 - .2 Overall performance of the system is compromised due to a defective control component(s), improper installation or programming.
 - .3 Major recalibration (by greater than 5 times the catalogued accuracy) is required for a sensor during one of the service visits.
 - .4 Changes required to meet design, compliance, and functionality, that were not part of the Demonstration and Acceptance process, will be made at no cost to the Owner.
 - .5 Any changes to programming, inclusive of but not limited to set-points, schedules, sequences, alarms, history, network addressing, object naming, etc.
- .10 Run all diagnostics and correct all previously diagnosed problems.
- .11 Resolve and correct any previous outstanding problems.

- .12 Software: Provide all software updates and verify operation in the system. These updates shall be accomplished in a timely manner, fully coordinated with the system operators, and shall be incorporated into the operations and maintenance manuals, and software documentation.
- .13 Warranty Coverage:
 - .1 Applies to parts and labour.

3.14 WARNING LABELS

- .1 Permanent warning labels shall be affixed to all equipment that can be automatically started by the DDC system.
 - .1 Labels shall use white lettering (12-point type or larger) on a red background.
 - .2 Warning labels shall read as follows:

CAUTION
"Operating under automatic control". "Switch disconnect to "Off" position before servicing".
- .2 Permanent warning labels shall be affixed to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.
 - .1 Labels shall use white lettering (12-point type or larger) on a red background.
 - .2 Warning labels shall read as follows:

CAUTION
"Fed from more than one power source".

3.15 CLEANING

- .1 The contractor shall clean up all debris resulting from his/her activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.
- .2 At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.
- .3 At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.
- .4 All equipment shall be cleaned, including interior and exterior surfaces at completion of the work.

END OF SECTION

Part 1 General

1.1 GENERAL NOTES

- .1 This section is to be read in conjunction with Division 1, the General Conditions, the General Requirements of the Mechanical Trades, the remainder of the Division 25 specifications and the documents required by the BIDDING REQUIREMENTS and CONDITION OF THE CONTRACT SECTIONS.

.2 APPROVED SYSTEMS

- .1 Bids for the BAS contract will be tendered separately by the school board.
.2 Bidders: Johnson Controls, Siemens

1.2 BACNET INTEGRATION AND CONTROL POINTS

- .1 The BAS contractor is responsible to provide a full and operable system that meets all required specifications and sequences.
.2 The BAS contractor shall provide hard wired control points, sensors and all other components of the system as required to either supplement available BACNet points, or in the absence of a BACNet card make the system completely operable.
.3 Sequences of operation may or may not be achievable through BACNet integration, as not all points required may be available from the unit manufacturer.
.4 Not all equipment in the project has been specified with BACNet cards. The BAS contractor is responsible to review the entirety of the mechanical specification to confirm which equipment is being specified with BACNet integration cards and which equipment will not be provided with BACNet integration.
.5 Quoting or pricing work as BACNet integration only is not acceptable.

1.3 RELATED SECTIONS

- .1 This contractor shall review work specified elsewhere in the mechanical specifications to confirm integration methodology:
- | | | |
|----|-------------|----------------------------------|
| .1 | Sections | Plumbing and Drainage |
| .2 | Sections | Ventilation and Air Conditioning |
| .3 | Sections | Testing and Balancing |
| .4 | Sections | Integrated Automation Systems |
| .5 | Division 26 | Electrical |

1.4 PRODUCTS FURNISHED BUT NOT INSTALLED BY BAS CONTRACTOR

- .1 Hydronic Piping:
- | | |
|----|--------------------------------------|
| .1 | Control Valves |
| .2 | Flow Switches |
| .3 | Temperature Sensor Wells and Sockets |
| .4 | Flow meters. |

- .2 Refrigerant Piping:
 - .1 Pressure and Temperature Sensor Wells and Sockets.
- .3 Ductwork Accessories:
 - .1 Automatic Dampers
 - .2 Airflow Stations
- .4 Variable Frequency Drives

1.5 PRODUCTS INSTALLED BUT NOT FURNISHED BY THE BAS CONTRACTOR

- .1 Refrigerant Leak Detection System
- .2 Rooftop Air-Handling Equipment:
 - .1 Thermostats
 - .2 Duct Static Pressure Sensors
- .3 Gas Detection Systems.
- .4 Security System.

1.6 PRODUCTS NOT FURNISHED OR INSTALLED BUT INTEGRATED WITH THE WORK OF THE BAS CONTRACTOR

- .1 Heat Generation Equipment:
 - .1 Boiler Controls.
- .2 Refrigeration Equipment:
 - .1 Chiller Controls.
- .3 Rooftop Air-Handling Equipment:
 - .1 Discharge Air Temperature Control.
 - .2 Economizer Control.
 - .3 Volume Control.
- .4 Unit Ventilators and Fan Coil Units:
 - .1 Set Point Reset.
 - .2 Day/Night Indexing.
- .5 VAV Terminal Units:
 - .1 Cross-Flow Velocity Sensor.
 - .2 Damper Control.
- .6 Heat Pump Units.

1.7 WORK INCLUDED

- .1 Provide all labour, materials, products, equipment and services to supply, install and commission the Building Management System, utilizing Direct Digital Control (DDC) and monitoring system with electronic actuation.

- .2 Provide all computer hardware and software, operator input/output communication devices, communication units, communication interface to digital system controllers, field sensors and controls as required to meet the specified performance.
- .3 Provide all labour, materials, products, equipment and services to supply, install and commission the electronic control and monitoring system to interface with the Owner's Operations Centre under Terminal Service Option communication protocol.
- .4 Provide all calibration, commissioning, software programming and data base generation of colour graphics and additional work necessary to provide a complete and fully operating system.
- .5 Provide all control wiring in accordance with Electrical Division as necessary to provide a complete and fully operating system as specified in this Section of the Specification.
- .6 120 Volt Wiring
 - .1 New Construction: BAS contractor is responsible to provide and install all 120 volt wiring required for the BAS system from designated junction boxes above electrical panels that have had breakers assigned to "BAS Power." BAS contractor shall review electrical drawings prior to tender. **Any additional breakers or power requirements shall be provided and installed by the electrical contractor at the BAS contractors cost to ensure warranty of the panels.**
 - .2 Existing Buildings: Provide and install 120 Volt, 20 amp circuits in existing electrical panels as required to power field panels and other devices requiring a main supply from electrical panels. Provide updated, type written panel directories to indicate new breakers.
 - .3 All wiring shall be to the standards of Division 26.
- .7 Obtain Ontario Hydro Permits for work specified in this Section of the Specification and submit final certificates in manual.
- .8 Surge transient protection shall be incorporated in design of system to protect electrical components.
- .9 Testing, debugging, confirmation of total system operation and owner training on the complete operation of the system and the computer software shall also be provided in this section.

1.8 EXISTING SYSTEM

- .1 The existing facility is controlled by SIEMENS Automation System. The scope of work for this project involves expanding the existing system to accommodate the newly required points.
- .2 The successful contractor shall locate the communication line and identify its entire length with yellow caution tape. The successful contractor shall maintain it during construction and verify proper operation after construction. Educate other trades and repair all damages that may have occurred.
- .3 Relocate controls and wiring to accommodate new services being installed i.e. ductwork, piping, etc.

- .4 Non compatible manufacturers shall provide their own communication loop in the building for their new services. Wherever possible both communication loops shall be beside each other.
- .5 Non compatible manufacturers shall be required to provide integrated graphics. Provide for a monolithic programming so the operator does not have to alter between software programs. All systems shall be graphically shown on the same floor plan of the building.

1.9 QUALITY ASSURANCE

- .1 Materials and equipment shall be the catalogue products of a single manufacturer regularly engaged in production and Installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.
- .2 Install system using competent workmen who are fully trained in the installation of temperature control equipment. Single source responsibility of the supplier shall be the complete installation and proper operation of the DDC control system and BAS shall include debugging and proper calibration of each component in the entire system.

1.10 SHOP DRAWINGS

- .1 Product Data and Shop Drawings: meet requirements of general conditions on Shop Drawings, Product Data, and Samples. In addition, Contractor shall provide shop drawings or other submittals on all hardware, and installation to be provided. No work may begin on any segment of this project until submittals have been successfully reviewed for conformity with the design intent.
- .2 Submittals shall be provided within 2 weeks of contract award. Submittals shall include:
 - .1 Direct Digital Control System Hardware:
 - .1 A complete bill of materials of equipment to be used indicating quantity, manufacturer, model number, and other relevant technical data.
 - .2 Manufacturer's description and technical data, such as performance curves, product specification sheets, and installation/maintenance instructions for the items listed below and other relevant items not listed below:
 - .1 Direct Digital Controller (controller panels)
 - .2 Transducers/Transmitters
 - .3 Sensors (including accuracy data)
 - .4 Actuators
 - .5 Valves
 - .6 Relays/Switches
 - .7 Control Panels
 - .8 Power Supply

- .9 Batteries
 - .10 Operator Interface Equipment
 - .11 Wiring
- .3 Wiring diagrams and layouts for each control panel. Show all termination numbers.
- .4 Schematic diagrams for all field sensors and controllers. Provide floor plans of all sensor locations and control hardware.
- .2 Central System Hardware and Software:
 - .1 A complete bill of material of equipment used, indicating quantity, manufacturer, model number, and other relevant technical data.
 - .2 Manufacturer's description and technical data, such as product specification sheets and installation/maintenance instructions for the items listed below and other relevant items not listed below:
 - .1 Central Processing Unit
 - .2 Power Supply
 - .3 Battery Backup
 - .4 Interface Equipment Between CPU and Control Panels
 - .5 Operating System Software
 - .6 Operator Interface Software
 - .7 Color Graphic Software
 - .8 Third-Party Software
 - .9 Software License
 - .3 Schematic diagrams for all control, communication, and power wiring.
 - .4 Riser diagrams of wiring between central control unit and all control panels.
 - .5 A list of the color graphic screens to be provided. For each screen, provide a conceptual layout of pictures and data and show or explain which other screens can be directly accessed.
- .3 Controlled Systems:
 - .1 A schematic diagram of each controlled system. The schematics shall have all control points labeled with point names shown or listed. The schematics shall graphically show the location of all control elements in the system.
 - .2 A schematic wiring diagram for each controlled system. Each schematic shall have all elements labeled. Where a control element is the same as that shown on the control system schematic, it shall be labeled with the same name. All terminals shall be labeled.
 - .3 An instrumentation list for each controlled system. Each element of the controlled system shall be listed in table format. The table shall show element name, type of device, manufacturer, model number, and product data sheet number.

- .4 A complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system.
- .5 A point list for each system controller including both inputs and outputs (I/O), point number, the controlled device associated with the I/O point, and the location of the I/O device. Software flag points, alarm points, etc.
- .6 A list of trended points and alarms.
- .4 Provide a riser diagram showing the physical location of building control system equipment and the system architecture. DDC controller trunk conductors shall also be shown on a floor plan.
- .5 Testing and commissioning plan.
- .6 Provide 24 VAC power layout and load calculation for each transformer.

1.11 REFERENCE STANDARDS

- .1 Provide electrical material and installation in accordance with the appropriate sections of the current edition of the applicable local codes for signaling systems. Install wiring in conduit or approved totally enclosed raceways. Do not use cable raceways or troughs.
- .2 Provide materials and equipment, which are standard components regularly manufactured and guaranteed to be available as regular inventory as replacement parts.
- .3 Provide electrical and electronic equipment which is CSA or Ontario Hydro approved where such approvals are required by the regulatory authorities.
- .4 Provide ASCII American Standard for Communication and Information Interchange code input/output devices with standard EIA Electronic Industry Association interface.

1.12 DOCUMENTATION – GENERAL

- .1 Provide documentation for the BAS before the commencement of acceptance testing.
- .2 Provide two (2) sets of operator and programmer manuals to serve the diverse needs of personnel concerned with the operation, and maintenance of the facility.
- .3 Provide prior to project completion three (3) sets of maintenance documentation of a standard, which would enable the Owner to undertake planned maintenance, repair, calibration and other adjustments as may be necessary from time to time, on any component provided under this Contract without additional documentation being required and without assistance from others.

1.13 AS BUILT DRAWINGS AND INFORMATION

- .1 Upon completion of the work, the BMS Contractor shall submit three (3) copies of all Operating and Maintenance Manuals for equipment and materials supplied, and one set of "As- Built" plans showing reasonably exact routes of all cabling, specifications marked "As-Built", plans and specifications marked "As-Built".

- .2 Provide a manual divided into 3 sections describing the following functions:
 - .1 System Hardware Specification Manual, which provides a functional description of all hardware component installation/configuration with detailed instructions.
 - .2 System Operator's Manual, which provides concise instructions for operation of each system an explanation recovery route for all system alarms.
 - .3 System Data Manual, which provides the applications data, programmed into the system including a list of virtual points and a print out of the programs and point labels.
 - .4 A complete English language description of each control program for each system shall be provided. Clearly identify the function of each point reference used in the program for each system and/or equipment.
 - .5 Calibrate these points and establish units, limits and alarms;
 - .6 Incorporate these points in screen displays and reports;
 - .7 Incorporate these points in software sequences and control loops.
 - .8 Incorporate these points dynamically in graphic displays.
 - .9 Modify designation of control and virtual points.
- .3 A description of all maintenance procedures for each system's components, including inspection, periodic preventive maintenance, fault diagnosis and repair or replacement of defective module shall be provided. This shall include calibration, maintenance and repair of sensors, transmitters, transducers and panels plus diagnostics and repair or replacement of all system hardware.
- .4 Control damper schedules with construction details and dimensions. Identify dampers in accordance with specification and drawings. Dampers shall be identified as parallel or opposed blade, c/w frame style and actuator position.
- .5 Valve schedules with construction details calculated, CVs, selected valve CV pressure drops and flows.
- .6 Specifications and data sheets for all control system components including relays, switches, thermostats, controllers, dampers, indicators, flow switches, sensors and similar components.
- .7 Two (2) copies of all software programs for controlled systems on disk
- .8 Revised points list, panel schedule and sequences of operations and all other information submitted with the original shop drawings, reflecting the "as built" condition.
 - .1 The point list shall consist of the following information:

PHYSICAL POINT IDENTIFIER ON THE DDC	SIGNAL TYPE
POINT TYPE (AI, AO, BI, BO)	TREND / TANTALIZATION
POINT NAME	ALARM
POINT DESCRIPTOR	CALIBRATED
PERIPHERAL DEVICE PART NUMBER	COMMISSIONED
WIRE NUMBER	
COMMENT	

- .2 The as-built drawings shall consist of a single page showing the system architecture with BACnet (MSTP & I/P) network numbers, instance and MAC address.

1.14 UNITS

- .1 All equipment and instrumentation shall be graduated in System International (SI) units.

1.15 OWNERSHIP OF PROPRIETARY MATERIALS

- .1 All project developed software and documentation shall become property of the owner. These include, but are not limited to:"
 - .1 Project graphic images
 - .2 As-built drawings
 - .3 Project database
 - .4 Project specific application programming code
 - .5 All documentation

Part 2 Products

2.1 ACCEPTABLE MANUFACTURERS

- .1 Bids for the BAS contract will be tendered separately by the school board.
- .2 Bidders: Johnson Controls, Siemens
- .3 The contractor shall use only products from the corresponding manufacturer and product line listed.
- .4 The above list of manufacturers applies to operator workstation software, controller software, the custom application program language and controllers.
- .5 All other products specified in the Building Automation specifications need not be manufactured by the above manufacturers (i.e. sensors, valves, dampers and actuators)

2.2 DESCRIPTION OF SYSTEM

- .1 The BAS shall include control of the following systems as detailed in this Section of the Specification under Sequence of Operation:
 - .1 CENTRAL PLANT
 - .1 Heating Water Plant consisting of:
 - .1 Boilers.
 - .2 Heating System Pumps and loop.
 - .2 Chilled Water Plant consisting of:
 - .1 Cooling Tower.
 - .3 Heat Pump Loop consisting of:
 - .1 Heat Exchangers.
 - .2 Circulation Pumps.
 - .4 Domestic Hot Water Circulation Pump and Boilers

- .2 FAN PLANT
 - .1 Air Handling Units.
 - .2 HVAC Equipment.
 - .3 Energy or Heat Recovery Units.
- .3 FLOOR LEVEL CONTROL
 - .1 VAV Terminal.
 - .2 Heat Pumps.
 - .3 Vestibule Heaters.
 - .4 Dx Split Systems.
 - .5 Supply, Return and Exhaust Fans.
 - .6 Perimeter Radiation.
 - .7 Reheat Coils.
 - .8 Unit Heaters.
 - .9 Misc. Mechanical and Electrical Room Temperature Control.
- .4 OUTDOOR LIGHTING
- .5 INDOOR LIGHTING CONTROL
- .6 FIRE PANEL MONITORING
- .7 SECURITY MONITORING
- .8 UTILITY MONITORING
 - .1 Switchboard electrical meter monitoring.
 - .2 Gas meter monitoring.
 - .3 Domestic water meter monitoring.
- .9 Fire/Smoke damper monitoring.
- .2 Refer to sequences of operation section for full description of systems.

2.3 LICENSE

- .1 The system shall be licensed to the owner.
- .2 Provide license for minimum of three years.

2.4 GENERAL SYSTEM REQUIREMENTS

- .1 All applications programs shall be pre-engineered and pre-tested.
 - .1 All the controllers used on the project must use the same programming language, and programs developed for one model of controller must be cross platform transferable to any other model of controller that has sufficient RAM and suitable input/output points.
- .2 Temperature control system shall be completely microprocessor based Direct Digital Control (DDC) electrically and /or electronically operated except where otherwise stated. System shall be installed by competent mechanics and electricians regularly employed by the BMS Company. Energy management system shall be an integral part of BMS.

- .3 In event of power or system failure, equipment shall fail safe, and heating valves open, dampers closed, cooling off. Provide spring return feature on all valves to ensure this condition. (Exception: valve and damper actuators on radiation, reheat valves, etc.) Floating point valves shall not be accepted. Wax valves shall not be acceptable
- .4 All system hardware and associated equipment shall be standard OEM items regularly manufactured for this and/or other systems and not custom designed especially for this project. All components shall have been thoroughly tested and proven in actual use. All electronic circuits shall be self-diagnostic.
- .5 Design scope documents establish minimum acceptable system and component capability. They are not all inclusive. All additional construction, equipment, interfaces and software required for a complete and operating systems providing the specified functions are required.
- .6 The fire/life safety system (F/LS) shall have priority with respect to control of equipment that is subject to control by both the F/LS and BMS. The BMS Contractor shall coordinate installation of the BMS to ensure that interfacing and connection of BMS to such equipment and H-O-A switches shall not pass or interfere with F/LS operation under either normal mode or failure mode operation of the BMS.
- .7 Freeze stats and other safety controls shall have priority with respect to control of equipment that is also controlled by the BMS. Contractor shall co-ordinate installation of the BMS to ensure that interfacing and connections of the BMS and H-O-A switches to such equipment shall not by-pass or interfere with freeze stats or other safety controls.
- .8 System shall be fully modular, permitting point expansion by adding computer memory, remote terminal units, or applications software without obsolescence of existing communication or processing equipment.
 - .1 Provide licences for the software packages normally used by the BMS contractor to create, modify and add programming and graphics to the system. The software shall enable owner to add points to system and to program complex routines. Owner shall be able to add and modify all point information. Owner accessible software shall include:
 - .1 Direct Digital Control Library.
 - .2 Report Generation Library.
 - .3 Energy Management Library.
 - .4 Graphics Library.
 - .5 Programming Tool.
 - .6 Engineering Graphics Tool.
 - .2 Once programmed, the results may be used to start/stop points, and readjust set points, sequence equipment, report abnormal conditions, etc.
- .9 Set points and values given are for initial set-up only. All points shall be adjustable from the operator workstation.
- .10 All electrical and electronic components shall be CSA; ULC, UL or Ontario Hydro approved where such approvals are required by the regulatory authorities.

- .11 Failure of any Direct Digital Controller Unit (DDC) or its communication link in the system shall not affect the proper operation of the operator workstation or any other Direct Digital Controllers.
- .12 If the Host Computer (CPU) or transmission network fails but power to the DDC does not, the DDC shall continue to monitor all changes of state and/or values and shall retain the most recent values. The DDC shall also maintain all analog set points and command positions.
- .13 Components shall not require any customizing other than setting of jumpers and switches, adding of firmware modules or software modules or any software programming to perform required functions. System shall be a true distributed processing system without any form of network management device used. All software control functions shall be performed by intelligent field panels and by intelligent unit controllers as appropriate.

2.5 GENERAL MATERIALS REQUIREMENTS

- .1 The CPU and peripheral equipment shall operate in the following conditions:
 - .1 Temperature 15°C to 27°C
 - .2 Humidity 20% to 80% (non condensing)
 - .3 Power 120 VAC +/-10%
 - .4 Frequency 60HZ +/-3HZ
 - .5 Power factor 0.6 to 1.0
- .2 Local field panels and peripheral equipment shall be rated to operate in following conditions:
 - .1 Temperature 0° C to 50° C
 - .2 Humidity 10% to 90% RH (non condensing)
 - .3 Power 120 VAC + 10% on primary side of control transformers and plus or minus 25% of nominal voltage on the secondary side.
 - .4 Frequency 60 Hz + 3 Hz
 - .5 Power Factor 0.6 to 1
- .3 Controls shall be D.D.C. solid state type as noted elsewhere, and with exception of actuators, contain no moving parts.
- .4 Sensor accuracy shall be within 0.6% of maximum range, maximum $\pm 0.25^{\circ}\text{C}$. Mixed air sensors must give a true average across duct cross section.

2.6 GENERAL SYSTEM PERFORMANCE REQUIREMENTS

- .1 Comply with the following performance requirements:
 - .1 Graphic Display: Display graphic with minimum 20 dynamic points with current data within 5 seconds.
 - .2 Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 5 seconds.

- .3 Object Command: Reaction time of less than 5 seconds between operator command of a binary object and device reaction.
 - .4 Object Scan: Transmit change of state and change of analogue values to control units or workstation within 5 seconds.
 - .5 Alarm Response Time: Annunciate alarm at workstation within 2 seconds. Multiple workstations must receive alarms within five seconds of each other.
 - .6 Program Execution Frequency: Programmable controllers shall execute DDC PI control loops, and scan and update process values and outputs at least once per second.
- .2 Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
- .1 Water Temperature: Plus or minus 0.25°C.
 - .2 Water Flow: Plus or minus 5% of full scale.
 - .3 Water Pressure: Plus or minus 2% of full scale.
 - .4 Space Temperature: Plus or minus 0.25°C.
 - .5 Ducted Air Temperature: Plus or minus 0.25°C.
 - .6 Outside Air Temperature: Plus or minus 0.5°C.
 - .7 Dew Point Temperature: Plus or minus 0.75°C.
 - .8 Temperature Differential: Plus or minus 0.25°C.
 - .9 Relative Humidity: Plus or minus 2%.
 - .10 Airflow (Pressurized Spaces): Plus or minus 3% of full scale.
 - .11 Airflow (Measuring Stations): Plus or minus 5% of full scale.
 - .12 Airflow (Terminal): Plus or minus 10% of full scale.
 - .13 Air Pressure (Space): Plus or minus 0.01-inch wg.
 - .14 Air Pressure (Ducts): Plus or minus 0.1-inch wg.
 - .15 Carbon Monoxide: Plus or minus 5% of reading.
 - .16 Carbon Dioxide: Plus or minus 50 ppm.
 - .17 Electrical: Plus or minus 5% of reading.

Part 3 Execution

3.1 EXAMINATION

- .1 The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the architect/consultant for resolution before rough-in work is started.
- .2 The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the consultant for resolution before rough-in work is started.

- .3 The contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate-or if any discrepancies occur between the plans and the contractor's work and the plans and the work of others-the contractor shall report these discrepancies to the consultant and shall obtain written instructions for any changes necessary to accommodate the contractor's work with the work of others. Any changes in the work covered by this specification made necessary by the failure or neglect of the contractor to report such discrepancies shall be made by-and at the expense of-this contractor.

3.2 A2L REFRIGERANT CONTAINING EQUIPMENT

- .1 A2L refrigerants are classified as mildly flammable. CSA B52-2023 has specific safety clauses related to the use of refrigerants with this classification within buildings.
- .2 This contractor shall be responsible to ensure that the installation requirements of CSA B52-2023 are met.
- .3 Throughout this specification various pieces of equipment have been specified with refrigerant leak detection systems. Field wiring of the alarm status of this system to various downstream system components is required under Annex P of the standard and is the responsibility of this contractor. These devices include the following:
 - .1 Open all zone dampers connected to the affected system.
 - .2 Disable electric reheat coils within the affected system.
 - .3 Activate field installed safety shut off valves on the affected refrigeration systems
 - .4 De-energize any potential sources of ignition with the ductwork system of the affected system.
 - .5 Energize fans within the ductwork system.
 - .6 Activate any designated refrigeration leak ventilation systems.

3.3 VERIFICATION OF REFRIGERATION LEAK DETECTION SYSTEM OPERATION

- .1 The commissioning process shall include the verification of the refrigeration leak detection system.
- .2 All interlocks between leak detection systems installed and system components, as well as interlocks between field installed detection systems and associated safety system components shall be tested and verified to operate as per the requirements of CSA B52. Specifically, the following shall occur for each independent system on registration of a refrigerant leak:
 - .1 Open all zone dampers in the affected system.
 - .2 Disable all electric reheat coils within the affected system.
 - .3 Activate field installed safety shut off valves within the affected refrigeration system.
 - .4 Energize all fans within the affected ductwork system.
 - .5 Activate and refrigerant leak system specific ventilation systems.
 - .6 De-energize any other potential sources of ignition within the affected system.

3.4 PROTECTION

- .1 The contractor shall protect all work and material from damage by his/her work or employees and shall be liable for all damage thus caused.
- .2 The contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The contractor shall protect any material that is not immediately installed. The contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.5 INSTALLATION

- .1 Install all equipment, accessories, conduit and interconnecting wiring in a neat and protected manner by skilled and qualified work persons using the latest standard practices of the industry.
- .2 Meet Owner's requirements.
- .3 Cooperate with the air and water balance technicians during the balancing of the system.
- .4 Trip test high and low temperature protection devices to ensure satisfactory operation, in the presence of the Owner.
- .5 Unless otherwise specified, meet manufacturer's latest printed instructions for materials, planned maintenance and installation methods.
- .6 Notify Consultant in writing of any conflict between these Specifications and manufacturer's instructions.
- .7 Install equipment so as to allow for easy maintenance access and such that it does not interfere in any way with access to adjacent equipment and personnel traffic in the surrounding space.
- .8 Shield and ground communication trunk wiring at a single end.
- .9 Do not splice trunk line.
- .10 Provide complete installation, testing, debugging and interfacing of specified software.

3.6 LABELLING

- .1 Provide engraved black and white Lamacoid plastic nameplates, 25 x 65 mm minimum at all duct mounted instruments, reset controls, thermometers and panels so as to clearly indicate service of particular device. All manual switches unless they come with standard nameplate shall be similarly labeled.

3.7 NAMING

- .1 Object and Point Naming
 - .1 All BACnet objects and points programmed under these specifications, shall conform to the following case sensitive convention:
 - .1 First group of characters = Building Unique Identifier (Enterprise systems only)
 - .2 Second group of characters = Network number

- .3 Third group of characters = Device number
 - .4 Fourth group of characters = Controller / Equipment Identifier
 - .5 Last segment = Point name abbreviation
 - .2 Example: S1156_2_15_HP10_RmTemp
 - .3 Object name segment shall be delimited by () character, however, must be consistent by Vendor across all owner sites
- .2 Controller and Device Addressing and Naming
 - .1 Each device or network installed and programmed under these specifications, shall be addressed and/or named as follows:
 - .2 Device Instance
 - .1 First group of characters = Building Unique Identifier (Enterprise systems only)
 - .2 Second group of characters = Network number
 - .3 Third group of characters = Device number
 - .4 Fourth group of characters = Controller / Equipment Identifier
 - .5 Example: S1156_2_15_HP10
 - .3 BACnet Network Number
 - .1 First group of characters = Building Unique Identifier (Enterprise systems only)
 - .2 Second group of characters = Network number
 - .3 Third group of characters = Network and Type
 - .4 Example: S1156_2_1 (S1156 = Forest Trail, 2 = Network 2, 1 = 1st MS/TP network)
 - .4 MAC Addresses
 - .1 B-BC
 - .2 Maintenance Connection
 - .3 Reserved
 - .4 -127. Master Range
 - .5 128.– 254. Slave Range
 - .6 255. Broadcast
 - .5 Object name segment shall be delimited by () character, however, must be consistent by Vendor across all owner sites
 - .3 Controller and Equipment identifiers shall match the standard adopted within the owner's enterprise level network. In the case of no enterprise level network or owner standard identifiers shall match the drawings.

3.8 COORDINATION

- .1 Site
 - .1 Where the mechanical work will be installed in close proximity to, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment. If the contractor installs his/her work before coordinating with other trades, so as to cause any interference with work of other trades, the contractor shall make the necessary changes in his/her work to correct the condition without extra charge.
 - .2 Coordinate and schedule work with all other work in the same area, or with work that is dependent upon other work, to facilitate mutual progress.
- .2 Submittals. Refer to the "Submittals" article in Part 1 of this specification for requirements.
- .3 Test and Balance
 - .1 The contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.
 - .2 The contractor shall provide training in the use of these tools. This training will be planned for a minimum of 4 hours.
 - .3 In addition, the contractor shall provide a qualified technician to assist in the test and balance process.
 - .4 The tools used during the test and balance process will be returned at the completion of the testing and balancing.
 - .5 During the system testing and balancing by an independent agency fully demonstrate the operation of all sensors, dampers, actuators, controls, valves, etc. This contractor shall be present during the testing and balancing and make adjustments as often as necessary to satisfy the testing and balancing agency.
- .4 **Commissioning**
 - .1 **This contractor shall work with the commissioning agent to demonstrate the operation of all systems.**
- .5 Life Safety
 - .1 Duct smoke detectors required for air handler shutdown are supplied under the mechanical section of this specification. The contractor shall interlock smoke detectors to air handlers for shutdown as described in Part 3, "Sequences of Operation."
 - .2 Smoke dampers and actuators required for duct smoke isolation are provided under mechanical section. The contractor shall interlock these dampers to the air handlers as described in Part 3, "Sequences of Operation."
 - .3 Fire/smoke dampers and actuators required for fire rated walls are provided under another Section of mechanical section. Control of these dampers shall be by electrical. The contractor shall monitor the position of these dampers.

- .6 Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:
 - .1 All communication media and equipment shall be provided as specified in Part 2, "Communication" of this specification.
 - .2 Each supplier of a controls product is responsible for the configuration, programming, startup, and testing of that product to meet the sequences of operation described in this section.
 - .3 The Contractor shall coordinate and resolve any incompatibility issues that arise between the control products provided under this section and those provided under other sections or divisions of this specification.
 - .4 The contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
 - .5 The contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

3.9 ACCEPTANCE TESTING

- .1 Upon completion of the system control contractor will request, in writing, to the Engineer and Owner that the acceptance procedures can commence.
- .2 After installation forward submittal data relevant to point index, functions, limits, sequences, interlocks, software routines and associated parameters and other pertinent information for the operating system and data base to the Owners authorized representative. Enter software into the central computer and debug.
- .3 Prior to on-line operation perform a complete demonstration and readout of the computer real-time responsibilities of surveillance and command in the presence of the Owner's authorized representative.
- .4 Adjust all devices and components to ensure that the operations are performed correctly and that all analog values are displays to the accuracy specified. Check all alarms, start/stop and status conditions to ensure proper operation.
- .5 Upon successful completion of on-line operation provide the Owner's authorized representative with written confirmation, inspection and approval of the satisfactory operation of the building automation system.
- .6 Complete all outstanding deficiencies as determined by the Owner's representative in his inspection report, after which a resubmission of formal acceptance shall be made. Repeat this procedure, if necessary, until acceptable performance has been established.

3.10 CONTROL SYSTEM CHECKOUT AND TESTING BY BAS CONTRACTOR

- .1 Start-up Testing: All testing listed in this article shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. Submit test worksheets to the consultant. This testing shall be completed before the owner's representative is notified of the system demonstration.
 - .1 The contractor shall furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.
 - .2 Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
 - .3 Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturers' recommendations.
 - .4 Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.
 - .5 Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The contractor shall check all control valves and automatic dampers to ensure proper action and closure. The contractor shall make any necessary adjustments to valve stem and damper blade travel.
 - .6 Verify that the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops and optimum start/stop routines.
 - .7 Alarms and Interlocks:
 - .1 Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
 - .2 Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
 - .3 Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.
- .2 Submit copies of test sheets to the consultant and include in as-built information.

3.11 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

- .1 Verify to the Owner's Representative and Architect/Engineer in letter form that supplier has in place support facility. Letter shall show location of support facility, name and titles of technical staff, engineers, supervisors, fitters, electricians, managers and all other personnel responsible for the completion of the work on this project.
- .2 Demonstration
 - .1 Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests.

- .2 The tests described in this section are to be performed in addition to the tests that the contractor performs as a necessary part of the installation, start-up, and debugging process and as specified in the "Control System Checkout and Testing" article in Part 3 of this specification. The consultant will be present to observe and review these tests. The consultant shall be notified at least 10 days in advance of the start of the testing procedures.
- .3 The demonstration process shall follow that approved in Part 1, "Submittals." The approved checklists and forms shall be completed for all systems as part of the demonstration.
- .4 The contractor shall provide at least two persons equipped with two-way communication and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point and system. Any test equipment required to prove the proper operation shall be provided by and operated by the contractor.
- .5 As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.
- .6 Demonstrate compliance with Part 1, "System Performance."
- .7 Demonstrate compliance with sequences of operation through all modes of operation.
- .8 Manually generate an alarm at a remote DDC Controller as selected by the Architect/Engineer to demonstrate the capability of the workstation and alarm printer to receive alarms within 5 seconds.
- .9 Disconnect an operator workstation in the central control room and manually generate an alarm at a remote DDC Controller to demonstrate the capability of the system printer to receive alarms when the workstation is disconnected from the system.
- .10 Disconnect one DDC Controller from the network to demonstrate that a single device failure shall not disrupt or halt peer to peer communication. Panel to be disconnected shall be selected by the Architect/Engineer.
- .11 At an ASC of the Architect/Engineer's choice, disconnect the LAN connection to demonstrate its lack of reliance on a DDC Controller to maintain full control functionality.
- .12 Demonstrate complete operation of operator interface.
- .13 Additionally, the following items shall be demonstrated:
 - .1 DDC loop response. The contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in set point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.

- .2 Demand limiting. The contractor shall supply a trend data output showing the action of the demand limiting algorithm. The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting set point, and the status of sheddable equipment outputs.
- .3 Optimum start/stop. The contractor shall supply a trend data output showing the capability of the algorithm. The change-of-value or change-of-state trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.
- .4 Interface to the building fire alarm system.
- .5 Operational logs for each system that indicate all set points, operating points, valve positions, mode, and equipment status shall be submitted to the architect/consultant. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats.
- .14 Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.
- .3 Acceptance
 - .1 All tests described in this specification shall have been performed to the satisfaction of both the consultant and owner prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the consultant. Such tests shall then be performed as part of the warranty.

3.12 TRAINING

- .1 The Contractor shall provide a competent instructor to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed, rather than a general training course.
- .2 Provide 16 hours of training for Owner's operating personnel. Training shall include:
 - .1 Explanation of drawings, operations and maintenance manuals
 - .2 Walk-through of the job to locate control components
 - .3 DDC Controller
 - .4 Explanation of adjustment, calibration and replacement procedures
 - .5 Review of Operator Work Station Functions (set point adjustment, scheduling etc.)
- .3 Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If such training is required by the Owner, it will be contracted at a later date. Provide description of available local and factory customer training.

3.13 WARRANTY AND SERVICE

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.
- .3 Warrant in writing, all provided equipment, accessories, installations, software, and firmware against defects in workmanship and materials for a period of one year commencing from the date of issue of the Certificate of Substantial Performance.
- .4 Maintain the affected parts operational during repair of defective equipment covered by the warranty.
- .5 Provide warranty service at no cost to the owner for the guarantee period, this shall include, but not limited to the following:
 - .1 Repair service on hour basis during warranty. Provide emergency service where malfunction would result in property damage. If not emergency, respond to site within 24 hours and resolve issue within three (3) days.
 - .2 Replacing defective parts and components as required.
 - .3 Servicing by factory trained and employed service representatives of system manufacture.
- .6 Supplier shall have an in-place support facility within 100 km of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.
- .7 Provide all labour, associated travel and expenses, materials, and equipment necessary for the successful operation of this system for a period of 12 months from the date of Ready for Takeover.
- .8 **In addition, provide three (3) visits for testing and evaluating the performance of the hardware and software installed per this specification, to be coordinated with the owner's Building Automation Manager. One visit shall be during the cooling season, one visit shall be during the heating season, and one visit shall be during a shoulder season, either spring or fall. Provide a written report after each visit is complete. This service visit shall include, but not be limited to, the following:**
 - .1 **Check calibration and re-calibrate if needed instrumentation sensors for air flow, liquid flow, pressure, humidity, temperature, and transducers. Written records shall be kept indicating the performance of such calibrations along with pertinent data.**
 - .2 **Check the operation of dampers and damper actuators to assure no lock up has occurred and stroke is proper. Written records shall be kept indicating the performance of such calibrations along with pertinent data.**
 - .3 **Check the overall system field operations by performing a review of all points. Verify that all monitoring and command points are valid and active. Written records shall be kept indicating the performance of such exercises.**

- .9 If a problem develops at any time during the warranty/service period, the affected BAS point/object shall be monitored and logged for the remainder of the warranty/service period. "A problem" in the above statement will refer to an incident in which any of the following occur:
 - .1 An alarm occurs due to a defective control system component(s), improper installation or programming.
 - .2 Overall performance of the system is compromised due to a defective control component(s), improper installation or programming.
 - .3 Major recalibration (by greater than 5 times the catalogued accuracy) is required for a sensor during one of the service visits.
 - .4 Changes required to meet design, compliance, and functionality, that were not part of the Demonstration and Acceptance process, will be made at no cost to the Owner.
 - .5 Any changes to programming, inclusive of but not limited to set-points, schedules, sequences, alarms, history, network addressing, object naming, etc.
- .10 Run all diagnostics and correct all previously diagnosed problems.
- .11 Resolve and correct any previous outstanding problems.
- .12 Software: Provide all software updates and verify operation in the system. These updates shall be accomplished in a timely manner, fully coordinated with the system operators, and shall be incorporated into the operations and maintenance manuals, and software documentation.
- .13 Warranty Coverage:
 - .1 Applies to parts and labour.

3.14 WARNING LABELS

- .1 Permanent warning labels shall be affixed to all equipment that can be automatically started by the DDC system.
 - .1 Labels shall use white lettering (12-point type or larger) on a red background.
 - .2 Warning labels shall read as follows:

CAUTION
"Operating under automatic control". "Switch disconnect to "Off" position before servicing".
- .2 Permanent warning labels shall be affixed to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.
 - .1 Labels shall use white lettering (12-point type or larger) on a red background.
 - .2 Warning labels shall read as follows:

CAUTION
"Fed from more than one power source".

3.15 CLEANING

- .1 The contractor shall clean up all debris resulting from his/her activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.
- .2 At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.
- .3 At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.
- .4 All equipment shall be cleaned, including interior and exterior surfaces at completion of the work.

END OF SECTION

Part 1 General

1.1 SYSTEM ARCHITECTURE DESCRIPTION

- .1 All devices supplied under this specification, excluding sensors, shall be connected to the site LAN and shall communicate natively using the following BACnet/IP, BACnet MS/TP, Peer to Peer, or Ethernet (ISO 8802-3), as defined in the ANSI/ASHRAE Standard 135, latest or Peer-to-Peer using Niagara's Fox Protocol or SNMP.
- .2 The network architecture shall consist of multiple levels for communication efficiency:
 - .1 A management level ethernet network based on BACNet IP protocol with other standardized protocols, such as web services, html, JAVA, SOAP, XML, etc. to transmit data to non-BAS software applications and databases. The BAS Server and Operator workstation shall reside on this level of the network.
 - .2 Building level ethernet network based on BACNet IP protocol. This network shall connect the building controllers to the BAS Server and Operator Workstation. Controllers for central plant equipment and large infrastructure shall reside on this network.
 - .3 A floor level network will connect all DDC controlled terminal heating and cooling equipment on a floor or in a system that is controlled by Advanced Application or Application Specific Controllers. Devices on this network shall be connected to a router that connects to the building level ethernet network. A router will be provided for each subnetwork and be capable of handling all of the BACNet interoperability building blocks that are listed for the controllers that reside on the network. This network shall be based on the following communications protocol:
- .3 Program data-bases, data acquisition, and all control sequence logic shall reside in the respective controller. Each device shall, to the greatest extent possible, perform its programmed sequence. Operation of each device shall not be dependent on a connection to a server or master controller.
- .4 Mechanical and Electrical Systems i.e., VFD's, chillers, boilers, unitary equipment, etc. units that are equipped with manufacturers furnished controls shall be BTL certified. Gateways are not to be used unless prior written approval has been acquired. A single controller can be used in combination with the manufacturer supplied controls, only where the manufacturer's controls are unable to meet the functional intent.
- .5 The use of multiple application controllers used to control a single piece of equipment is strictly prohibited, except those specifically noted.
- .6 The network shall permit the automatic transferring of all point values from one controller to the other on a planned, prioritized basis. The transfer of point values shall be performed directly between controllers. Systems that rely on a control, network, master or gateway controllers to perform these functions are not acceptable.
- .7 Controller firmware must be flash upgradeable over the network.

- .8 The Building Controller shall be connected to the owner's VLAN.**
- .9 Site workstations, otherwise referred to as Caretaker PC, will be provided by the owner as required. This contractor shall facilitate setting up the PC to access the BAS system.**
- .10 This contractor shall provide a site workstation, otherwise referred to as a Caretake PC on site that can access the BAS.**

1.2 NETWORK TOPOLOGY

- .1 Management/Enterprise Level Network**
 - .1 A single ethernet connection shall be provided on site for a controller to reside on the owner's VLAN. This controller shall interface to the owner's existing Management Level Network/Enterprise level server.**
 - .2 Contractor shall connect the operator work station to the Building Level Network.**
- .2 Building Level Network**
 - .1 Each building level controller shall be provided with a homerun ethernet connection to the building level controller that interfaces to the Management Level Network.**
 - .2 Each building level controller shall be provided with a homerun ethernet connection to the nearest owner provided network switch. The controller shall reside on the owners LAN/VLAN. This contractor is responsible for all wiring to the network switch.**
 - .3 Each building level controller shall be provided with a homerun ethernet connection to the nearest owner provided network switch. The controller shall reside on the owners LAN/VLAN. The data wiring contractor shall provide a network drop in the vicinity of each building level controller.**
- .3 Floor Level Network**
 - .1 BACNet IP Network:**
 - .1 Ring Topology shall be used.**
 - .2 Daisy Chain Topology shall be used.**
 - .3 Star Topology shall be used**
 - .2 This contractor shall provide all network infrastructure, switches etc. to enable this topology.**
 - .3 BACNet MS/TP Networks: Daisy Chain**

1.3 WIRING RESPONSIBILITY OF THIS CONTRACTOR

- .1 This contractor is responsible for the following wiring:**
 - .1 All fibre cabling required to implement the ethernet network.**
 - .2 All ethernet wiring, switches etc. required to implement the Building Level Network.**
 - .3 All ethernet wiring, switches, routers etc. required to implement the Floor Level Network(s).**

- .4 All BACNet MS/TP wiring required to implement the Floor Level Network(s).**
- .5 All 120V wiring associated with control device power and line voltage control devices, including, but not limited to actuators, line voltage thermostats etc.
- .6 All low voltage electrical wiring between sensors, starters, etc. and control device input and output wiring as required to provide a complete and operable system.
- .7 All raceways, boxes, cables, circuit breakers, grounding, relays, motors, starters and wirings from existing panel boards or switchgear through splitters, starters and field disconnect switches to complete power supply required for equipment supplied under this Contract not indicated on the electrical plans and specifications.
- .8 All horizontal copper communications cabling shall be terminated within local IT closet within patch panel. Provide appropriate length patch panel for final termination to owner's network switch.**

1.4 PERMITS, INSPECTIONS AND TESTING

- .1 Contractor will arrange for submission to the Electrical Safety Authority (ESA) for review of this project and pay all associated fees. Provide Certificate(s) of Acceptance from ESA and other Authorities having jurisdiction upon completion of the Work.
- .2 Where modification to mechanical or electrical equipment control wiring is necessary to meet the requirements of the specifications, the contractor is responsible for arranging any testing required by the Authority Having Jurisdiction to maintain the required certification and ensure the safe operation of the equipment modified.

Part 2 Products

2.1 GENERAL

- .1 All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

2.2 BACnet ETHERNET COMMUNICATION CABLING

- .1 Data cable shall Category 6 or better Ethernet cable.
- .2 Data cable shall be four twisted pair 24 AWG solid copper, Plenum Rated FT-6 / CMP or Riser Rated FT-4 / CMR (as required by local codes) unshielded twisted cable meeting EIA / TIA 568B.1 Category 5e classification.
- .3 The maximum cable length for each run shall be limited to 90 meters.
- .4 All cables must be Power Sum accepted and recognized by the manufacturer.
- .5 Cable Skew must be specified as 20Ns or less per 100 meters.
- .6 Cables must display the manufacturer's stamp stating that the cable is included in the latest UL verified publication for respective Category standards.
- .7 Cables shall be rated for installation in return air plenums (where allowed in this specification).

- .8 Cables shall be colored to match owner's BAS standard. If owner does not have a standard a different color than the data contractor shall be used.

2.3 120 VOLT WIRING

- .1 This contractor is responsible to provide all of their own power wiring, including 120V to transformers. Wiring shall meet the requirements of the Electrical Division specifications.

2.4 LOW VOLTAGE AND CONTROL WIRING

- .1 Minimum #20 AWG stranded copper conductors (larger gauge wire/cable shall be provided where required by BAS equipment and where applications warrant (e.g. rated load, long runs, etc.).
- .2 Wire type used for MSTP, RS-485 twisted pair communications must be balanced twisted pair with 100 to 120 Ohms Characteristic Impedance. The wire shall be less than 30 pF per foot, and preferred 20 AWG or lower. A shield wire shall be included for ground connection.
- .3 All BMS input/output point wire/cable and communication cable shall be shielded.
- .4 Non-shielded cables may be approved for BAS input and output field point wiring following certification from the BAS manufacturer that non-shielded cables will function satisfactorily for the life of the building and that the use of non-shielded cables will not negatively affect other building systems/cabling.
- .5 The manufacturers certification shall guarantee to the Board that should it be determined that BAS system performance is negatively affected or another building system or equipment is negatively affected due to the non-shielded cable, the BAS manufacturer shall replace the cable at no cost to the Board.
- .6 Provide FT-6 rated cable where cable is run free air.

2.5 POWER SUPPLIES AND LINE FILTERING

- .1 Control transformers shall be ULC listed. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.
 - .1 DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand a 150% current overload for at least three seconds without trip-out or failure.
 - .1 Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MIL-STD 810C for shock and vibration.
 - .2 Line voltage units shall be UL recognized and CSA approved.

- .2 Power line filtering.
 - .1 Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component. Surge protection shall have the following at a minimum:
 - .1 Dielectric strength of 1000 volts minimum
 - .2 Response time of 10 nanoseconds or less
 - .3 Transverse mode noise attenuation of 65 dB or greater
 - .4 Common mode noise attenuation of 150 dB or better at 40 Hz to 100 Hz.
- .3 Battery Backup with Surge Protection.
 - .1 Provide a battery backup unit with surge protection on the supply to the Supervisory Controller with a minimum capacity of 1000 Volt-amps.

Part 3 Execution

3.1 GENERAL WORKMANSHIP

- .1 Install equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.
- .2 Install wiring in EMT conduit in exposed areas and drops in walls. Comply with all requirements of Electrical Division.
- .3 Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
- .4 Install all equipment in readily accessible locations as defined by Chapter 1, Article 100, Part A of the National Electrical Code (NEC).
- .5 Control system wiring and cabling installed for this project shall be performed by professionals in a workmanlike manner and in accordance with National Electric Code (NFPA 70), CSA C22.2 and latest NEMA standards, FCC, and any/all applicable local codes and/or Authorities Having Jurisdiction (AHJ).
- .6 All materials must be CSA and NEMA approved. Where this is not possible, arrange and pay for unconditional Electrical Safety Authority approval.
- .7 Follow manufacturer recommendations for installation of all wiring
- .8 All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
- .9 Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.
- .10 Free air cabling installed in non-combustible rated buildings shall be fire rated cable with a minimum rating of FT-6.
- .11 Wiring located in combustible rated buildings above T-bar ceiling shall be run in free air using fire rated cable with a minimum rating of FT-6.

- .12 Note: all free air cabling used in combustible rated buildings to interface to security or fire alarm systems shall be FT-6 rated.
- .13 Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.
- .14 Cables be installed in bundles resting in a cabling support system (J-hooks) where provided by the Electrical Division.
- .15 Cable supports shall be attached to the wall or ceiling of the area they are running through. Cable supports shall not be attached to:
 - .1 Electrical raceways,
 - .2 Duct work,
 - .3 Ceiling suspension systems,
 - .4 Piping,
 - .5 Wilson joists.
 - .6 All wire/cable terminations shall be made at screw type terminal strips. Wire nut terminations and butt splices shall not be acceptable. Wiring runs shall be continuous runs without splices.
- .16 All BAS equipment and components shall be grounded to building ground facilities.
- .17 BAS shall only be capable of controlling electric motors when the associated hand/off/auto (HOA) motor control switches are in the "auto" position. BAS control shall be wired into the auto circuit of the hand/off/auto motor control circuit only. Where hand/off/auto switches do not exist they shall be provided by the Controls Contractor.
- .18 Life safety and equipment protection interlocks shall be wired to override equipment whenever it is in operation.
- .19 Existing interlocks and override control should typically not be removed or overridden by the application of new BAS control without the specific instruction and/or approval of the Owner.
- .20 Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
- .21 Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 15 cm (6 in.) from high-temperature equipment (e.g., steam pipes or flues).
- .22 Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.
- .23 Adhere to this specification's Electrical Division requirements where raceway crosses building expansion joints.
- .24 Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.
- .25 Size of raceway and size and type of wire shall be the responsibility of the contractor, in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.

- .26 All wiring in mechanical, electrical, or service rooms-or where subject to mechanical damage- shall be installed in raceway at levels below 3 m (loft).
- .27 Include one pull string in each raceway 2.5 cm (1 in.) or larger.
- .28 Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.

3.2 ETHERNET WIRING

- .1 Cabling shall be installed as continuous links, including shielding. Field splices are strictly prohibited.
- .2 Network installation shall strictly adhere to the manufacturer's network installation instructions and procedures.
- .3 Data cabling shall be run separately from power and signal wiring
- .4 Network installation shall conform to standards for the LAN types and cabling types selected. Specific network rules inherent to the ANSI/AHRAE Standard 135, latest will be followed. Those include but are not limited to:
 - .1 The maximum length and cabling type of an MS/TP segment shall be in accordance with manufacturers specifications and shall comply with EIA-485.
 - .2 Each internetwork LAN must have a unique Network Number (1 - 65,545).
 - .3 The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard.
- .5 Primary LAN Network wire and cable shall be run separately from all other wiring.
- .6 Other LAN Network wire and cabling shall be installed separate from any wiring over thirty (30) volts.
- .7 All communications shielding shall be grounded as per Networked System manufacturer's recommendations.

3.3 120 VOLT WIRING

- .1 All NEC Class 1 (line voltage) wiring shall be UL Listed in approved raceway according to NEC and the Electrical Division requirements.
- .2 Power wiring for all enclosures and equipment, including branch circuit wiring from circuit breaker panels shall be the responsibility of the System Contractor unless specifically shown on the Plans or Specifications.
- .3 The Building Controller panel shall be served from isolated ground receptacle via UPS by dedicated branch circuits.
- .4 Power shall NOT be obtained by tapping into miscellaneous circuit that could inadvertently be switched off.
- .5 Power for controls equipment shall be from a dedicated circuit. Where a controller is dedicated to controlling a single piece of equipment, power may be obtained directly from that equipment.

- .6 All other enclosures, sensor and control devices shall be fed from separate circuits in the electrical distribution panels and shall not be served from the typical floor receptacle or lighting circuits.

3.4 LOW-VOLTAGE ELECTRICAL AND CONTROL WIRING

- .1 All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be subfused when required to meet Class 2 current limit.)
- .2 Cabling shall be installed as continuous links, including shielding. Field splices are strictly prohibited.
- .3 Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.
- .4 All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.
- .5 Maximum allowable voltage for control wiring shall be 120-volts.

3.5 POWER CONDITIONING

- .1 Provide integral or supplementary power conditioning equipment for all BAS hardware so as to ensure that power line noise or electrical spikes, noise, bursts, sags or surges shall not damage equipment or software or cause erroneous computations.

3.6 IDENTIFICATION OF HARDWARE AND WIRING

- .1 All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.
- .2 The Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
- .3 Permanently label or code each point of field terminal strips to show the instrument or item served.
- .4 Identify control panels with minimum 1 cm (1/2 in.) letters on laminated plastic nameplates.
- .5 Identify all other control components with permanent labels. All plug-in components shall be labeled such that removal of the component does not remove the label.
- .6 Identify room sensors relating to terminal box or valves with nameplates.
- .7 Manufacturers' nameplates and UL or CSA labels are to be visible and legible after equipment is installed.
- .8 Identifiers shall match as-built documents.
- .9 Ethernet cabling shall be a separate color than the building data cabling and be labelled as BUILDING AUTOMATION SYSTEM at 20 foot intervals.

END OF SECTION

Part 1 **General**
Not Used

Part 2 **Products**

2.1 **ACCEPTABLE MANUFACTURER**

- .1 Operator software shall be matched to the Building Automation System supplier.

2.2 **BUILDING AUTOMATION SYSTEM SERVER AND OPERATOR WORKSTATION
HARDWARE**

- .1 The owner shall provide the operator workstation. Software shall be compatible with 64 bit Windows operating systems.
- .2 Install all software necessary to permit the operator to create, modify, delete, file and recall all graphics. The package shall encompass all graphics, control, control schematics and wiring details for all points and systems contained in the Input/output Point Summary. Provide a separate, valid license, complete with manuals, disks, and documentation for the graphics engineering software. Provide a separate valid license for of the software necessary to view the graphics with each Operator Workstation,
- .3 Set up an icon on the desktop to take the Owner directly to the BAS system login page.
- .4 Provide a copy of the software (or all software's if there are multiple) used to program and download sequences to controllers.
- .5 Provide a backup of the all of the programs used in the system for storage by the Owner.

2.3 **OPERATOR WORKSTATION SOFTWARE - GENERAL**

- .1 Provide a graphical user interface that shall minimize the use of keyboard through the use of a mouse or similar pointing device, with a "point and click" approach to menu selection and a "drag and drop" approach to inter-application navigation.
- .2 Operator workstation interface software shall minimize operator training through the use of user-friendly and interactive graphical applications, 30-character English language point identification, on-line help, and industry standard Windows application software.
- .3 Interface software shall simultaneously communicate with and share data between any combination of dedicated, modem autodial, and Ethernet-connected building level networks. The software shall provide, as a minimum, the following functionality:
 - .1 Real-time graphical viewing and control of the BAS environment.
 - .2 Reporting of real time and historical information.
 - .3 Scheduling and override of building operations.
 - .4 Collection and analysis of historical data.

- .5 Point database editing, storage, and downloading of controller databases. The editor shall allow the user to create, view existing, modify, copy, and delete points from the database. The point editor shall also allow the user to configure the alarm management strategy for each point. The editor shall provide the option for editing the point database in an online or offline mode with the DDC Controllers.
- .6 The workstation software shall also provide the capability to perform bulk modification of point definition attributes to a single or multiple user-selected points. This function shall allow the user to choose the properties to copy from a selected point to another point or set of points. The selectable attributes shall include, but are not limited to, Alarm management definitions and Trend definitions.
- .7 Utility for combining points into logical Point Groups. The Point Groups shall then be manipulated in Graphics, trend graphs and reports in order to streamline the navigation and usability of the system.
- .8 Alarm reporting, routing, messaging, and acknowledgment.
- .9 "Collapsible tree," dynamic system architecture diagram application:
 - .1 Showing the real-time status and definition details of all workstations and devices on an enterprise level network.
 - .2 Showing the real-time status and definition details of all DDC and HVAC Mechanical Controllers at the building level.
 - .3 Showing the status and definition details of all field-level application controllers.
- .10 Definition and construction of dynamic colour graphic displays.
- .11 Online, context-sensitive help, including an index, glossary of terms, and the capability to search help via keyword or phrase.
- .12 On-screen access to User Documentation, via online help or PDF-format electronic file.
- .13 Automatic and manual database backup at the workstation for database changes initiated at DDC Controller operator interface terminals.
 - .1 Backups shall produce a configuration file that contains pertinent details regarding the specific backup. This log file shall be created each time a backup is run and be stored in the backup directory.
 - .2 Restore dialog box shall list detailed information to facilitate the restore of the correct database.
 - .3 Ability to restore selected components of a backup.
 - .4 Delete old backup directories automatically or individually from a detailed list.
- .14 Provide automatic backup and restore of all DDC controller and HVAC Mechanical Equipment controller databases on the workstation hard disk.

- .15 Display dynamic trend data graphical plot.
 - .1 Must be able to run multiple plots simultaneously.
 - .2 Each plot must be capable of supporting 10 pts/plot minimum.
 - .3 Must be able to plot both real-time and historical trend data.
 - .4 Must be able to plot real time data without prior configuration.
- .16 Program editing.
- .17 Transfer trend data to 3rd party spreadsheet software.
- .18 Scheduling reports.
- .19 Operator Activity Log.
- .20 Open communications via BACnet Client & Server option.
- .21 Tracking of supervised objects.
- .22 A colour graphics application to build and edit graphics.
- .23 Provide functionality such that any of the following may be performed simultaneously on-line, and in any combination, via adjustable user-sized windows. Operator shall be able to drag and drop information between the following applications, reducing the number of steps to perform a desired function (e.g., Click on a point on the alarm screen and drag it to the dynamic trend graph application to initiate a dynamic trend on the desired point):
 - .1 Dynamic colour graphics application.
 - .2 Alarm management application.
 - .3 Scheduling application.
 - .4 Dynamic trend graph data plotter application.
 - .5 Dynamic system architecture diagram application.
 - .6 Control Program and Point database editing applications.
 - .7 Reporting applications.
 - .8 Report and alarm printing shall be accomplished via Windows Print Manager, allowing use of network printers.
- .4 Standard Windows applications shall run simultaneously with the BAS software. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BAS alarms and monitoring information

2.4 CLIENT SERVER CONNECTIVITY

- .1 Client sessions must be allowed to run on the server and on other devices connected to the server via Intranet, Extranet, or Internet connections.
- .2 Internet connections, ISP services, as well as necessary firewalls or proxy servers shall be provided by the owner as required to support remote access features.

- .3 The following client options must be supported:
 - .1 Installed Client.
 - .1 Software application installed from installation media on to the client machine.
 - .2 Installed client software must be configurable to allow it to run in a Closed Mode such that the BAS software can lock down the client machine and prevent users without permission from minimizing the application or running other Windows applications that might cover the BAS software interface.
 - .3 Communication between the server and Installed Clients must be monitored so that any break in communication between the server and an installed client results in notification at the Server and Installed Client machine
 - .4 Installed client machines communicate directly with the BAS server.
 - .2 Web Client.
 - .1 Software that runs in a browser on the client machine as a Full Trust client application.
 - .2 Connected to the BAS software server via Microsoft IIS Server.
 - .3 Windows App.
 - .1 Software application downloaded from the BAS server to run on the client machine like an installed application.
 - .2 Application must be automatically updated whenever new apps are available at the server.
 - .3 Connected to the BAS software server via Microsoft IIS Server.
 - .4 Each of the client options shall provide the same functionalities including operation and configuration capabilities.

2.5 CERTIFICATIONS AND APPROVALS

- .1 BAS software shall have been tested against the following norms and standards:
 - .1 BACnet Revision 1.13, certified by BACnet Testing Laboratory as BACnet Advanced Workstation Software (BTL B-AWS).
 - .2 IT security compliant with the ISA-99/IEC 62443 Security Level: SL1.
 - .3 OPC DA V2.05a and V3.0 Server, certified by the OPC Foundation certification program.
 - .4 UL-listed to UL864 9th edition Standard for Control Units and Accessories (when installed on a UL-approved computer).

2.6 ACCESS RIGHTS AND USER PRIVILEGES

- .1 Operator-specific password access protection shall be provided to allow the administrator/manager to limit users' workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall "follow" the operator to any workstation logged onto (up to 999 user accounts shall be supported). The administrator/manager shall be able to grant discrete levels of access and privileges, per user, for each point, graphic, report, schedule, and BAS workstation application. And each BAS workstation user account shall use a Windows user account as a foundation.
- .2 The workstation software shall also include an application to track the actions of each individual operator, such as alarm acknowledgement, point commanding, schedule overriding, database editing, and logon/logoff. The application shall list each of the actions in a tabular format and shall have sorting capabilities based on parameters such as ascending or descending time of the action, or name of the object on which the action was performed. The application shall also allow querying based on object name, operator, action, or time range.

2.7 WORKSTATION APPLICATION EDITORS

- .1 Each PC system shall support editing of all system applications. Provide editors for each application at the workstation. The applications shall be downloaded and executed at one or more of the controller panels.
 - .1 Colour Graphics Application. Provide a full-screen editor for each type of application that shall allow the operator to view and change the configuration, name, control parameters, and set points for all controllers.
 - .2 Scheduling Application. An editor for the scheduling application shall be provided at each workstation. Provide a method of selecting the desired schedule and month. This shall consist of a monthly calendar for each schedule. Exception schedules and holidays shall be shown clearly on the calendar. Provide a method for allowing several related objects to follow a schedule. The start and stop times for each object shall be adjustable from this master schedule. Schedules shall be easy to copy to other objects and/or dates.
 - .3 Custom Application Programming Application: Provide the tools to create, modify, and debug custom application programming. The operator shall be able to create, edit, and download custom programs at the same time that all other system applications are operating. The system shall be fully operable while custom routines are edited, compiled, and downloaded.

2.8 DYNAMIC COLOUR GRAPHICS APPLICATION

- .1 Must include graphic editing and modifying capabilities.
- .2 Graphics shall be available with the same look and functionality whether they are displayed at an installed client workstation or via browser interface.
- .3 User shall be able to add/delete/modify system graphics for floor plan displays and system schematics for each piece of mechanical equipment from the standard user interface without need for specialized tools.

- .4 Provide the user the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.
- .5 A library of standard control application graphics and symbols must be included. A library of minimum 400 symbols will be provided consisting of common systems, including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams, piping and laboratory symbols.
- .6 In the development of a graphic picture, the graphics software shall support all operator actions necessary to:
 - .1 Define the background;
 - .2 Establish colours;
 - .3 Locate, orient and size the symbols;
 - .4 Position and edit alphanumeric descriptors;
 - .5 Establish connecting lines;
 - .6 Establish sources of real time data and location of their readouts.
- .7 The Graphics application shall include a set of standard Terminal Equipment controller application-specific background graphic templates. Templates shall provide the automatic display of a selected Terminal Equipment controller's control values and parameters, without the need to create separate and individual graphic files for each controller.
- .8 The Graphics application shall be capable of automatically assigning the appropriate symbol for an object (point) selected to be displayed on the graphic based on what the object represents (fan, duct sensor, damper, etc.) when the object is placed on a graphic. The user shall be able to override the assigned symbol if desired.
- .9 User shall be able to add custom symbols to the symbol library.
- .10 Software shall permit the importing of AutoCAD or scanned pictures for use in graphics.
- .11 Must be able to command points directly off graphics application.
- .12 Graphic display shall include the ability to depict real-time point values dynamically with animation, picture/frame control, symbol association, or dynamic informational text-blocks. At a minimum animation shall reflect, ON or OFF conditions, and shall also be optionally configurable for up to five rates of animation speed. Animation shall also indicate the priority and alarm status of the point.
- .13 Animation status indicators shall give you a quick visual indication of a point's value, priority, or status in the form of an icon.
- .14 Software shall provide animation that depicts movement of mechanical equipment, or air or fluid flow.
- .15 Navigation through various graphic screens shall be optionally achieved through a hierarchical "tree" structure or view recently opened graphics through a backward and forward paging.
- .16 Graphics viewing shall include dynamic pan and zoom capabilities.
- .17 Graphics viewing shall include the ability to switch between multiple layers with different information on each layer.

- .18 Graphics shall include a decluttering capability that allows layers to be programmatically hidden and displayed based on zoom level.
- .19 The software must provide the ability to create dashboard views consisting of gauges and charts that graphically display system and/or energy performance.
- .20 Advanced linking within the Graphics application shall provide the ability to navigate to outside documents (e.g., .doc, .pdf, .xls, etc.), Internet web addresses, e-mail, external programs, and other workstation applications, directly from the Graphics application window with a mouse-click on a customizable link symbol.
- .21 Colours shall be used to indicate status and change as the status of the equipment changes. The state colours shall be user definable.
- .22 The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, point alarm association, or text-based commands.

2.9 REPORTS

- .1 Reports and Logs. Provide a reporting package that allows the operator to select, modify, or create reports. Each report shall be definable as to data content, format, interval, and date. Report data shall be archivable on the hard disk for historical reporting. Provide the ability for the operator to obtain real-time logs of all objects by type or status (e.g., alarm, lockout, normal). Reports and logs shall be stored on the PC hard disk in a format that is readily accessible by other standard software applications, including spreadsheets and word processing. Reports and logs shall be readily printed to the system printer and shall be set to be printed either on operator command or at a specific time each day.
- .2 Provide ability for the owner to readily customize these reports:
 - .1 All Objects: All system (or subsystem) objects and their current values.
 - .2 Alarm Summary: All current alarms (except those in alarm lockout).
 - .3 Disabled Objects: All objects that are disabled.
 - .4 Alarm Lockout Objects: All objects in alarm lockout (whether manual or automatic).
 - .5 Alarm Lockout Objects in Alarm: All objects in alarm lockout that are currently in alarm.
 - .6 Logs:
 - .1 Alarm History
 - .2 System Messages
 - .3 System Events
 - .4 Trends
- .3 Custom Reports. Provide the capability for the operator to easily define any system data into a daily, weekly, monthly, or annual report. These reports shall be time and date stamped and shall contain a report title and the name of the facility.

- .4 Override Reports. Provide a monthly report showing the daily total time in hours that each system has requested after-hours HVAC and lighting services. Provide an annual summary report that shows the override usage on a monthly basis.
- .5 Reports shall be generated on demand or via pre-defined schedule, and directed to displays, printers, or file. As a minimum, the system shall allow the user to easily obtain the following types of reports:
 - .1 A general listing of all or selected points in the network.
 - .2 A status report showing present value and alarm status.
 - .3 List of all points currently in alarm.
 - .4 List of all points currently in override status.
 - .5 List of all disabled points.
 - .6 List of all points currently locked out.
 - .7 List of user accounts and access levels.
 - .8 List all weekly schedules and events.
 - .9 List of holiday programming.
 - .10 List of control limits and dead bands.
 - .11 Custom reports from 3rd party software.
 - .12 System diagnostic reports including, list of DDC panels on line and communicating, status of all DDC terminal unit device points.
 - .13 List of programs.
 - .14 List of point definitions.
 - .15 List of logical point groups.
 - .16 List of alarm strategy definitions.
 - .17 List of DDC Control panels.
 - .18 Point totalization report.
 - .19 Point Trend data listings.
 - .20 Initial Values report.
 - .21 User activity report.

2.10 SCHEDULING AND OVERRIDE

- .1 The software shall provide a calendar type format for simplification of time and date scheduling and overrides of building operations.
- .2 The software shall support the definition of BACnet schedules that are defined at the workstation and are downloaded to Building Controller to ensure time equipment scheduling when PC is off-line, such that the operating software is not required to execute time scheduling. The software must provide the following capabilities for BACnet scheduling capabilities as a minimum:
 - .1 Fully support all BACnet Schedule, Calendar, and Command objects.
 - .2 Daily and Weekly schedules.

- .3 Ability to combine multiple points into a logical Command Groups for ease of scheduling (e.g., all Building 1 lights).
 - .4 Ability to schedule for a minimum of up to ten (10) years in advance.
- .3 The software shall support the definition of schedules that are configured and executed to run at the workstation, to support scheduling of workstation software activities and to support field systems that do not include internal scheduling mechanisms. The software must provide the following capabilities for BACnet scheduling capabilities as a minimum:
 - .1 Schedule predefined reports.
 - .2 Schedule Trend collections.
 - .3 Schedule automated system backups.
 - .4 Schedule commands to be sent to field panels.
 - .5 Daily and weekly schedules.
 - .6 Setting up and executing Holiday schedules.
 - .7 Ability to combine multiple points into a logical Command Groups for ease of scheduling (e.g., all Building 1 lights).
 - .8 Ability to schedule for a minimum of up to ten (10) years in advance.
- .4 The software shall support the definition of Schedules Objects that are defined at the workstation and are downloaded to Building Controller to ensure time equipment scheduling when PC is off-line, such that the operating software is not required to execute time scheduling The software must provide the following capabilities for BACnet scheduling capabilities as a minimum:
 - .1 Equipment schedule Zones.
 - .2 Equipment schedule Events.
 - .3 Configuration of Daily, Weekly, Monthly schedules.
 - .4 Configuration of Replacement Days.
- .5 The software shall provide the ability for users to override regular weekly schedules through menu selection, graphical mouse action or function key.
- .6 The software shall provide a timeline view, showing the results of any number of combined selected workstation and field panel controller schedules for an overview of facility operation.
- .7 Additionally, the scheduling application shall:
 - .1 Provide filtering capabilities of schedules, based on name, time, frequency, and schedule type (event, zone, report).
 - .2 Provide sorting capabilities of schedules, based on name, time and type of schedule (zone, event, report).
 - .3 Provide searching capabilities of schedules based on name – with wildcarding options.

2.11 COLLECTION AND ANALYSIS OF HISTORICAL DATA

- .1 Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals (up to four time-based definitions per point) or change of value, both of which shall be user-definable. Trend data shall be collected stored on hard disk for future diagnostics and reporting. Automatic Trend collection may be scheduled at regular intervals through the same scheduling interface as used for scheduling of zones, events, and reports. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.
- .2 The software must support configuration of panels that have a trending level threshold, above which the data will be automatically uploaded to the BMS server to prevent overwriting the data in the field panel. The trending level will be user defined in % of available space (e.g., automatically upload when the trend buffer is at 75% of allocated space).
- .3 The entire collection process shall be automated so that the data collection definition, amount of data to be collected, collection report and scheduling take the form a wizard, or online assist utility, in order to complete this process within a small amount of time for a large group of points.
- .4 Trend data reports shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of selected points. Provide additional functionality to allow predefined groups of up to 250 trended points to be easily transferred on-line to Microsoft Excel. DDC contractor shall provide custom designed spreadsheet reports for use by the owner to track energy usage and cost, equipment run times, equipment efficiency, and/or building environmental conditions. DDC contractor shall provide setup of custom reports including creation of data format templates for monthly or weekly reports.
- .5 Provide additional functionality that allows the user to view real-time trend data on trend graphical plot displays. A minimum of fifteen points may be plotted, of either real-time or historical data. The dynamic graphs shall continuously update point values. At any time, the user may redefine sampling times or range scales for any point. In addition, the user may pause the graph and take "snapshots" of plot screens to be stored on the workstation disk for future recall and analysis. Exact point values may be viewed and the graphs may be printed. A minimum of 8 true graphs shall run simultaneously. Operator shall be able to command points directly on the trend plot by double clicking on the point. Operator shall be able to zoom in on a specific time range within a plot. Operator must be able to configure separate left and right axis for easier differentiation of point values and be able to display historical data for the same group of points at different times simultaneously for easy comparison of system behaviour over time. The dynamic trend plotting application shall support the following types of graphs, with option to graph in 3D: line graph, area graph, curve graph, area-curve graph, step graph, and scatter graph. Each graph may be customized by the user, for graph type, graph text, titles, line styles and weight, colours, and configurable x- and y-axes.

2.12 ALARM MANAGEMENT

- .1 Alarm Routing shall allow the user to send alarm notification to selected printers or workstation location(s) based on time of day, alarm severity, or point type.
- .2 Alarm Notification shall be presented to each workstation in a tabular format application, and shall include the following information for each alarm point: name, value, alarm time & date, alarm status, priority, acknowledgement information, and alarm count. Each alarm point or priority shall have the ability to sound a discrete audible notification.
- .3 Only events for which the logged on user has privileges to view shall be displayed on each workstation.
- .4 The software shall provide the ability to users to limit the list of events displayed at each workstation, no matter who is logged on (i.e. workstation will only show fire events).
- .5 Each event shall have the ability to sound an audible notification based on the category of the event.
- .6 Alarm Display shall have the ability to list & sort the alarms based on alarm status, point name, ascending or descending alarm time.
- .7 Directly from the Alarm Display, the user shall have the ability to acknowledge, silence the alarm sound, print, or erase each alarm. The interface shall also have the option to inhibit the erasing of active acknowledged alarms, until they have returned to normal status. The user shall also have the ability to command, launch an associated graphic or trended graphical plot, or run a report on a selected alarm point directly on the Alarm Display.
- .8 Each alarm point shall have a direct link from the Alarm Display to further user-defined point informational data. The user shall have the ability to also associate real-time electronic annotations or notes to each alarm, which can be viewed from the alarm display screen, graphic display screen, and anytime the point is being commanded to a new value or state.
- .9 Alarm messages shall be customizable for each point, or each alarm priority level, to display detailed instructions to the user regarding actions to take in the event of an alarm. Alarm messages shall also have the optional ability to individually enunciate on the workstation display via a separate pop-up window, automatically being generated as the associated alarm condition occurs.
- .10 Software shall provide the option to configure detailed operating procedures that guide a user through predetermined standard operating procedures for handling critical events. Users shall be able to log completion of each operating step as it is performed.
- .11 Alarm Display application shall allow workstation operators to send and receive real-time messages to each other, for purposes of coordinating Alarm and BAS system management.

- .12 Remote notification of messages
 - .1 Workstation shall be configured to send out messages to numeric pagers, alphanumeric pagers, phones (via text to speech technology), SMS (Simple Messaging Service, text messaging) Devices, and email accounts based on a point's alarm condition. A point's alarm status will be configurable for remote notification whether the point is in a specific alarm priority, has returned to normal, failed, out of service, in trouble, alarm disabled by program or operator and alarm by command.
 - .2 There shall be no limit to the number of points that can be configured for remote notification of alarm conditions and no limit on the number of remote devices, which can receive messages from the system.
 - .3 On a per point basis, system shall be configurable to send messages to an individual or group and shall be configurable to send different messages to different remote devices based on alarm message priority level.
 - .4 Remote devices may be scheduled as to when they receive messages from the system to account for operators' work schedules.
 - .5 System must be configurable to send messages to an escalation list so that if the first device does not respond, the message is sent on to the next device after a configurable time has elapsed.
 - .6 Message detail shall be configurable on a per user basis.
 - .7 During a mass influx of alarms, remote notification messages shall have the ability to optimize several alarms into an individual remote notification message.
 - .8 Workstation shall have the ability to send manual messages allowing an operator to type in a message to be sent immediately.
 - .9 Workstation shall have a feature to send a heartbeat message to periodically notify users that they have communication with the system.
 - .10 Ability to configure Fire and Life Safety points for remote notification through the point editor application.
- .13 Expanded Alarm Issue Management
 - .1 As optional functionality, configurable point-by-point, the system shall impose an ordered process for managing the lifecycle of an alarm. The process requires the operator to:
 - .1 Acknowledge the alarm.
 - .2 Assign the alarm issue to a contact (e.g., tradesperson or trained staff).
 - .3 Answer – an explanation of the diagnosis or solution to the alarm.
 - .4 Resolve – this happens when at least one Answer is provided and the point has returned to a stable Normal state.
 - .5 Clear – the operator may clear the alarm issue from the display.
 - .2 Each step in the lifecycle is automatically recorded for audit trail historical purposes.
- .14 Provide alarm priority functionality to meet requirements of sequences of operation.

2.13 AUDIT TRAIL OF USER ACTIONS

- .1 To protect against inadvertent changes damaging critical system functions, and to enable audit-trail tracking on selected database objects, optional functionality shall be provided to configure selected objects for increased supervision. The additional supervision functionality shall allow for designation of points, control programs, trend collection reports, panels on a building level network and user account objects for detailed tracking of user modifications and deletions. Display an icon, which indicates the level of supervision for an object within specified applications.
 - .1 The minimal setting for additional supervision shall warn the user that he is attempting to modify or delete a supervised object and will require the user to input a reason-for-change in order to proceed. The warning shall be customizable for each object.
 - .2 Additional supervision levels shall be optional to require the user to re-enter his user password, and/or require that a "supervisor" enter his user password, in order to proceed with the modification or deletion of the supervised object.
 - .3 Supervised objects shall be assigned a dedicated "revision number," and the revision number shall be incremented automatically by the system upon each user modification. This revision number may serve as a method for tracking changes to objects.
 - .4 Point in an alarm state can have annotations added which can be viewed from the alarm display screen, graphic display screen, and anytime the point is being commanded to a new value or state. For supervised objects, the point annotation will automatically populate the reason for change field.
- .2 Audit Trail tracking of supervised objects shall record the following:
 - .1 The property of the object that was changed.
 - .2 The value of the property before the change.
 - .3 The value of the property after the change.
 - .4 Who made the change.
 - .5 The reason for change (entered by the operator).
 - .6 Who the change was authorized by (if configured for this level of supervision).

2.14 EXTERNAL DATA ACCESS

- .1 The software shall provide the ability to expose configuration properties and real-time values through CSV files, OPC DA, OPC UA, or REST-based Web Services.
- .2 The software shall provide the ability for external applications to change configuration and real-time values through OPC DA, OPC UA, or REST-based Web Services.
- .3 The software shall provide the ability for external applications to access historical Trend data through CSV files or REST-based Web Services.
- .4 External data access must be secured using the level of permissions configured for users and operator workstations.

- .5 Web service interfaces must allow for exchanging data (object's values, events and trend series) between workstation and external applications such as facility management systems, enterprise applications, mobile applications or other value-added services.
- .6 Documentation describing web services interfaces must be included to allow external developers to write applications that leverage the data exchange.

2.15 DATA SECURITY

- .1 Each operator shall be required to log on to the system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system supervisor shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the functions accessible to viewing and/or changing each system application, editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto logoff time period shall be user-adjustable. All system security data shall be stored in an encrypted format.
- .2 The BAS software must allow that all communication paths between clients and the server are encrypted and protected against replay attacks as well as data manipulation.
- .3 Any runtime data transfer between the system server and Web Server (IIS) must be allowed to be encrypted by Designo CC.
- .4 Communication between any Web Server (IIS) and the Web Clients must be allowed to be encrypted.
- .5 Passwords must be handled with encrypted storage and transmission
- .6 The software must support the use of public domain algorithms for cryptographic functions, including AES, DiffieHellmann, RSA, and SHA-2. No self-coded algorithms shall be allowed.
- .7 All symmetrical encryption must use 256 bit AES or stronger.
- .8 All asymmetrical encryption must use 2048 bit or stronger.
- .9 The software must support the use of commercial certificates for securing client-server communications.
- .10 The software must support the use of self-signed certificates to allow local deployments without the overhead of obtaining commercial certificates.
- .11 The BAS software shall be compatible with the following Virus Scanners:
 - .1 Kaspersky.
 - .2 Avira.
 - .3 McAfee.
 - .4 Bitdefender.
 - .5 TrendMicro Office Scan.

2.16 SUBSYSTEM CONNECTIVITY

- .1 The BAS application software must be capable of connecting simultaneously to multiple control systems and data sources.
- .2 Interface software shall simultaneously communicate with and share data between multiple Ethernet-connected building level networks.
- .3 The BAS application software must support the following standard protocols:
 - .1 BACnet IP (standard Revision 1.13).
 - .2 OPC (OLE for Process Control) OPC DA 2.05, 3.0.
 - .3 Modbus TCP.
 - .4 SNMP (Agent V1 and V2).
- .4 Any break in system controller communication must result in a notification at the server.

2.17 BACnet INTEROPERABILITY

- .1 The Operator Workstation Software shall be capable of BACnet IP communications.
- .2 The Operator Workstation Software shall have demonstrated interoperability during at least one BTL Interoperability Workshop.
- .3 The Operator Workstation Software shall have demonstrated compliance to BTL B-AWS device classification through BTL listing as specified in ANSI/ASHRAE 135 under revision 1.13 or higher.
- .4 The BAS software shall meet the BACnet device profile of an Advanced Workstation Server (B-AWS) and Operator Workstation (B-OWS) and shall support all BACnet BIBBs required to deliver a full and operable system.
- .5 The BAS Server and Workstations shall support the following Data Link Layers:
 - .1 BACnet IP Annex J.
 - .2 BACnet IP Annex J Foreign Device.
 - .3 ISO 8802-3, Ethernet (Clause 7).
- .6 The BAS Server and Workstations shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as they relate to features in the workstation software:
 - .1 Calendar – Creatable, Deletable.
 - .2 Command – Creatable, Deletable.
 - .3 Event Enrollment – Creatable, Deletable.
 - .4 Notification Class – Creatable, Deletable.
 - .5 Schedule - Creatable, Deletable.
- .7 The BAS Server and Workstations shall support transmitting and receiving segmented messages.
- .8 The BAS Server and Workstation shall have the capability to be the BACnet/IP Broadcast Management Device (BBMD) and support foreign devices.

Part 3 Execution

3.1 GRAPHICS

- .1 Provide linked graphic pictures as follows:
 - .1 Building Identification front plate with menu.
 - .2 Photo of front elevation of building.
 - .3 Floor Plan of each building level.
 - .4 Schematic for each system.
 - .5 Tables summarizing temperatures in each zone.
 - .6 Tables summarizing the monitored functions off all air handling units.
 - .7 Table summarizing weekly schedules.
 - .8 Tables summarizing fault detection results.
 - .9 Outside Lighting Schematic.
 - .10 Time of Day schedules.
 - .11 Up to five additional graphics as defined by the owner.
 - .12 Global Setpoints, summarizing items such as Min/Max Setpoints, Override Period, etc.
 - .13 Global Statistics, summarizing lowest temp, highest temp, number of heat pumps heating/cooling, number of zones occupied, number of zones in override, etc.
 - .14 The graphics shall be submitted to the Owner for preapproval before final implementation.
- .2 Graphic Display Screens
 - .1 Individual schematics shall include, where applicable:
 - .1 Navigation buttons to each major system in the building which indicate current screen display by a change in button colour.
 - .2 Outdoor air temperature shall be displayed on every graphic screen.
 - .3 Access links to all global schedules or specific screens affecting entire building operation.
 - .4 Access buttons links to Set Time, Holiday Schedule, Alarms, Points on Manual, Conversion °C - °F, 24 Hour Clock, Operations Manual, Autocad Drawings, BAS Manual, and Work Orders
 - .5 Status of monitored and controlled on/off points;
 - .6 Current value of analog input;
 - .7 Identification for each point;
 - .8 Current value of the setpoint & DDC output for each control loop;
 - .9 Current state of each control loop (computer auto/computer manual);
 - .10 Schematic and systems identification;
 - .11 Point alarm lock-out status;
 - .12 Equipment symbolic information (pump, fan, etc);
 - .13 Alarm/normal indication

- .14 All points pertinent to one system shall be on one screen.
- .15 Symbols shall have the ability to change colour, depending on the status.
- .16 Animations are to indicate point status. Animations are to include pumps, fans and boilers. The BMS contractor shall obtain from the owner the final numbering and name convention to be used for all spaces in the building for incorporation in the "As Built" drawings and manuals.
- .2 System Architecture.
 - .1 Control panel layout and network architecture.
 - .2 Indicating BAS panels and panel type (model).
 - .3 Panel locations room number text on screen.
 - .4 Systems controlled by each panel.
 - .5 Links to points list accessible from each panel.
- .3 Architecture Panel Layout (Locations on Floor Plans)
 - .1 Locations of each panel on each floor plan level.
 - .2 Panel types indicated by different icon.
 - .3 Controls transformers locations.
 - .4 Main network wiring and sub-network wiring layout.
- .4 Floor Plans Graphics
 - .1 Room numbers accurate as per room signage.
 - .2 Mechanical rooms locations and signage tags.
 - .3 space temperatures for every temperature on each floor in appropriate room.
 - .4 space focus pick area for individual room control where applicable shall be yellow text.
 - .5 Air Handler symbols indicating areas of the floor plan serviced by each air handler by a corresponding colour.
 - .6 Status of Air Handler by colour change Red for off status, or text indication.
 - .7 Supply air temperature for each air handler.
- .5 HVAC/AHU Unit Graphic
 - .1 Accurate representation of the HVAC design.
 - .2 All associated control points to be displayed.
 - .3 A calculated percentage of fresh air shall be indicated on the HVAC graphic.
 - .4 Operator offset adjustment of the supply air setpoint, adjustable directly from the graphic.
 - .5 HVAC physical location shall be indicated on the graphic.

- .6 Weekly occupied time of day schedule for the associated HVAC shall be accessible directly from the graphic by selecting an icon.
- .7 Trend logs shall be accessible directly from the graphic by selecting an icon.
- .6 Exhaust Fans Graphic
 - .1 Exhaust fans control shall be editable directly from the graphic.
 - .2 Exhaust fan status shall be indicated in text and a change in the exhaust fan icon.
 - .3 Exhaust fan physical location shall be indicated on the graphic.
 - .4 Area of the building being exhausted shall be indicated on the graphic.
- .7 Boiler and Chilled Water Plants
 - .1 Accurate representation of piping design and layout.
 - .2 All associated control points to be displayed.
 - .3 Temperature reset curve to be displayed, along with calculated value.
 - .4 Operator shall be able to adjust set point from the graphic.
 - .5 Physical location of the plant equipment shall be indicated.
 - .6 All piping loops shall be labelled.
 - .7 Weekly occupied time of day schedule for the associated HVAC shall be accessible directly from the graphic by selecting an icon.
 - .8 Trend logs shall be accessible directly from the graphic by selecting an icon.
- .8 Terminal Units/Misc. Items
 - .1 Accurate representation of equipment.
 - .2 All associated control points to be displayed.
 - .3 Space temperature.
 - .4 Mode of operation.
 - .5 Current setpoint.
 - .6 Trend logs shall be accessible directly from the graphic by selecting an icon.

END OF SECTION

Part 1 General

1.1 RELATED SECTIONS

- .1 This section is to be read in conjunction with the remainder of the Division 25 specifications.

Part 2 Products

2.1 ACCEPTABLE MANUFACTURERS

- .1 Controller shall be matched to the Building Automation System supplier.

2.2 GENERAL REQUIREMENTS

- .1 Provide BACnet controllers. DDC controllers that are not BACnet compliant shall not be acceptable under this specification and are strictly prohibited.
- .2 All BAS DDC Devices at all levels shall be fully custom-programmable in the field using the standard Operators Workstation Software. No configurable, canned program application specific controllers will be permitted unless specifically noted in this specification.
- .3 All BAS controllers shall be tested, certified, clearly stamped and listed by the BACnet Testing Laboratories (BTL)
- .4 The BACnet operating stack must be embedded directly in every Device at the board level, and in all operator interface software packages.
- .5 No Gateways, Communication Bridges, Protocol Translators or any other device that translates any proprietary or other communication protocol to the BACnet communication protocol shall be permitted as a part of the BAS installation pursuant with this specification section. Gateways may only be used as required for communication to existing systems or systems installed pursuant with other specification sections.
- .6 Program database, data acquisition, and all control sequence logic shall reside in each DDC Device. The Building Level Network shall not be dependent upon connection to a Server or Master Controller for performance of the Sequence of Operation. Each individual Device shall, to the greatest possible extent, perform its programmed sequence without reliance on the Building Level Network.
- .7 All BAS DDC Devices shall be capable of updating firmware using software via internetwork without replacing any hardware, microprocessors or chips.
- .8 All binary output points shall be protected from short cycling via output configuration and/or programming. This feature shall allow minimum on time and off-time to be configurable.

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- .9 Panels shall use only following signal types to interface with field data points:
- .1 Binary Input (BI) also known as Digital Input (DI) contacts. Internal voltage source shall be dry contact or 0-5 V.D.C.
 - .2 Analogue Input (AI) is to be standard 4 - 20 ma transmitter, 0 – 5 VDC, 2-10 VDC or 0-10 VDC.
 - .3 Binary Output (BO) also known as Digital Output contacts rated at 24 V.D.C., 20 mA.
 - .4 Analogue Output (AO) to be standard 4 to 20 mA or 0-10 V.D.C. @ 20 mA maximum.
- .10 Each output on major controllers shall have an ON, OFF, AUTO select with status indication lamp and internal voltage source.
- .11 Controls shall be D.D.C. solid state type as noted elsewhere, and with exception of actuators, contain no moving parts.
- .12 Building level controllers must have real time clocks. Time keeping methods that depend on the clock speed of the processor chip are not accurate enough and are not acceptable. One designated controller shall keep the time for the entire system.
- .13 Control algorithms shall be available and resident in digital system controller to permit proportional, integral derivative, incremental, floating and two position control modes in any combination to meet requirements of application.
- .14 Canned packages shall not be permitted in controllers. Controllers must be flexible enough to accommodate custom programs and additional points.
- .15 Digital system controller shall be expandable by adding additional field interface units that operate through processor of digital controller to expand its control loop and energy management point capacity, without making any of the original equipment redundant.
- .16 To maintain long term analog accuracy in controller sensing circuits, digital controller shall sense voltage being supplied to resistance sensing element and through firmware compensate for power supply.
- .17 The non-volatile EPROM memory shall, as a minimum, support the operating system. Tape or disk media is not acceptable. All control languages, application functions and operating data or software shall reside in SuperCap or battery backed RAM. Data or control software (such as I/O point characteristics, schedules, set points and alarm limits) must remain in RAM and, hence, modifiable on-line through an operators terminal connected to any panel on the system or from a remote location via modem without the use of specialized software not provided in this contract. Controllers using batteries that require periodic replacement shall not be used. Standard off the shelf communications software packages are acceptable but in no case shall a hardware key or any other protection method be permitted that restricts the Board from connection to the system from multiple remote locations to display system command language and graphics displays.

- .18 All BMS components must be internally protected from loss of memory or operation due to power surges and brown outs. Controllers must be capable of operating without overheating or other damage at as little as 75% of nominal voltage, and as much as 125% of nominal voltage on the secondary side of the control transformers.
- .19 **Controllers shall be able to maintain communication (i.e. "pass through") in the event of a loss of power to the controller when wired in a daisy chain arrangement.**

2.3 BUILDING CONTROLLERS

- .1 The Building Controller shall be able to operate as a standalone panel and shall not be dependent upon any higher level computer or another controller for operation.
- .2 Provide all processors, power supplies, and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.
- .3 DDC controllers shall use the same programming language and tools. DDC controllers, which require different programming language or tools on a network, are not acceptable.
- .4 Modular Controller
 - .1 This controller shall have the BTL listing and meet the BACnet device profile of a Building Controller (B-BC) and shall the BACNet BIBBs required to provide a complete and operable system:
 - .2 The Building Level Controller shall support the following Data Link Layers:
 - .1 BACnet IP Annex J.
 - .2 BACnet IP Annex J Foreign Device.
 - .3 MS/TP Master (Claus 9).
 - .3 The Building Level Controller shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as they relate to features in the workstation software:
 - .1 Calendar – Creatable, Deletable.
 - .2 Command – Creatable, Deletable.
 - .3 Event Enrollment – Creatable, Deletable.
 - .4 Notification Class – Creatable, Deletable.
 - .5 Schedule - Creatable, Deletable.
 - .4 The Building Level Controller shall support transmitting and receiving segmented messages.
 - .5 The Building Level Controller shall have the capability to be the BACnet/IP Broadcast Management Device (BBMD) and support foreign devices.
 - .6 The Building Level Controller shall have the capability to act as a BACnet router between MS/TP subnetworks and BACnet/IP.
 - .7 Computing power and memory minimum
 - .1 A 32 bit, stand alone, multi tasking, multi user, real-time 100MHz digital control microprocessor module.
 - .2 Inputs shall be 16-bit minimum analog-to-digital resolution.

- .3 Outputs shall be 10-bit minimum digital-to-analog resolution.
- .4 Memory module (24 Megabyte, minimum) to accommodate all Primary Control Panel software requirements, including but not limited to, its own operating system and databases (see Controllers Software section), including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, password protected operator I/O, dial up communications.
- .5 Real time clock and battery.
- .6 Data collection/ Data Trend module sized for 10,000 data samples.
- .7 Flash Memory Firmware: Each Building Level Control Panel shall support firmware upgrades without the need to replace hardware.
- .8 Onboard or Modular hardware and connections:
 - .1 Primary Network communication module, if needed for primary network communications.
 - .2 Secondary Network communication module, if needed for secondary network communications.
 - .3 RJ45 port 10/100Mbaud.
 - .4 RS485 ports for subnetworks and point expansion.
 - .5 Man to Machine Interface port (MMI).
 - .6 USB Port.
- .9 Input and Output Points Hardware
 - .1 Input/output point modules as required including spare capacity.
 - .2 Input/output point modules shall have removable terminal blocks.
 - .3 Monitoring of the status of all hand off auto switches.
 - .4 Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.
 - .5 Local status indication for each digital input and output for constant, up to date verification of all point conditions without the need for an operator I/O device. Each primary control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.
 - .6 Graduated intensity LEDs or analog indication of value for each analog output.
- .10 Accessories:
 - .1 Appropriate NEMA rated metal enclosure.
 - .2 Power supplies as required for all associated modules, sensors, actuators, etc.

- .5 Compact Controllers
 - .1 Compact Controllers shall be a 16-bit stand-alone, multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors.
 - .2 Each Compact Controller shall have sufficient memory to support its own operating system and databases, including:
 - .1 Control processes.
 - .2 Energy management applications.
 - .3 Alarm management applications including custom alarm messages for each level alarm for each point in the system.
 - .4 Historical/trend data for points specified.
 - .5 Maintenance support applications.
 - .6 Custom processes.
 - .7 Operator I/O.
 - .8 Network communications.
 - .3 Compact Controllers shall provide a data communication port for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals.
 - .4 Compact Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.
 - .5 Accessories:
 - .1 Appropriate NEMA rated metal enclosure.
 - .2 Power supplies as required for all associated modules, sensors, actuators, etc.
- .6 The operator shall have the ability to manually override automatic or centrally executed commands at the primary control panels via local, point discrete, on board hand/off/auto operator override switches. If on board switches are not available, provide separate control panels with HOA switches. Mount panel adjacent to primary control panel. Provide hand/off/auto switch for each digital output, including spares.
- .7 Each Building Level Control Panel shall continuously perform self diagnostics on all hardware modules and network communications. The System Level Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication with any system.
- .8 Panel setup, point definitions and sequencing diagrams shall be backed up on EEPROM memory.
- .9 Building Level control panels shall provide at least two data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. Primary control panels shall allow temporary use of portable devices without interrupting the normal communications, operation of permanently connected modems, printers or terminals.
- .10 Building Level Controllers shall have the capability to serve as a gateway between Modbus subnetworks and BACnet objects. Provide software, drives and programming.

- .11 Immunity to power and noise:
 - .1 Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
 - .2 Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
- .12 In the event of the loss of normal power, there shall be an orderly shutdown of all DDC Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 60 days.
 - .1 Upon restoration of normal power, the DDC Controller shall automatically resume full operation without manual intervention.
 - .2 Should DDC Controller memory be lost for any reason, the user shall have the capability of reloading the DDC Controller via the local connection port, via telephone line dial-in or from a network workstation PC.

2.4 BUILDING LEVEL CONTROLLER LEVEL SOFTWARE

- .1 General
 - .1 **Provide a full capability user license to the owner for the operator to be able to see, modify, create, upload, download and save control programs to the DDC controllers.**
 - .2 The software programs specified in this section shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer for execution.
 - .3 The software application shall be accessible from a PC using the Windows environment but shall use all of its own services and data files so as to not be susceptible to Microsoft Windows operating systems based viruses.
 - .4 The Building Controller Software shall be capable of BACnet communications. The BACnet Building Controller (B-BC) shall have demonstrated interoperability during at least one BTL Interoperability Workshop and have demonstrated compliance to BTL through BTL listing.
- .2 System Security
 - .1 User access shall be secured using individual security passwords and user names.
 - .2 Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.
 - .3 Building Controllers shall be able to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any Operator Interface or portable operator terminal) shall enable the operator to monitor, adjust and control only the points that the operator is authorized for. All other points shall not be displayed at the Operator Interface or portable terminal. Passwords and priorities for every point shall be fully programmable and adjustable.

- .4 User Log On/Log Off attempts shall be recorded.
 - .5 The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.
 - .6 Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the DDC controller software.
 - .7 Passwords shall have the option to be configured to expire within a selected timeframe (1-365 days).
 - .8 Configuring the password expiration shall also enable the functionality to lock out a user account after three failed log-on attempts.
- .3 User Defined Control Applications: The application software shall program DDC routines to meet the sequences of operations.
- .1 The Building Controllers shall have the ability to perform the following pre tested control algorithms:
 - .1 Two position with differential control and time delays
 - .2 Floating control
 - .3 Proportional control
 - .4 Proportional plus integral control
 - .5 Proportional, integral, plus derivative control
 - .6 Automatic tuning of control loops
 - .7 Model-free adaptive control
 - .8 Start Stop Time Optimization
 - .2 Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
 - .3 Each controller shall support plain language text comment lines in the operating program to allow for quick troubleshooting, documentation, and historical summaries of program development.
 - .4 DDC Controllers shall have the ability to perform energy management routines for the purposes of optimizing energy consumption while maintaining occupant comfort. Routines shall include but are not limited to time of day scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating/cooling interlock, supply temperature reset, priority load shedding, and power failure restart.
 - .1 Start-Stop Time Optimization (SSTO) shall automatically be coordinated with event scheduling. The SSTO program shall start HVAC equipment at the latest possible time that will allow the equipment to achieve the desired zone condition by time of occupancy. The SSTO program shall also shut down HVAC equipment at the earliest possible time before the end of the occupancy period and still maintain desired comfort conditions.
 - .1 The SSTO program shall operate in both the heating and cooling seasons.

- .1 It shall be possible to apply the SSTO program to individual fan systems.
 - .2 The SSTO program shall operate on both outside weather conditions as well as inside zone conditions and empirical factors.
 - .2 The SSTO program shall meet the local code requirements for minimum outside air while the building is occupied.
- .2 Event Scheduling: Provide a comprehensive menu driven program to automatically start and stop designated points or groups of points according to a stored time.
 - .1 It shall be possible to individually command a point or group of points.
 - .2 For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start and stop within that group.
 - .3 The operator shall be able to define the following information:
 - .1 Time, day
 - .2 Commands such as on, off, auto, occupied, unoccupied and so forth.
 - .3 Time delays between successive commands.
 - .4 There shall be provisions for manual overriding of each schedule by an appropriate operator.
 - .4 It shall be possible to schedule events up to one year in advance.
 - .1 Scheduling shall be calendar based.
 - .2 Holidays and exceptions shall allow for different schedules.
- .3 Enthalpy switchover (economizer). The Energy Management Control Software (EMCS) will control the position of the air handler relief, return, and outside air dampers. If the outside air dry-bulb temperature falls below changeover set point the EMCS will modulate the dampers to provide 100 percent outside air. The user will be able to quickly changeover to an economizer system based on dry bulb temperature and will be able to override the economizer cycle and return to minimum outside air operation at any time.
- .4 Temperature-compensated duty cycling.
 - .1 The DCCP (Duty Cycle Control Program) shall periodically stop and start loads according to various patterns.
 - .2 The loads shall be cycled such that there is a net reduction in both the electrical demands and the energy consumed.
- .5 Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.

- .6 Night setback control: The system shall provide the ability to automatically adjust set points for night control.
- .7 The Peak Demand Limiting (PDL) program shall limit the consumption of electricity to prevent electrical peak demand charges.
 - .1 PDL shall continuously track the amount of electricity being consumed, by monitoring one or more electrical kilowatt-hour/demand meters. These meters may measure the electrical consumption (kWh), electrical demand (kW), or both.
 - .2 PDL shall sample the meter data to continuously forecast the demand likely to be used during successive time intervals.
 - .3 If the PDL forecasted demand indicates that electricity usage is likely to exceed a user preset maximum allowable level, then PDL shall automatically shed electrical loads.
 - .4 Once the demand peak has passed, loads that have been shed shall be restored and returned to normal control.
- .5 A single process shall be able to incorporate measured or calculated data from any and all other DDC and HVAC Mechanical Equipment Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC and HVAC Mechanical Equipment Controllers on the network. Database shall support 30-character, English language point names, structured for searching and logs.
- .6 DDC Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task-orientated information from the user manual.
- .4 Peer-to-peer access to other DDC controllers
 - .1 It shall be possible to use any actual or virtual point data or status, any system calculated data, a result from any process, or any user-defined constant in any controller in the system without dependence upon a central or intermediate processing device.
 - .2 Any process shall be able to issue commands to points in any and all other controllers in the system.
 - .3 Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of an advanced annunciation feature, such as:
 - .1 Generate a report
 - .2 Annunciate an alarm
 - .3 Issue a text message or email
 - .4 DDC and HVAC mechanical equipment controllers shall send alarm reports to multiple workstations without dependence upon a central or intermediate processing device.
 - .5 The peer-to-peer network shall also allow any DDC and HVAC mechanical equipment controller to access, edit, modify, add, delete, back up, and restore all system point database and all programs.

- .5 Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC and HVAC mechanical equipment controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC controllers ability to report alarms be affected by either operator or activity at a pc workstation, local i/o device, or communications with other panels on the network.
 - .1 All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
 - .2 Conditional alarming shall allow generation of alarms based upon user defined multiple criteria.
 - .3 An alarm "shelving" feature shall be provided to disable alarms during testing of systems.
 - .4 Binary Alarms shall be set to alarm based on the operator specified state. Provide the capability to automatically and manually disable alarming.
 - .5 Analog alarms shall have both high and low alarm limits. Provide the capability to automatically and manually disable alarming.
 - .6 The user shall be able to define the specific system reaction for each point. Each DDC Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
 - .7 Alarm reports and messages will be directed to a user-defined list of operator devices or PCs based on time (after hour's destinations) or based on priority.
 - .8 In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.
 - .9 Operator selected alarms shall be capable of initiating a trigger to an advanced annunciation, such as text, email, etc.
 - .10 An alarm history log shall report the start of the alarm condition, acknowledgement by a user and return of the alarm to normal condition.
 - .11 Remote Communication. The system shall have the ability to remotely communicate to the remote monitoring station.
- .6 Provide a PID (proportional-integral-derivative) closed-loop control algorithm with direct or reverse action and anti-windup. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, setpoint, and weighting parameters shall be accessible from the operator workstation.
- .7 Adaptive Loop Tuning
 - .1 Building Controllers shall also provide high resolution sampling capability for verification of DDC control loop performance. Documented evidence of tuned control loop performance shall be provided on a monthly, seasonal, quarterly, annual period.

- .2 For Model-Free Adaptive Control loops, evidence of tuned control loop performance shall be provided via graphical plots or trended data logs. Graphical plots shall minimally include depictions of setpoint, process variable (output), and control variable (e.g., temperature). Other parameters that may influence loop control shall also be included in the plot (e.g., fan on/off, mixed-air temp).
- .3 For PID control loops, operator-initiated automatic and manual loop tuning algorithms shall be provided for all operator-selected PID control loops. Evidence of tuned control loop performance shall be provided via graphical plots or trended data logs for all loops.
 - .1 In automatic mode, the controller shall perform a step response test with a minimum one-second resolution, evaluate the trend data, calculate the new PID gains and input these values into the selected LOOP statement.
 - .2 Loop tuning shall be capable of being initiated either locally at the Building Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.
- .8 Logic programming: Provide a software routine that can build ladder logic to control using many conditional statements.
 - .1 The logic programming syntax shall be able to combine ladder logic with other software features, such as combining status, scheduling, PDL and alarm conditions into one conditional decision.
 - .2 Logic programming shall be able to reference conditions in any other controller in the system.
- .9 Staggered Start:
 - .1 This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started, along with the time delay between starts, shall be user definable in an application and shall not require written scripts or ladder logic.
 - .2 Upon the resumption of power, each Building Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.
- .10 Totalization Features:
 - .1 Run-Time Totalization. Building Controllers shall automatically accumulate and store run-time hours for all digital input and output points. A high runtime alarm shall be assigned, if required, by the operator.
 - .2 Consumption totalization. Building Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and digital pulse input type points.

- .3 Event totalization. Building Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly or monthly basis for all points. The event totalization feature shall be able to store the records associated with events before reset.
- .11 A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for points as specified in the i/o summary. The entire collection process shall be automated so that the data collection definition, amount of data to be collected, collection report and scheduling take the form a wizard, or online assist utility, in order to complete this process within a short amount of time for a large group of points. Ability to produce a summary of changes in a log file.
- .12 Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC Controllers point group. Two methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of 1 minute to 7 days shall be provided. Each DDC shall have a dedicated RAM-based buffer for trend data and shall be capable of storing data samples. All trend data shall be available for transfer to a Workstation without manual intervention.
 - .1 Time-interval based trending shall have the capability of synchronizing the trend sampling of discrete points. This allows for the comparison of values of several different points at the same moment in time.
 - .2 Trended points shall have the option of sampling data values based on the condition of a "trigger" point (i.e., conditional trending). Options for sampling shall include always sampling as defined, only sampling when the trended point is in the alarm condition, or not sampling.
- .13 System Coordination. Provide a standard application for the proper coordination of equipment. This application shall provide the operator with a method of grouping together equipment based on function and location. This group may then be used for scheduling and other applications.

2.5 ADVANCED APPLICATION CONTROLLERS

- .1 The Advanced Application level control panel shall be able to operate as a standalone panel and shall not be dependent upon any higher level computer or another controller for operation.
- .2 The Advanced Application Controller Software shall be capable of BACnet communications. The BACnet Advanced Application Controller (B-AAC) shall have demonstrated compliance to BTL through BTL listing and shall substantially conform to BACnet Advanced Application Controller (B-AAC) device profile. Support all required BACnet BIBBS that are required to provide a complete and operable system.
- .3 The Advanced Application Controller shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as they relate to features in the workstation software:
 - .1 Calendar – Creatable, Deletable.

- .2 Command – Creatable, Deletable.
- .3 Event Enrollment – Creatable, Deletable.
- .4 Notification Class – Creatable, Deletable.
- .5 Schedule - Creatable, Deletable.
- .4 The Advanced Application Controller shall support transmitting and receiving segmented messages.
- .5 Communication: The Advanced Application Controller shall support the communications protocols and methodologies indicated in Specification Section 25 05 02 – Network Architecture and Wiring.
- .6 Serial Communication: Temporary use of portable devices shall not interrupt the BAS communication, nor the normal operation of permanently connected printers or terminals.
 - .1 Provide at least one EIA-232C serial data communication port for operation of operator I/O devices such as industry standard printers, operator terminals, and portable laptop operator's terminals.
 - .2 A USB port shall alternatively be available to support local HMI tools connection.
- .7 Input/Outputs
 - .1 Inputs shall be 16-bit minimum digital resolution.
 - .2 Outputs shall be 10-bit minimum digital resolution.
- .8 The following I/O port types shall be available on the controller
 - .1 Universal Input (software configurable):
 - .2 Digital Input choices:
 - .1 Pulse Accumulator.
 - .2 Contact Closure Sensing.
 - .3 Dry Contact/Potential Free inputs only.
 - .4 Digital Input (10 ms settling time).
 - .5 Counter inputs up to 20 Hz, minimum pulse duration 20 ms (open or closed).
 - .3 Analog Input Choices:
 - .1 0-10 Vdc.
 - .2 4-20 Ma.
 - .3 1K Ni RTD @ 32°F (Siemens, JCI, DIN Ni 1K).
 - .4 1K Pt RTD (375 or 385 alpha) @ 32°F.
 - .5 10K NTC Type 2 or Type 3 Thermistor.
 - .6 100K NTC Type 2 Thermistor.
 - .4 Universal Input or Output (software configurable):
 - .1 All of the above input types.
 - .2 Analog Output Types:
 - .1 0 to 10 Vdc @ 1 mA max

- .5 Super Universal Input or Output (software configurable):
 - .1 All of the above input types.
 - .2 All of the above output types.
 - .3 Super digital output type:
 - .1 0 to 24 Vdc, 22 mA max. (for controlling pilot relay)
 - .4 Super Analog Output Choices:
 - .1 0 to 20 mA @ 650 Ω max.
- .6 Provide software configurable I/O ports such that a programmer make a port either an input or an output.
- .9 Each System Level Control Panel shall, at a minimum, be provided with:
 - .1 A 32 bit, multi tasking, real-time 100 MHz digital control microprocessor with plug-in, enclosed processors.
 - .2 Each Advanced Application Controller shall have sufficient memory, a minimum of 24 megabyte, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, and operator I/O.
 - .3 Real time clock and battery.
 - .4 Data collection/ Data Trend module sized for 10,000 data samples.
 - .5 Power supplies as required for all associated modules, sensors, actuators, etc.
 - .6 Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.
 - .7 Local status indication for each digital input and output for constant, up to date verification of all point conditions without the need for an operator I/O device.
 - .8 Each control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.
 - .9 Graduated intensity LEDs or analog indication of value for each analog output.
- .10 Power loss. In the event of the loss of power, there shall be an orderly shutdown of all controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for the operating system software and firmware.
 - .1 Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
 - .2 Brownout protection and power recovery circuitry protect the controller board from power fluctuations.
 - .3 Battery backup shall be provided to support the real-time clock for 10 years.
 - .4 The program and database information stored SDRAM memory shall be battery backed for a minimum of 30 days and up to 60 days. This eliminates the need for time consuming program and database re-entry in the event of an extended power failure.

- .11 Database Restore: Each AAC controller shall automatically save the latest programmed database. The controller shall be able to automatically restore a lost or corrupt database without involvement from the operator.
- .12 Each System Level Control Panel shall continuously perform self diagnostics on all hardware modules and network communications. The System Level Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication with any system.
- .13 Each Control Panel shall support firmware upgrades without the need to replace hardware.
- .14 System Level control panels shall provide at least two data communication ports for operation of operator I/O devices such as operator terminals, and additional memory. Control panels shall allow temporary use of portable operator interface devices without interrupting the normal communications.
- .15 Immunity to noise: Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

2.6 ADVANCED APPLICATION CONTROLLER SOFTWARE

- .1 General
 - .1 Provide a full capability user license to the owner for the operator to be able to see, modify, create, upload, download and save control programs to the DDC controllers.
 - .2 The software programs specified in this section shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer for execution.
 - .3 The software application shall be accessible from a PC using the Windows environment but shall use all of its own services and data files so as to not be susceptible to Microsoft Windows operating systems based viruses.
- .2 Advanced Application Controllers shall have the ability to perform energy management routines including but not limited to
 - .1 Scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides
 - .2 Automatic daylight savings time switch over
 - .3 Night setback control
 - .4 Economizer switch over using enthalpy, dry bulb or a combination
 - .5 Peak demand limiting,
 - .6 Temperature-compensated duty cycling
 - .7 Heating/cooling interlock
 - .8 Supply temperature reset
 - .9 Priority load shedding
 - .10 Power failure restart
- .3 The software shall have a routine for automatic tuning of control loops

- .4 System Security in the Field Panel
 - .1 User access shall be secured using individual security passwords and user names.
 - .2 Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.
 - .3 The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.
 - .4 Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the field panel.
- .5 User Defined Control Applications:
 - .1 Controllers shall be fully-programmable. Controllers shall execute custom, job-specific sequences to automatically perform calculations and special control routines. Factory installed or pre-configured sequences shall only be allowed if they exactly match the sequence specified herein.
 - .2 Programs shall combine control logic, control loop algorithms, and energy management routines
 - .3 Each controller shall support plain language text comment lines in the operating program to allow for quick troubleshooting, documentation, and historical summaries of program development.
 - .4 Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task oriented information from the user manual
- .2 Adaptive Loop Control:
 - .1 Each AAC controller shall come standard with an Adaptive Control Loop Algorithm
 - .1 Tuning parameter shall automatically adjust for non-linear applications
 - .2 Model-Free Adaptive (MFA) algorithm
 - .1 The algorithm shall not require modeling of the non-linear system in order to maintain control at all points of the non-linear load.
 - .2 The controlled variable, setpoint, and weighting parameters shall be user-selectable.
 - .3 Output shall be analog or shall stage a series of outputs.
 - .4 Adaptive Control shall take the place of Proportional, Proportional + Integral, and PID type algorithms for non-linear applications. Adaptive Control routines shall:
 - .1 Improve response time.
 - .2 Improve System efficiency.
 - .3 Improve Stability.
 - .4 Result in Consistent outputs.
 - .5 Reduce cycling and repositioning.
 - .6 Reduce wear and tear on actuators.
 - .5 Adaptive control shall auto-adjust to compensate for
 - .1 Mode changes.
 - .2 Load changes.
 - .3 Seasonal changes.

- .4 Heating and cooling changeover.
- .5 Heating or cooling capacity changes on the primary side.
- .6 Flow changes on the primary or secondary side.
- .7 Airflow changes across coil.
- .8 Flow across a heat exchanger.
- .6 Adaptive control shall auto-adjust to compensate for
 - .1 Non-linear coils and heat exchangers.
 - .2 Hot water and chilled water reset routines.
 - .3 Water flow reset routines.
 - .4 Duct Static reset routines.
- .7 Auto-Tune PID loops are not acceptable substitutions.
- .8 If Adaptive Loop Control is not available, then the BAS contractor shall provide re-tuning of the control loops for coils and heat exchangers for each of the following conditions:
 - .1 Low heating supply water, high heating supply water.
 - .2 Low load on steam coil, high load on steam coil.
 - .3 Chilled water coil, non dehumidification and condensing.
 - .4 Chilled water coil, low airflow, high airflow, economizer.
 - .5 Dual temperature systems tune for heating and cooling modes.
 - .6 Each of 4 seasons.

2.7 APPLICATION SPECIFIC CONTROLLERS (ASC)

- .1 Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor. Each ASC shall be capable of control of the terminal device independent of the manufacturer of the terminal device.
- .2 All controller sequences and operation shall provide closed loop control of the intended application. Closing control loops over the floor, building or management level networks is not acceptable.
- .3 Each ASC shall be capable of control of the terminal device independent of the manufacturer of the terminal device.
 - .1 Provide for control of each piece of terminal equipment where indicated.
 - .2 Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be industry standard signals such as 24V floating control, allowing for interface to a variety of modulating actuators. Terminal controllers utilizing proprietary control signals and actuators shall not be acceptable.

- .3 Each controller performing space temperature control shall be provided with a matching room temperature sensor. The sensor may be either RTD or thermistor type providing the minimum performance requirements of +/- .6 deg. C accuracy, operating in the range of +/- .6 C° ($\pm 1F^{\circ}$) accuracy, operating in the range of 2 to 46°C (36°F to 115°F), adjustable between 2°C to 30°C (36°F to 86°F).
- .4 Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. The temperature indicator shall be digital readout visible without removing the sensor cover.
- .5 Each controller shall perform its primary control function independent of other DDC Controller LAN communication, or if LAN communication is interrupted. Reversion to a fail-safe mode of operation during interruption is not acceptable. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) gains for all applications.
- .6 **Each controllers communication system shall be capable of maintaining communication (i.e. "pass through") between the building level controller and the downstream application controllers in the event of a loss of power at the individual controllers when installed in a daisy chain configuration.**
- .7 Provide each terminal equipment controller with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM, or 72-hour battery backup shall be provided. Controllers that require factory changes of all applications are not acceptable.

Part 3 Execution

3.1 CONTROLLER APPLICATIONS

- .1 Building Level Controllers shall be used for the following types of systems. It is intended that each unique system be provided with its own point resident DDC Controller.
 - .1 Heating plant systems.
 - .2 Pumping systems.
 - .3 VAV air handlers.
 - .4 Air handlers over 15,000 cfm.
 - .5 Systems with over 24 input/output points.
- .2 Advanced Application Controllers shall be used for systems with custom sequences that meet all of the criteria below:
 - .1 No primary pumping systems.
 - .2 Secondary Pumping systems that are remote from Central Plants.
 - .3 Air handlers up to 15,000 cfm.
 - .4 Systems up to 20 input/output points.

- .5 BAS Network or Architecture or Sequences do not require the system to be on an IP network.
- .6 No systems that require integration to meters, VFDs or other smart equipment.
- .7 Integration to smart thermostats is allowed.
- .8 When application specific controllers are not allowed.
- .9 Rooftop systems.
- .3 Application Specific Controllers are intended to be used for only the following systems:
 - .1 Variable Air Volume (VAV) boxes
 - .2 Constant Air Volume (CAV) boxes
 - .3 Unit Conditioners
 - .4 **Application Specific Controllers are not allowed. Provide Advanced controllers with custom programming capability for all systems.**

3.2 CONTROLLER INSTALLATION

- .1 Install all DDC controllers in heated space. Keep all electronic equipment away from temperature extremes and wild fluctuations and shielded from electromagnetic interference.
- .2 Proposed panel locations shall be approved by Engineer/Board. Panels containing controllers shall be installed only in heated areas not subject to extremes of temperature or rapid temperature variations.
- .3 Label all wiring at termination point, reflect labelling in as-built shop drawings.
- .4 Isolation shall be provided at all primary control panel terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587 1980.
- .5 Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
 - .1 RF-Conducted Immunity (RFI) per ENV 50141 (IEC 1000-4-6) at 3 V.
 - .2 Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact.
 - .3 Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500 V signal, 1 kV power.
 - .4 Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).
- .6 Isolation shall be provided at all peer-to-peer panel's AC input terminals to suppress induced voltage transients consistent with:
 - .1 IEEE Standard 587-1980.
 - .2 UL 864 Supply Line Transients.
 - .3 Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11).
- .7 Install all panels in a metal enclosure. Use of controller plastic enclosures is not acceptable.

3.3 FUTURE EXPANSION

- .1 Controllers shall perform all of the functions described in these specifications, including all of the options described even if the options are not required in the initial work.
- .2 Controllers shall have an allowance of a minimum of 10% in spare points for each type of point.
- .3 If a certain type of point is not associated with a specific panel, the required minimum spare points shall be two (2).

3.4 PANELS

- .1 Local equipment cabinets shall be provided for each controller or group of controllers, of free standing or wall mounted type. Respective controllers, transducers, shall be mounted within cabinet. Relays, transformers and any other devices using a voltage above 24 VAC must be housed in a separate enclosure from the controllers. Transformers may be enclosed type, mounted outside of the enclosures. Panel instruments shall be designated as to type and function of black Lamicoid tags 6.4 mm white engraved, secured with drive screws. Cabinets shall be located where shown or as later directed and may be grouped per Mechanical Room.
- .2 Control panels shall be fully enclosed cabinets with all steel constructions. Cabinets shall have hinged door with locking latch or bolt on cover plate. All cabinet locks shall be common keyed.
- .3 Controller Panels
 - .1 Controllers in mechanical rooms shall be mounted in NEMA 1 enclosures.
 - .2 Controllers in areas where moisture is a concern shall be mounted in NEMA 12 enclosures.
 - .3 Controllers installed outdoors shall be mounted in NEMA 4X enclosures. Provide heaters where freezing temperatures are normally experienced.
- .4 Provide power supplies for control voltage power.
- .5 Dedicate 1 power supply to the DDC controller. Other devices shall be on a separate power supply, unless the power for the control device is derived from the controller terminations.
- .6 Power supplies for controllers shall be a transformer with a fuse or circuit breaker. Power supplies for other devices can be plain transformers.
- .7 All power supplies for 24V low voltage wiring shall be class 2 rated and less than 100VA. If low voltage devices require more amps, then provide multiple power supplies. If a single device requires more amps, then provide a dedicated power supply in a separate enclosure and run a separate, non-class 2 conduit to the device.
- .8 Surge transient protection shall be incorporated in design of system to protect electrical components in all DDC Controllers and operator's workstations.
- .9 All devices in a panel shall be permanently mounted, including network switches, modems, media converters, etc.
- .10 Provide a pocket to hold documentation.

- .11 Panels shall be wall mounted or free standing and shall be as located on the mechanical drawings.
- .12 All relays, transducers etc., shall be located within the control panels.
- .13 Each DDC Controller enclosure shall have a standard duplex AC power receptacle located within the enclosure to provide power for test equipment, operation communication devices.
- .14 Enclosures shall be large enough to accommodate the components without crowding, after allowing sufficient space for good wiring management. In all cases, the local field panel must have a minimum of 25% free mounting area within the enclosure
- .15 If the DDC controllers come with plastic enclosures, the plastic enclosures must be themselves enclosed in a metal enclosure.

3.5 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.
- .3 Warranty Coverage:
 - .1 Applies to parts and labour.

END OF SECTION

Part 1 **General**
Not Used

Part 2 **Products**

2.1 **ACCEPTABLE MANUFACTURERS**

- .1 Any devices listed in this specification shall be branded by the BAS supplier or one of the following manufacturers:
 - .1 Sensors, Relays Etc.
 - .1 Greystones
 - .2 Enercorp
 - .3 Johnson
 - .4 Siemens
 - .5 ACI
 - .6 Honeywell
 - .7 Setra
 - .2 Thermostats
 - .1 Match BAS provider
 - .3 Control Valves
 - .1 Siemens
 - .2 Belimo
 - .3 Johnson Controls
 - .4 Actuators
 - .1 Siemens
 - .2 Belimo
 - .3 Johnson Controls
 - .4 Honeywell
 - .5 Schneider Electric

2.2 **GENERAL REQUIREMENTS**

- .1 Actuation of control devices shall be electronic. Spring return fail-safe actuation shall be provided when loss of property and/or property damage is possible and where specified.
- .2 All equipment, unless specified to contrary, shall be fully proportioning, modulating in operation.
- .3 Space and duct sensors shall be electronic suitably located for specific application. Space sensing units shall be mounted 1500 mm from floor to centre for non-adjustable and 1200 mm from floor for adjustable unless otherwise noted or agreed to by the consultant.

- .4 Sensors shall meet or exceed the specified standards.
- .5 All sensors shall be capable of operating over the expected operating range and humidity.
- .6 **Detectors and electrical components within the airstream shall be classified for use in a Class I, Zone 2 system (as defined by the Electrical Safety Code).**

2.3 MOTORIZED CONTROL DAMPERS

- .1 Control dampers shall be the parallel or opposed blade type as below or as scheduled on drawings.
 - .1 Outdoor and/or return air mixing dampers and face and bypass (F & BP) dampers shall be parallel blade, arranged to direct air-streams toward each other.
 - .2 Other modulating dampers shall be the opposed blade type.
 - .3 Two-position shutoff dampers may be parallel or opposed blade type with blade and side seals.
- .2 Damper frames shall be 13 gauge galvanized steel channel or 1/8 in. extruded aluminum with reinforced corner bracing.
- .3 Damper blades shall not exceed 20 cm (8") in width or 125 cm (48") in length. Blades are to be suitable for medium velocity performance (10 m/s [2000 fpm]). Blades shall be not less than 16 gauge.
- .4 Damper shaft bearings shall be as recommended by manufacturer for application, oil impregnated sintered bronze or better.
- .5 All blade edges and top and bottom of the frame shall be provided with replaceable butyl rubber or neoprene seals. Side seals shall be spring-loaded stainless steel. The blade seals shall provide for a maximum leakage rate of 1% of total flow based on a approach velocity of 7.62 m/s (1500 ft/min) at 1000 Pa (4 in. w.g.) differential pressure. Provide air foil blades suitable for a wide-open face velocity of 7.5 m/s (1500 fpm).
- .6 Individual damper sections shall not be larger than 125 cm x 150 cm (48" x 60"). Provide a minimum of one damper actuator per section.
- .7 Modulating dampers shall provide a linear flow characteristic where possible.
- .8 Dampers shall have exposed linkages.
- .9 **Aluminum Airfoil Dampers**
 - .1 **Aluminum airfoil frames and blades shall be a minimum of 12 gauge extruded aluminum. Blades to be 6" wide single air foil design.**
 - .2 **Frames shall be extruded aluminum channel and grooved inserts for vinyl seals. Standard frames 2" x 4" x 5/8" on linkage side, 1" x 4" x 1" on the other sides.**
 - .3 **Pivot rods shall be 7/8" 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 is 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 linage 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 48" long per section**
- .8 Dampers greater than 1 section wide shall be arranged so they can be operated from either side. Note: this means the maximum damper width is 96". No jackshafts shall be used.**
- .9 Dampers on building exterior to be the insulated type.**

2.4 CONTROL VALVES

- .1 General:**
 - .1 All automatic control valves shall be fully proportioning, unless specified otherwise. The valves shall be quiet in operation and fail safe in normally open position unless specified otherwise. All valves shall be capable of operating at varying rates of speed to correspond to the exact dictates of the controllers and variable load requirements. The valves shall be capable of operating in sequence with other valves and/or dampers when required by the sequence of operation. All control valves shall be suitable for the pressure conditions and shall close against the differential pressures involved.**
 - .2 All control valves shall be sized by the control vendor and be guaranteed to accommodate the flow rates as scheduled.**
 - .3 The valve seat differential pressure rating shall exceed the pump dynamic head design pressure.**
 - .4 All control valve bodies shall be suitable for the static and dynamic pressures of the system. Control valve operators shall be sized to close against a differential pressure equal to the design pump head plus 10 percent.**
 - .1 Design body pressure shall be determined by the adding the static pressure due to the height of the system plus the compression tank charge plus the maximum head of the system pump at cut off. Provide 10% design factor.**
 - .5 The valve seat differential pressure rating shall exceed the pump dynamic head design pressure.**
 - .6 Cold water, hot water and steam valves, throttling type, and bypass valves shall have equal percentage flow characteristics.**
 - .7 All automatic control valves installed exposed to the elements shall be provided with electric actuators with operating characteristics and accessories as described in herein. Coordinate with electrical contractor for power availability and point of connection.**
 - .8 All automatic control valves controlled by the BAS shall be furnished by the controls contractor unless noted otherwise in these documents.**

- .2 Controlled Media
 - .1 The control valve shall be suitable for chilled water to a minimum of 35°F (2°C) and hot water to a maximum temperature of 250°F (121°C). 3-way 1-1/2" and 2" valves shall be suitable for chilled water to a minimum of 35°F (2°C) and hot water to a maximum temperature of 230°F (110°C). The control valve shall be suitable for up to 50% ethylene or propylene glycol solutions where applicable.
- .3 Threaded Valves, line size 1/2" to 2":
 - .1 Control valve bodies shall be constructed of forged brass according to ASTM B283 (C37700, CuZn39Pb2 or equivalent), and shall meet requirements of ANSI 250 and 600WOG pressure classes.
 - .2 Inlets and outlets shall be clearly marked on the valve bodies.
 - .3 Valve ball shall consist of nickel-plated brass, chrome-plated brass or stainless steel.
 - .4 End connections shall be NPT internally threaded according to ANSI B1.20.1.
 - .5 The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.
 - .6 The control valve shall have an equal percentage flow characteristic, according to ANSI/ISA S75.11. A single glass filled PTFE V port insert shall provide both the ball seal and shall establish the flow coefficient of the valve. The V port insert shall be retained by the valve body itself, not requiring additional retaining components. Flow coefficient adapters requiring a retainer clip or installed after final assembly of the valve or as inserts in the ball shall not be allowed.
 - .7 2-way valves and the A-AB path on 3-way valves shall meet the requirements of ANSI Class IV (0.01% of rated Cv) seat leakage, or better, according to ANSI/FCI 70.2, at the specified close-off pressure. Bypass path (B-AB) on 3-way valves shall meet the requirements of ANSI Class III (0.1% of rated Cv) seat leakage, or better, according to ANSI/FCI 70.2.
 - .8 Chilled and Hot water valve shall have a blow-out proof stem with two EPDM (peroxide cured) O-rings. External stem retainers will not be allowed.
 - .9 Valve stem shall be made of brass or stainless steel.
 - .10 Valve shall have the ability to be manually operated in the event of a power failure.
- .4 Flanged Valves, line size 2 1/2" and greater
 - .1 Valves 2 1/2" and larger shall be cast iron ANSI Class 125 with guided plug and PTFE packing.
- .5 Pressure Control Valves:
 - .1 Provide for all water systems where modulating water flow conditions are required to prevent excessive pump pressure build-up. Provide a valve for each closed loop water system. Valve to be globe type. Provide valves 2" and smaller with screwed end bodies and provide valves 2-1/2" and larger with flanged ends.

2.5 ELECTRONIC DAMPER AND VALVE ACTUATORS

.1 General

- .1 Electric control shall be direct coupled actuators.
- .2 Damper actuators shall be Brushless DC Motor Technology with stall protection, bi-directional, fail safe spring return, all metal housing, manual override, independently adjustable dual auxiliary switch.
- .3 The actuator assembly shall include the necessary hardware and proper mounting and connection to a standard 1/2" diameter shaft or damper blade.
- .4 Actuators shall be designed for mounting directly to the shaft without the need for connecting linkages.
- .5 All actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered.
- .6 All actuators having more than 100 lb-in torque output shall have a self-centering damper shaft clamp that guarantees concentric alignment of the actuator's output coupling with the damper shaft. The self-centering clamp shall have a pair of opposed "v" shaped toothed cradles; each having two rows of teeth to maximize holding strength. A single clamping bolt shall simultaneously drive both cradles into contact with the damper shaft.
- .7 All actuators having more than a 100 lb-in torque output shall accept a 1" diameter shaft directly, without the need for auxiliary adapters.
- .8 All actuators shall be designed and manufactured using ISO900 registered procedures and shall be Listed under Standards UL873 and CSA22.2 No. 24-93 I.
- .9 Provide visual scale indicating percent of travel.
- .10 Provide feedback signal on all control valves over 2 inches and all damper actuators where specified.
- .11 Actuators shall be UL and CSA listed.

.2 Electronic Valve Actuators

- .1 The valves shall be provided with an actuator by the same manufacturer, factory installed.
- .2 All actuators shall have visual position indication.
- .3 No external programming device shall be required.
- .4 Actuator shall be electric motor driving, microprocessor signal controlled.
- .5 Electric Control Rangeability: 40:1
- .6 Control Signal 0 to 10 VDC or 0 to 20 mA signal. 2 to 10 VDC or 4 to 20 mA operating range.
- .7 Power 24 VAC, 50-60 Hz
- .8 Fail Safe: Valves actuators shall position the valve in a fail safe position when the power supply is disrupted or the signal goes to 0. Fail-safe according to the following guidelines unless otherwise stated in the sequence of operations
 - .1 Power fail safe shall be via spring loaded mechanical means
 - .2 Any AHU hot water exposed to ventilation air shall fail open

- .3 AHU Chilled water coils exposed to ventilation air in possible freezing conditions shall be fail open
- .4 Terminal unit valves shall fail-in-place
- .9 Fail in place valves on primary equipment such as chilled water systems, hot water systems and condenser water systems shall have a means to manually open the valve when power is not available, such as a hand wheel or a geared crank with a clutch.
- .10 The actuator shall be designed with a current limiting motor protection. A release button (clutch) or handle on the actuator shall be provided to allow for manual override (except when actuator is spring return type).
- .11 Actuator shall provide minimum torque required for proper valve close-off. The close-off differential pressure rating of the valve shall exceed the highest possible head pressure available at the pump plus 10% and still be rated for a Class IV leakage.
- .12 The actuator shall have the capability of adding auxiliary switches or feedback potentiometer if specified.
- .13 All automatic control valves installed in locations exposed to the elements shall be provided with weather resistant housings and heaters for climates that reach below freezing.
- .3 Electronic Damper Actuators
 - .1 Actuator shall be direct coupled (over the shaft), enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The actuator-to-shaft clamp shall use a "V" bolt and "V" shaped, toothed cradle to attach to the damper shaft for maximum holding strength. Single bolt or set screw type fasteners are not acceptable.
 - .2 Damper operators shall be of the replaceable diaphragm piston type with external adjustable stops to limit the length of stroke in either direction. Operators shall be mounted on adjustable brackets. Operating arms shall have double yoke linkages and double set screws for fastening to damper shaft.
 - .3 Damper operators shall be selected to operate maximum damper loads of 2.6 m² (135 ft²). Where damper sizes exceed this area rating, multiple damper operators shall be provided.
 - .4 Actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator. End switches to deactivate the actuator at the end of rotation or magnetic clutch are not acceptable.
 - .5 For power-failure/safety applications, a mechanical, spring return mechanism

2.6 DAMPER STATUS SWITCHES

- .1 Damper status switches shall be a lever operated, activated by damper blade movement and mounted securely on damper frame.
- .2 Damper switch shall have contact rating of 5 amperes at 120V AC and be CSA approved.

2.7 PRESSURE TO CURRENT TRANSDUCERS

- .1 Pressure to Current Transducer
 - .1 Range 3 to 15 psig (21 to 103 kPa) or
3 to 30 psig (21 to 207 kPa)
 - .2 Output signal 4 – 20 mA

2.8 DIFFERENTIAL PRESSURE SENSORS

- .1 Differential pressure sensors shall be provided for water differential pressure air and static pressure applications.
 - .1 Monitoring Range To suit application
 - .2 Output Signal 4 to 20 mA
 - .3 Accuracy +/- 1.0% full scale
- .2 Select materials suitable for the measured variable, i.e. water and air, and to withstand a minimum of twice the normal pressure.
- .3 The transmitter output shall be linear proportional signal over the full operating range.

2.9 FILTER BANK STATUS DIFFERENTIAL PRESSURE SWITCHES

- .1 Provide switches with SPDT contacts rated at 9 amperes at 120 VAC and be CSA approved.
- .2 Select the differential pressure range of the switch to suit the application.
- .3 Provide switches with adjustable setpoint.
- .4 Mounted switches with diaphragm in a vertical plane.

2.10 TEMPERATURE THERMOSTAT (DDC)

- .1 Digital room sensors without LCD display, day / night override button, and setpoint slide adjustment to $\pm 5^{\circ}\text{C}$ adjustment and override options. The setpoint slide adjustment can be software limited by the automation system to limit the amount of room adjustment.
 - .1 Temperature monitoring range $+20/120^{\circ}\text{F}$ -13° to 49°C
 - .2 Output signal Changing resistance
 - .3 Accuracy at Calibration point $\pm 0.5^{\circ}\text{F}$ ($\pm 0.3^{\circ}\text{C}$)
 - .4 Set Point and Display Range 55° to 95°F (13° to 35°C)
- .2 Provide metal guards on thermostat in common areas and gymnasiums. Common area thermostats shall not have temperature adjustment.
- .3 Sensor to be 10k wire, thermistor style
- .4 **Do not provide LCD display of space temperature.**
- .5 **Sensor shall have integral CO2 sensor. Refer to CO2 sensor details for requirements.**

2.11 LINE VOLTAGE ROOM THERMOSTATS

- .1 Provide electric wall mounted 120 volt thermostats as indicated. Each thermostat shall be equipped with a thermometer and shall be tamperproof with locking covers.

- .2 A metal guard and adapter plate shall be supplied for all thermostats mounted in storage areas.

2.12 FLUID TEMPERATURE SENSORS

- .1 Immersion sensors shall be provided with a separable stainless steel well. Pressure rating of well is to be consistent with the system pressure in which it is to be installed. The well must withstand the flow velocities in the pipe.
- .2 The sensor shall have the following characteristics:
 - .1 Range Appropriate to application
 - .2 Output Signal 4 to 20 mA or resistive
 - .3 Accuracy 0.05% of maximum range, max 0.1 C

2.13 SEPARABLE BRASS THERMOWELLS

- .1 These shall be provided with immersion type bulbs for installation by plumbing section. (Stainless steel shall be used for immersion in glycol solutions.) Wells shall be packed with thermal conductive grease to increase speed of response. Thermowells shall have 1/2" IPS threads to receive sensor and be of suitable length for the pipe diameter.

2.14 AIR TEMPERATURE SENSORS

- .1 Sensors shall be a minimum of 1.5m (5ft) in length per 1 square meter of duct cross section.
- .2 All supply air sensors and mixed air sensors shall be 100 or 1000 OHM platinum, resistance temperature detector (RTD) type with a 7.5 m (25') averaging element. Each RTD may be provided with an industry standard, 4-20mA, transmitter mounted at the RTD as required.
 - .1 Temperature monitoring range -7°C to 49°C (20°F to 120°F)
 - .2 Output signal Changing resistance
 - .3 Accuracy at calibration point $\pm 0.3C (\pm 0.5F^{\circ})$
- .3 All return air sensors shall be RTD or thermistor type temperature detectors. The sensor probe shall have a minimum length of 450 mm (18"). Each RTD may be provided with an industry standard, 4-20mA, transmitter mounted at the RTD as required.
 - .1 Temperature and monitoring range 4°C to 66°C (40°F to 150°F).
 - .2 Output Signal Changing Resistance
 - .3 Accuracy ant calibration point 0.3C ($\pm 0.5F^{\circ}$)
- .4 Outdoor air sensor shall be the PT-100 platinum 3 wire RTD type with a 4-20mA transmitter mounted at the sensor. The RTD shall be mounted in a weatherproof enclosure, the 4-20mA transmitter shall be mounted inside the building within an electrical box.
 - .1 Temperature and monitoring range -18°C to 49°C (0°F to 120°F).
 - .2 Output Signal Changing Resistance
 - .3 Accuracy at calibration point $\pm 0.3C (\pm 0.5F^{\circ})$ over a range of

- .5 Sensors shall be provided with vented protective covers, mounted 1500 mm (60") from floor level.

2.15 HIGH LIMIT THERMOSTATS

- .1 Thermostats shall have liquid filled insertion probe.
- .2 Range shall be -3.9 to 101.7 C
- .3 Switch shall be snap acting and rated for 16 amperes at 120 VAC or 8 amperes at 575 VAC as required.
- .4 Thermostat shall have manual reset feature.
- .5 Provide one thermostat for each 1 sq. m of duct area.
- .6 Thermostats shall be CSA approved and have a dust tight enclosure.
- .7 Thermostats shall be SPDT or DPDT to facilitate monitoring by BMS.

2.16 LOW LIMIT THERMOSTATS

- .1 Thermostats shall have 6000 mm vapour tension sensing element sensitive to a temperature below its setpoint over 300 mm of its length.
- .2 Range shall be 1.7°C to 7.2°C.
- .3 Switch shall be snap acting and rated for 16 amperes at 120 VAC or 8 amperes at 575 VAC as required.
- .4 Provide one thermostat for each 1 sq. m of coil face area or part thereof.
- .5 Thermostats shall be DPDT to facilitate monitoring by BMS.
- .6 Mount sensing element rigidly and as close as possible to the downstream face of the coil being protected or where shown on schematic diagrams. Freeze controls shall have 6 m capillary arranged in ducts for best possible protection.
- .7 Provide freeze stat for each 5.5 square meters of duct area where necessary, wired in series. Sensing element shall extend at least to two diagonally opposite corners of the coil.

2.17 FLOW SWITCHES

- .1 Flow-proving switches shall be either paddle or differential pressure type, as shown.
- .2 Paddle type switches (water service only) shall be UL listed, SPDT snap-acting with pilot duty rating (125 VA minimum) and shall have adjustable sensitivity with NEMA 1 enclosure unless otherwise specified.
- .3 Differential pressure type switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application or as specified.
- .4 Flow switch to be DPDT, if possible to facilitate monitoring by BMS.

2.18 HUMIDITY SENSORS

- .1 The humidity sensor shall meet the following operating characteristics:
 - .1 Range 5-90% RH between 0°C to 60°C (32°F to 140°F).
 - .2 Output Signal 4-20 mA
 - .3 Accuracy $\pm 2\%$ RH over the humidity range
- .2 Duct mounted sensors shall be mounted half way across the duct. Room mounted sensor shall be provided with vented covers.

2.19 CO2 DETECTOR

- .1 The sensor shall be the non-dispersive infrared style.
- .2 The sensor shall meet the following operating characteristics
 - .1 Range 0 to 5000 ppm
 - .2 Output Signal 0 to 10 vDC or 4-20 mA
 - .3 Accuracy ± 50 ppm
- .3 Outputs shall be configured using optional software package to provide advanced control strategies using CO₂.
- .4 Sensor shall be self calibrating.
- .5 Wall mounting or duct mounting, depending on application.

2.20 ELECTRICAL DEVICES

- .1 Relays
 - .1 Control relays shall be UL listed plug-in type with dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
 - .2 Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable $\pm 200\%$ (minimum) from set point shown on plans. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.
- .2 Override timers.
 - .1 Override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration as required by application. Provide 0-to-6-hour calibrated dial unless otherwise specified. Timer shall be suitable for flush mounting on control panel face and located on local control panels or where shown.
- .3 Current transmitters.
 - .1 AC current transmitters shall be the self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4 to 20 mA two-wire output. Unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A full scale, with internal zero and span adjustment and $\pm 1\%$ full-scale accuracy at 500 ohm maximum burden.

- .2 Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA Recognized.
- .3 Unit shall be split-core type for clamp-on installation on existing wiring.
- .4 Current transformers.
 - .1 AC current transformers shall be UL/CSA Recognized and completely encased (except for terminals) in approved plastic material.
 - .2 Transformers shall be available in various current ratios and shall be selected for ± 1 % accuracy at 5 A full-scale output.
 - .3 Transformers shall be fixed-core or split-core type for installation on new or existing wiring, respectively.
 - .4 Status inputs for motors (pumps and fans) shall use inductive coils to monitor current draw from one phase of power.
 - .5 Current transformers shall be selected and configured for appropriate amperage range, and shall have 0 to 5 Volt output
 - .6 BMS shall use AI points to monitor current transformers.
- .5 Voltage transmitters.
 - .1 AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4 to 20 mA output with zero and span adjustment.
 - .2 Ranges shall include 100 to 130 VAC, 200 to 250 VAC, 250 to 330 VAC, and 400 to 600 VAC full-scale, adjustable, with ± 1 % full-scale accuracy with 500 ohm maximum burden.
 - .3 Transmitters shall be UL/CSA Recognized at 600 VAC rating and meet or exceed ANSI/ISA S50.1 requirements.
- .6 Voltage transformers.
 - .1 AC voltage transformers shall be UL/CSA Recognized, 600 VAC rated, complete with built-in fuse protection.
 - .2 Transformers shall be suitable for ambient temperatures of 4°C to 55°C (40°F to 130°F) and shall provide ± 0.5 % accuracy at 24 VAC and a 5 VA load.
 - .3 Windings (except for terminals) shall be completely enclosed with metal or plastic material.
- .7 Power monitors.
 - .1 Power monitors shall be the three-phase type furnished with three-phase disconnect/shorting switch assembly, UL Listed voltage transformers, and UL Listed split-core current transformers.
 - .2 They shall provide a selectable rate pulse output for kWh reading and a 4 to 20mA output for kW reading. They shall operate with 5 A current inputs with a maximum error of ± 2 % at 1.0 power factor or ± 2.5 % at 0.5 power factor.

- .8 Current switches.
 - .1 Current-operated switches shall be self-powered, solid-state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system. Switch shall be complete with LED and have four turn adjustment.

2.21 PHOTO SENSOR

- .1 Weathertight.
- .2 Operating Temperature -30 to +70 C.
- .3 Resistance at 0 Lux 15 Kohms minimum.
- .4 Resistance at 10 Lux 3 Kohms typical.

Part 3 Execution

3.1 NAMEPLATES

- .1 Duct and pipe mounted sensors and panels shall be provided with minimum size 75 x 25 x 3.2 mm nameplates, clearly identifying the equipment and functions with letter and number designation. Nameplates shall be mechanically secured and listed in the Operating and Maintenance manual.

3.2 ACTUATORS

- .1 Dampers: Actuators shall be direct-mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° available for tightening the damper seals. Actuators shall be mounted following manufacturer's recommendations.
- .2 Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.
- .3 Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
- .4 Provide all mounting hardware and linkages for actuator installation.
- .5 The controls contractor shall provide wiring as follows:
 - .1 All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.
 - .2 All wiring between the central control system (ATC/BMS) and the valve actuator shall be wired by the controls contractor.
 - .3 All wiring between the valve actuator and their associated thermostats, pressure switches, control devices, etc. shall be wired by the controls' contractor.
 - .4 All wiring shall comply with code requirements. Segregate high and low voltage wiring and circuits and segregate the FAS and controls (BMS) terminals.

3.3 CONTROL VALVE INSTALLATION

- .1 Valve submittals shall be coordinated for type, quantity, size, and piping configuration to ensure compatibility with pipe design.
- .2 All automatic control valves shall be installed by the mechanical trade.
- .3 BAS contractor shall co-ordinate porting of valves with mechanical contractor.
- .4 Slip-stem control valves shall be installed so that the stem position is not more than 60 degrees from the vertical up position. Ball type control valves shall be installed with the stem in the horizontal position.
- .5 Valves shall be installed in accordance with the manufacturer's recommendations.
- .6 Control valves shall be installed so that they are accessible and serviceable and so that actuators may be serviced and removed without interference from structure or other pipes and/or equipment.
- .7 Isolation valves shall be installed so that the control valve body may be serviced without draining the supply/return side piping system.
- .8 Unions shall be installed at all connections to screw-type control valves.
- .9 Provide tags for all control valves indicating service and number. Tags shall be brass, 1.5" in diameter, with 1/4" high letters. Securely fasten with chain and hook. Match identification numbers as shown on approved controls shop drawings.

3.4 CONTROL DAMPER INSTALLATION

- .1 Damper style and construction shall be coordinated for type, quantity, and size to ensure compatibility with sheet metal design.
- .2 Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting. Duct openings shall measure 1/4" larger than damper dimensions and shall be square, straight, and level.
- .3 Individual damper sections, as well as entire multiple section assemblies, must be completely square and free from racking, twisting, or bending. Measure diagonally from upper corners to opposite lower corners of each damper section. Both dimensions must be within 0.3 cm (1/8") of each other.
- .4 Follow the manufacturer's instructions for field installation of control dampers. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.
- .5 Install extended shaft or jackshaft according to manufacturer's instructions. (Typically, a sticker on the damper face shows recommended extended shaft location. Attach shaft on labeled side of damper to that blade.)
- .6 Damper blades, axles, and linkage must operate without binding. Before system operation, cycle damper after installation to ensure proper operation. On multiple section assemblies, all sections must open and close simultaneously.
- .7 Provide a visible and accessible indication of damper position on the drive shaft end.
- .8 Support ductwork in area of damper when required to prevent sagging due to damper weight.

- .9 After installation of low-leakage dampers with seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.

3.5 INSTALLATION OF THERMOSTATS

- .1 Install sensors in accordance with the manufacturer's recommendations.
- .2 Mount sensors rigidly and adequately for the environment within which the sensor operates.
- .3 Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.
- .4 All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.
- .5 Install thermostats at handicapped elevations 1200 mm above finish floor (AFF).
- .6 Where not indicated on drawing, place where directed by consultant.
- .7 Co-ordinate location with architectural and electrical items.

3.6 INSTALLATION OF SENSORS - GENERAL

- .1 Install sensors in accordance with the manufacturer's recommendations.
- .2 Mount sensors rigidly and adequately for the environment within which the sensor operates.
- .3 All wires attached to sensors shall be air in EMT raceways.
- .4 All din rail or screw mounted transmitters, shall be mounted in steel box of suitable size with removable cover and secured in place.
- .5 **The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.**

3.7 AIR TEMPERATURE SENSORS

- .1 Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
- .2 Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 3 m (10 ft.) of sensing element for each 1m² (1 ft of sensing element for each 1 ft²) of coil area.

3.8 LIQUID TEMPERATURE SENSORS

- .1 All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.

3.9 OUTDOOR AIR TEMPERATURE SENSORS

- .1 Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.

3.10 LOW LIMIT THERMOSTATS

- .1 Locate detectors after preheat coil or before cooling coil in air systems utilizing outside air.

3.11 DIFFERENTIAL PRESSURE SENSORS

- .1 Supply Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.
- .2 Return Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor.
- .3 Building Static Pressure: Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.
- .4 All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.
- .5 All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shutoff valves installed before the tee.

3.12 FLOW SWITCH INSTALLATION

- .1 Use correct paddle for pipe diameter.
- .2 Adjust flow switch in accordance with manufacturer's instructions.

3.13 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.
- .3 Warranty Coverage:
 - .1 Applies to parts and labour.

END OF SECTION

Part 1 General

1.1 RELATED SECTIONS

- .1 This section is to be read in conjunction with 25 10 01 Building Automation Systems – General Requirements and the remaining Section 25 specifications.

1.2 BACNET INTEGRATION AND CONTROL POINTS

- .1 The BAS contractor is responsible to provide a full and operable system that meets all required specifications and sequences.
- .2 The BAS contractor shall provide hard wired control points, sensors and all other components of the system as required to either supplement available BACNet points, or in the absence of a BACNet card make the system completely operable.
- .3 Sequences of operation may or may not be achievable through BACNet integration, as not all points required may be available from the unit manufacturer.
- .4 Not all equipment in the project has been specified with BACNet cards. The BAS contractor is responsible to review the entirety of the mechanical specification to confirm which equipment is being specified with BACNet integration cards and which equipment will not be provided with BACNet integration.
- .5 Quoting or pricing work as BACNet integration only is not acceptable.

Part 2 Products

2.1 Not Used.

Part 3 Execution

3.1 SYSTEM CONTROL STABILITY AND ACCURACY

- .1 Control Stability and Accuracy shall maintain measured variable at set-point within tolerances listed below:

Control Stability and Accuracy		
Controlled Variable	Control Accuracy	Range of Medium Accuracy
Air Pressure	±50 Pa (±0.2 in. w.g.) ±3 Pa (±0.01 in. w.g.)	0-1.5 kPa (0-6 in. w.g.) -25 to 25 Pa (-0.1 to 0.1 in. w.g.)
Airflow	±10% of full scale	
Space Temperature	±1°C (±2°F)	
Duct Temperature	±1.5°C (±3°F)	
Fluid Pressure	±10 kPa (±1.5 psi) ±250 Pa (±1 in. w.g.)	MPa (1-150 psi) 0-12.5 kPa (0-5 in. w.g.) differential

3.2 A2L REFRIGERANT CONTAINING EQUIPMENT

- .1 A2L refrigerants are classified as mildly flammable. CSA B52-2023 has specific safety clauses related to the use of refrigerants with this classification within buildings.
- .2 This contractor shall be responsible to ensure that the installation requirements of CSA B52-2023 are met.
- .3 Throughout this specification various pieces of equipment have been specified with refrigerant leak detection systems. Field wiring of the alarm status of this system to various downstream system components is required under Annex P of the standard and is the responsibility of this contractor. These devices include the following:
 - .1 Open all zone dampers connected to the affected system.
 - .2 Disable electric reheat coils within the affected system.
 - .3 Activate field installed safety shut off valves on the affected refrigeration systems
 - .4 De-energize any potential sources of ignition with the ductwork system of the affected system.
 - .5 Energize fans within the ductwork system.
 - .6 Activate any designated refrigeration leak ventilation systems.

3.3 VERIFICATION OF REFRIGERATION LEAK DETECTION SYSTEM OPERATION

- .1 The commissioning process shall include the verification of the refrigeration leak detection system.
- .2 All interlocks between leak detection systems installed and system components, as well as interlocks between field installed detection systems and associated safety system components shall be tested and verified to operate as per the requirements of CSA B52. Specifically, the following shall occur for each independent system on registration of a refrigerant leak:
 - .1 Open all zone dampers in the affected system.
 - .2 Disable all electric reheat coils within the affected system.
 - .3 Activate field installed safety shut off valves within the affected refrigeration system.
 - .4 Energize all fans within the affected ductwork system.
 - .5 Activate and refrigerant leak system specific ventilation systems.
 - .6 De-energize any other potential sources of ignition within the affected system.

3.4 NAMING OF POINTS AND CONTROLLERS

- .1 Refer to section 25 05 02 Building Automation Systems – General Requirements

3.5 START-UP AFTER POWER FAILURE

- .1 System shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started; along with the time delay between starts shall be user adjustable.

3.6 REQUIREMENTS TYPICAL TO ALL SEQUENCES

- .1 BAS contractor is responsible to provide a full and complete system that is capable of meeting all sequences, alarms, trends etc. specified. A point not being listed on a points list does not absolve the contractor from providing it if it is necessary to meet the Sequence of Operation.
- .2 All set points, reset curves etc. shall be adjustable by the operator.
- .3 This building is designed to comply with the prescriptive approach of the OBC SB-10 and ASHRAE 90.1 All mandatory control functions listed in the latest edition of ASHRAE 90.1 shall be included in sequences. These functions include, but are not limited to:
 - .1 Zone thermostatic control, complete with dead bands between heating and cooling set points.
 - .2 Set-point overlap protection
 - .3 Off-Hour Controls consisting of:
 - .1 Automatic shut down
 - .2 Temperature set back
 - .4 Optimum start controls
 - .5 Zone Isolation or grouping of HVAC equipment that is not expected to operate on the same schedule. All equipment in a single zone shall be scheduled together unless it was designed to operate 24/7. Each zone shall be capable of being provided it's own schedule or being scheduled together. As per ASHRAE 90.1 a zone shall not span more than one floor or be greater than 25,000 square feet.
 - .6 Provide logic to identify zones that may be excessively driving reset logic and generate an alarm for system operator to review. Provide functionality to remove any zone from reset logic.
 - .7 Where a space has a door to the exterior without an automatic closer, provide a door switch that resets heating set point to 55°F and cooling set point to 90°F if the opening is left open for more than 5 minutes.

3.7 ALARMS

- .1 Provide alarms, alarm hierarchy and alarm suppression as indicated in ASHRAE Guideline 36. Provide an alarm system capable of providing the following:
 - .1 Time and date is listed on the alarm
 - .2 Alarm Level. User shall be able to set alarm level for each individual alarm. The 4 levels of alarm shall be as follows:
 - .1 Level 1: Life-safety message
 - .2 Level 2: Critical equipment message
 - .3 Level 3: Urgent Message
 - .4 Level 4: Normal Message
 - .3 Sort alarms by level in the user interface
 - .4 Provide alarm description
 - .5 Provide equipment tags of units in alarm.
 - .6 Provide possible cause of alarm, if detected by fault detection routines.

- .7 User adjustable entry delay for alarms. The default time delays are as follows:
 - .1 Level 1: 1 second
 - .2 Level 2: 10 seconds
 - .3 Level 3: 1 minute
 - .4 Level 4: 5 minutes
- .8 Alarms shall be configured as latching or nonlatching. A latching alarm requires acknowledgement from operators before return to normal, even if exit deadband has been met. A nonlatching alarm does not require acknowledgement. Default latching status is as follows:
 - .1 Level 1 alarms: Latching
 - .2 Level 2 alarm: latching
 - .3 Level 3 alarms: nonlatching
 - .4 Level 4 alarms: nonlatching
- .9 Postexit suppression delay shall be provided to limit the number of alarms. Once an alarm has been triggered and reset it shall not be triggered again for a period of time. Default delay is as follows:
 - .1 Level 1 alarms: 0 minutes
 - .2 Level 2 alarm: 5 minutes
 - .3 Level 3 alarms: 24 hours
 - .4 Level 4 alarms: 7 days
- .10 Hierarchical Alarm Suppression. Provide a mechanism by which alarms in downstream equipment in the hierarchy are not presented to the operator if the source of the error is likely due to an alarm elsewhere in the building. (i.e. do not alarm that a VAV box cannot maintain discharge air temperature if the boiler plant or main circulation pumps are in alarm). Failure to start, Level 1, and command/status mismatch alarms are not subject to this hierarchy.

3.8 FAULT DETECTION ROUTINES

- .1 Provide automatic fault detection routines that will alert the operator to problems with sensors within the existing BAS system. There shall be a summary page provided which tabulates each Air Handling Unit with the list of following faults. Each fault limit shall be user adjustable by air handling unit:
 - .1 Duct Static Pressure Too Low with fan at full speed
 - .2 Mixed Air Temperature Too Low (not between RAT and OAT)
 - .3 Mixed Air Temperature Too High (not between RAT and OAT)
 - .4 Too Many Changes in OS (Set points have changed more than 10 times in last 60 minutes)
 - .5 SAT below MAT
 - .6 OA airflow is not within acceptable range for damper command
 - .7 SAT too low in full heating or too high in full cooling
 - .8 Temperature drop across coil with cooling inactive
 - .9 Temperature rise across coil with heating inactive

- .10 OAT too high for free cooling but mechanical cooling disabled.
- .11 SAT and MAT are not approximately equal in free cooling mode
- .2 Full formulas and definitions of these fault conditions are included in ASHRAE Guideline 36, High-Performance Sequences of Operation for HVAC Systems.
- .3 Provide indication of potential fault cause as per ASHRAE Guideline 36.

3.9 TRENDS

- .1 Provide Trends as follows:
 - .1 For HVAC Units:
 - .1 Unit/Fan Command and Status
 - .2 Fan Speed
 - .3 Unit Discharge Air Setpoint or Control Valve position
 - .4 Heating/Cooling Status (if applicable)
 - .5 Unit Supply and Return Air Temperatures
 - .6 Unit Supply and Return air Humidity
 - .7 Return Air CO₂
 - .8 Paired Exhaust fan command and status (if applicable)
 - .2 For Heating and Cooling Plants
 - .1 Boiler/Cooling Plant Command and status
 - .2 Pump Command and status
 - .3 Pump speeds
 - .4 Supply and Return water temperatures
 - .3 Energy Monitoring (Gas, Electric, Water etc.)
 - .1 Usage
 - .4 Temperature Sensitive Spaces (Boiler Rooms, IT Rooms, Electrical Rooms)
 - .1 Space Temperature
 - .2 Heating/Cooling Equipment status
 - .5 Exhaust Fans
 - .1 At owner request
 - .6 Misc. Heating Elements
 - .1 At owner request
 - .7 VAV/VVT Boxes
 - .1 At owner request

3.10 SCHEDULES

- .1 All equipment shall be assigned to logical zone groupings of equipment with each group having its own defined schedule.
- .2 Provide a standard schedule complete with options for both holiday and exception schedules for each zone.
- .3 User shall be able to assign multiple zones to the same schedule where appropriate.

3.11 ROOM TEMPERATURE SET POINTS

- .1 Heating:
 - .1 Occupied: 21° C.
 - .2 Unoccupied: 16° C.
- .2 Cooling:
 - .1 Occupied: 24° C.
 - .2 Unoccupied: 27° C.
- .3 **Occupied-Standby: Where lighting integration is provided, use BAS integration to determine occupancy of space. If unoccupied, set heating set point back 1°C and set cooling set point up 1°C after 5 minutes of unoccupied. If all spaces in an HVAC zone are unoccupied disable HVAC system fans.**
- .4 **Occupied Standby: Provide and install Occupancy Sensors to provide occupancy of space. If unoccupied, set heating set point back 1°F and set cooling set point up 1°F after 5 minutes of unoccupied. If all spaces in an HVAC zone are unoccupied disable HVAC system fans.**

3.12 GLOBAL TERMINAL UNIT INFORMATION DISPLAY

- .1 The display shall be updated at least once a minute and include the following information:
 - .1 Total number of heat pumps/VAV boxes in occupied mode.
 - .2 Total number of heat pumps/VAV boxes in override mode.
 - .3 Total number of heat pumps/VAV boxes in cooling.
 - .4 Total number of heat pumps/VAV boxes in heating.
 - .5 Total number of heat pumps/VAV boxes in alarm.
 - .6 Average Space Temperature
 - .7 Lowest space temperature
 - .8 Average heating offset
 - .9 Greatest heating offset
 - .10 Average cooling offset
 - .11 Greatest cooling offset

3.13 OCCUPANCY SENSOR INTEGRATION

- .1 **BAS shall monitor space occupancy levels for each room via BAS controlled occupancy sensors.**
- .2 **BAS shall monitor space occupancy levels for each room via integration with the lighting control system.**
- .3 Spaces shall be given a temporary unoccupied setback of 1°C from normal set back if the occupancy sensor picks up no occupants for 30 minutes during occupied hours.

3.14 BOILER PLANTS (CONDENSING PRIMARY SECONDARY)

.1 General

- .1 The boiler system provides primary hot water for the building.
- .2 There is an injection pump & 3-way valve that allows heat to be injected into the heat pump loop.
- .3 Boilers are equipped with factory supplied and installed controllers and safeties. The BAS will stage the boilers to maintain temperature
- .4 The lead boiler will be rotated weekly to equalize runtimes. The lead boiler designation shall alternate weekly. If the lead boiler should fail, the lag boiler will be started.
- .5 The two system pumps will be rotated weekly to equalize runtimes. The lead pump designation shall alternate weekly. If the lead pump should fail, the lag pump will be started after a 15 second delay.
- .6 The boiler circulation pumps shall be controlled by the boiler (BAS contractor to wire pumps to boiler). Pump status shall be monitored.
- .7 The boilers shall be integrated via terminal strip.

.2 Safeties and Limits

- .1 Minimum start and stop time delays are provided on all outputs to prevent short cycling of equipment.
- .2 Boilers have a minimum on time of 5 minutes and off time of 2.5 minutes.
- .3 If the outdoor air sensor fails, the boiler system will be enabled. The setpoints will set to -5° C outside air temperature.
- .4 The system pumps will run for 10 minutes after the boilers shut down to dissipate heat.
- .5 The boiler circulation pumps shall run for 10 minutes after the boilers shut down to dissipate heat.
- .6 Control each boiler's discharge temperature to ensure it does not cross the high limit of 93.3 degrees C (i.e. limit boiler modulation as discharge temperature approaches high limit).

.3 System Start/Stop

- .1 The system will be enabled whenever any of the following occurs:
 - .1 The outside air temperature is less than 5° C.
 - .2 The outside air temperature is less than 15° C and the building is occupied.
- .2 The system will be disabled whenever any of the following occur:
 - .1 There are no heat-requests from the building and the outside air temperature rises above 18° C for more than 30 minutes.
 - .2 There are no heat requests from the building and the outside air temperature rises above 5° C for more than 1 hour and the building is unoccupied.
- .3 When the system is enabled the lead boiler primary pump shall operate continuously.

.4 Control Strategy

- .1 Heating will be enabled once pump status is confirmed.
- .2 HWS temperature shall be reset based on a three point curve of outdoor air according to following schedule:

Primary Loop Temperature	Outdoor Air Temperature
66°C	-15°C
55°C	-5°C
42°C	21°C

- .3 The outdoor air reset schedule will shift up or down to satisfy the heating requests from the system and the set point will be adjusted between a minimum of 32 and a maximum of 66 degrees C.
- .4 If heating PID output is greater than 80%, lag boiler circulator pump shall start. Once pump status is confirmed both boilers shall modulate in unison to maintain set point.
- .5 If heating PID output drops below 40%, lag boiler is disabled. Lag pump shall disable after 10 minute time delay to dissipate excess heat.
- .6 Boilers shall be staged to bring on second boiler once first boiler reaches 50% firing (i.e. both boilers shall fire at 25% then modulate up together). The next boiler shall be brought on once both running boilers are at 50%, then all three boilers shall modulate together. This approach shall continue until all boilers in the system are firing.

.5 Pressure Control

- .1 The BAS shall control the pump VFD set point to maintain the system pressure set point.
- .2 Pressure set point reset shall be provided to maximize energy savings. Reset shall use a PID loop based on valve commands in the system.
- .3 If the system differential is below set point and pump on high speed for more than 15 minutes, the lag pump starts. If both pumps are on and the system differential pressure is at set point and the pumps are on high speed for more than 15 minutes the lag pump is stopped.
- .4 BAS shall modulate bypass valve as required to maintain minimum flow.
- .6 An alarm for the following shall be generated on the BAS:
 - .1 Boiler status is received and its primary pump status is off or the boiler is commanded off.
 - .2 Boiler status is not received and the boiler command is on (5 minute delay).
 - .3 Boiler alarm contact indicates boiler is in alarm.
 - .4 Pump status is received and the command is off (10 minute delay).
 - .5 Pump status is not received and the command is on, or status and command mismatch (5 minute delay).

- .6 The heating system is on and the primary supply water temperature is more than 10 degrees from setpoint (10 minute delay).
 - .7 An alarm will be generated with the outdoor temperature is below 4° C and the boiler return water temperature is below 32° C.
 - .8 An alarm will be generated if any space temperature is below 10° C.
 - .9 An alarm will be generated if the boiler loop pressure sensor drops below an adjustable threshold.
 - .10 System differential pressure deviates from set point.
- .7 Points List

Name	AI	AO	DI	DO
Boiler Command				X
Boiler Status			X	
Boiler Alarm			X	
Bypass Valve Command		X		
Boiler Modulation		X		
Boiler Circulator Command				X
Boiler Circulator Status	X			
System Pump(s) Command				X
System Pump(s) Status	X			
System Pump(s) Alarm			X	
System Pump(s) Speed Modulation		X		
Differential Pressure Set Point		X		
Differential Pressure Reading	X			
Hot Water Supply Temperature	X			
Hot Water Return Temperature	X			
Boiler Discharge Temperature	X			
Hot Water Supply Temperature Set Point		X		

3.15 HEAT PUMP LOOP CONTROL

- .1 General
 - .1 The heat pump loop provides water to the heat pumps.
 - .2 The distribution pumps operate on a lead/lag system. Lead designation to alternate weekly based on total runtime. If lead pump fails, lag pump shall start.
 - .3 Cooling Tower shall operate to cool the loop water. Refer to sequence for cooling tower operation.
 - .4 Boiler system shall operate to heat the loop water. Refer to sequence for boiler plant operation.

- .2 Safeties and Limits
 - .1 Minimum start and stop time delays are provided on all outputs to prevent short cycling of equipment.
 - .2 If the supply water temperature rises above 35° C or drops below 10° C for more than 5 minutes, a signal will be sent to shut down all the heat pump compressors.
 - .3 If both distribution pumps fail, a signal will be sent to shut down all heat pump compressors.
- .3 System Start/Stop
 - .1 A time of day schedule is provided for the heat pump loop.
 - .2 During the occupied time the lead pump will run continuously. The central plant will be enabled once pump status is received.
 - .3 During unoccupied mode the lead pump will start upon a request from any heat pump. If there are no requests for more than 10 minutes, the pump will be turned off.
 - .4 The system shall enter unoccupied mode if no request for heating or cooling is received for 30 minutes or it is scheduled off. The system can re-enter occupied mode upon a call for heating or cooling at a heat pump if not scheduled off.
 - .5 When the outdoor air temperature is less than 2° C, the heat pump loop will run continuously in both occupied and unoccupied mode.
- .4 Control Strategy
 - .1 The central plant is controlled to maintain the loop supply water temperature to set point.
 - .2 The heating set point is 16° C, adjustable 22° C and with throttling range adjustable between 1.7° and 4.4° C.
 - .3 The cooling setpoint is 32° C.
 - .4 When the loop supply water temperature is above the cooling setpoint the cooling tower shall be operated to cool the loop.
 - .5 When the loop supply water temperature is below the heating setpoint the boiler plant shall be enabled to provide heat to the loop. Modulate the control valve & injection pump as required.
- .5 Pressure Control
 - .1 The BAS shall control the pump VFD set point to maintain the system pressure set point.
 - .2 Pressure set point reset shall be provided to maximize energy savings. Reset shall use a PID loop based on valve commands in the system.
 - .3 If the system differential is below set point and pump on high speed for more than 15 minutes, the lag pump starts. If both pumps are on and the system differential pressure is at set point and the pump on high speed for more than 15 minutes the lag pump is stopped.
 - .4 BAS shall modulate bypass valve as required to maintain minimum flow.

- .6 An alarm for the following shall be generated on the BAS:
- .1 Pump status is received and the command is off (10 minute delay)
 - .2 Pump status is not received and the command is on (5 minute delay)
 - .3 Loop return temperature below 13° C (5 minute delay) (Critical Alarm)
 - .4 Loop return temperature above 35° C (5 minute delay) (Critical Alarm)
 - .5 In the event that flow is not proven within 20 second of starting the lag pump, the BMS shall report a Critical Alarm, which includes activating the alarm strobe in the administration area. Lock out heat pumps.

.7 Points List

Name	AI	AO	DI	DO
System Pump(s) Command				X
System Pump(s) Status	X			
System Pump(s) Alarm			X	
System Pump(s) Speed Modulation		X		
Differential Pressure Set Point		X		
Differential Pressure Reading	X			
Loop Supply Temperature	X			
Loop Return Temperature	X			
Control valve to Heat Exchanger (provide for all heat exchangers)		X		
Heat Pump Return Temperature into Heat Exchanger (Provide for all heat exchangers)	X			
Heat Pump Loop Supply Temperature out of Heat Exchanger (provide for all heat exchangers)	X			
Heating Loop from Central Plant Supply & Return Temperature	X			
Bypass Valve Modulation		X		

3.16 CONDENSER WATER LOOP CONTROL (HEAT PUMP SYSTEMS)

- .1 General
- .1 The system consists of two circulating pumps and cooling towers with individual control valves and fan speed VFDs. The operation of the heat exchanger is contained within the heat pump loop control sequences.
 - .2 The system operates to provide heat rejection from the heat pump loop.
 - .3 Alarms shall be forwarded to the Operator Work Station.

- .4 The distribution pumps shall operate on a lead/lag system. Lead designation shall alternate weekly based on total runtime. If lead pump fails, lag pump shall start. Note that both pumps shall run if both cooling towers are in operation.
- .2 Safeties and Limits
 - .1 Minimum start and stop time delays are provided on all outputs to prevent short cycling of equipment.
 - .2 If the tower water temperature rises above 32° C or drops below 10° C for more than 5 minutes, a signal will be sent to shut down all the heat pump compressors. Provide alarm at OWS. Reset when temperature is back in range.
 - .3 If both condenser pumps or towers fail, a signal will be sent to shut down all heat pump compressors.
- .3 System Start/Stop
 - .1 The system shall operate when there is a call for cooling from the heat pump loop.
- .4 Cooling Tower Control Strategies
 - .1 BAS shall cycle the spray pumps, two position spray valves, motorized dampers and VFD fans of the two cell cooling tower to maintain temperature of water in the heat pump loop to 35° C. The devices in the cooling tower shall be staged in the following order in 1° C increments, starting at 29.5° C.

Equipment Sequence	Temperature (C)
Cooling Tower Lead Cell Spray ON	29.4
Cooling Tower Lead Cell Fan ON and Modulate	30.6
Cooling Tower Lead Cell Fan HIGH	31.7
Cooling Tower Lag Cell Spray ON	32.8
Cooling Tower Lag Fan ON and Modulate	33.9
Cooling Tower Lag Fan HIGH	35

- .2 As needed, the BAS shall cycle the components off in reverse order.
- .3 BAS shall cycle sump heater to maintain temperature set point in common sump.
- .4 Individually monitor status of spray pumps, fans and sump water temperature.
- .5 BAS shall monitor temperature entering and leaving the heat exchanger, as well as entering and leaving condenser water temperature for each tower.
- .6 BAS shall modulate the existing three way heat injection valve to maintain the loop temperature at no less than 16°C.

- .5 An alarm for the following shall be generated on the BAS:
 - .1 Fan or Pump start/stop/status mismatch (10 minute delay)
 - .2 Fan VFD or Pump Alarm
 - .3 Tower return temperature above 32°C (5 minute delay) (Critical Alarm)
 Sump Temperature is below setpoint (5 minute delay) (Critical Alarm)
- .6 Points List

Name	AI	AO	DI	DO
System Pump(s) Command				X
System Pump(s) Status	X			
Loop Supply Temperature	X			
Loop Return Temperature	X			
Cooling Tower(s) fan Command				X
Cooling Tower(s) fan modulation		X		
Cooling Tower(s) fan status	X			
Intake Damper Status			X	
Exhaust Damper Status			X	
Intake Damper Command				X
Exhaust Damper Command				X
Cooling Tower Spray				X

3.17 SCHEDULED/PERIMETER HEATING LOOP CONTROL

- .1 General
 - .1 The perimeter heating loop is served by a three way valve mixing valve, circulation pumps **and a differential pressure sensor**.
- .2 Safeties and Limits
 - .1 Minimum start and stop time delays are provided on all outputs to prevent short cycling of equipment.
- .3 System Start/Stop
 - .1 The perimeter heating loop pumps shall operate whenever the boiler system is operating.
- .4 Control Strategy
 - .1 When boilers are enabled, and pump status is received, the three way mixing valve will modulate to maintain the secondary loop supply water temperature setpoint.
 - .2 Wall fin loop supply water setpoint will be reset upon heating requests from the zones. Provide a user adjustable three point schedule.

- .3 Heating requests shall shift the reset schedule up or down to eliminate requests. This shift is adjustable only between hardcoded limits of 30 and 75° C.
- .4 **The differential pressure bypass valve will modulate to maintain pressure differential between supply and return lines to set point. Coordinate setpoint with balancer.**
- .5 Pressure Control
 - .1 The BAS shall control the pump VFD set point to maintain the system pressure set point.
 - .2 Pressure set point reset shall be provided to maximize energy savings.
 - .3 If the system differential is below set point and pump on high speed for more than 15 minutes, the lag pump starts. If both pumps are on and the system differential pressure is at set point and the pump on high speed for more than 15 minutes the lag pump is stopped.
 - .4 The differential pressure bypass valve will modulate to maintain pressure differential between supply and return lines to set point. Coordinate setpoint with balancer.
- .6 An alarm for the following shall be generated on the BAS:
 - .1 Pump start/stop/status mismatch (10 minute delay)
 - .2 Low differential pressure alarm (10 minute delay)
 - .3 High differential pressure alarm (10 minute delay)
- .7 Points List

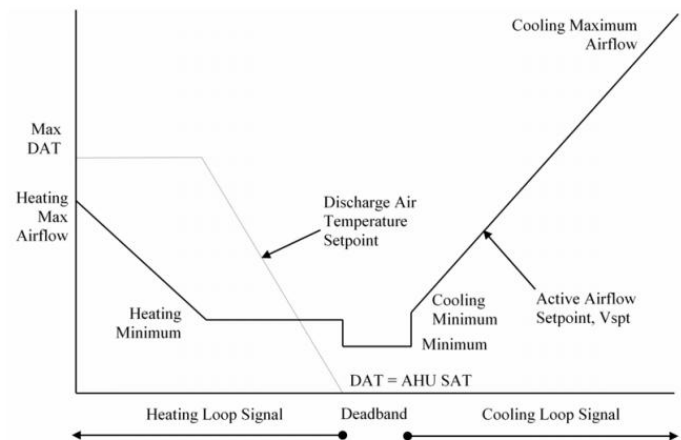
Name	AI	AO	DI	DO
System Pump(s) Command				X
System Pump(s) Status	X			
System Pump(s) Alarm			X	
System Pump(s) Speed Modulation		X		
Differential Pressure Set Point		X		
Differential Pressure Reading	X			
Control valve modulation for Heat Exchanger		X		
Loop HWR Temperature into Heat Exchanger (Provide for all heat exchangers)	X			
Loop HWS Temperature out of Heat Exchanger	X			
Boiler HWS Temperature into Heat Exchanger (provide for all heat exchangers)	X			
Boiler HWR Temperature out of Heat Exchanger	X			
Bypass Valve Modulation		X		

3.18 SINGLE DUCT VAV BOXES WITH REHEAT (Guideline 36 Version)

- .1 General
 - .1 Controls logic to be provided to meet ASHRAE Guideline 36, High-Performance Sequences of Operation for HVAC Systems. A summary of this standard follows, but BAS contractor remains responsible for the full implementation of the standard along with any additional notes indicated below.
 - .2 Design flow rates are indicated on the VAV Schedule on the drawings. Controls contractor shall calculate all required airflow settings as indicated elsewhere in this section. All settings shall be independently adjustable by the operator.
 - .3 Supply air temperature shall be monitored and displayed at the OWS.
 - .4 Supply air volume shall be monitored and displayed at the OWS.
 - .5 **Space temperature sensors are equipped with a warm/cool adjust and occupancy override button. Warm/cool adjust shall be set point by 2 degrees C. Override button will extend occupancy hours by two hours.**
- .2 Safeties and Limits
 - .1 The discharge air temperature shall be controlled to be no greater than 30 degrees F above the space set point.
 - .2 Upon signal from the associated HVAC unit's leak detection system:
 - .1 Disable any electric reheat or other sources of ignition in the ductwork system.
 - .2 Fully open zone dampers within the ductwork system/close bypasses.
 - .3 Energize all fans within the duct system/general exhaust fans in area affected.
- .3 System Start/Stop. Not applicable. Refer to multizone AHU sequences of operation.
- .4 Control Strategy
 - .1 Active maximum and minimum air flow set points shall vary depending on the mode of the zone group the VAV is a part of.

Set Point	Occupied	Cool down	Warm-Up	Unoccupied
Cooling Maximum	Vcool-max	Vcool-max	0	0
Cooling Minimum	Vcool-min	0	0	0
Minimum	Vmin	0	0	0
Heating Minimum	Larger of Vheat-min or Vmin	Heating Minimum	Heating Maximum	0
Heating Maximum	Larger of Vheat-max or Vmin	Heating Maximum	Cooling Maximum	0

- .2 Maximum and minimum airflows shall be set as follows:
 - .1 Vcool-max: Design airflow, plus 30%.
 - .2 Vcool-min: 30% of design airflow.
 - .3 Vheat-max: 80% of design airflow.
 - .4 Vheat-min: 0 cfm.
 - .5 Vmin: 30% of design airflow.
- .3 Control logic is depicted schematically in the figure below and described in the following sections.



- .4 **Cooling Zone State:** The cooling loop output shall be mapped to the airflow set point from the cooling minimum to the cooling maximum set points. Heating coil is disabled unless discharge air temperature is below the minimum set point. Note that if the supply air temperature from the air handler is greater than room temperature, cooling supply airflow set point shall be no higher than the minimum.
- .5 **Deadband Zone State:** The active airflow set point shall be the minimum airflow set point. Heating coil is disabled unless the discharge air temperature is below the minimum set point.
- .6 **Heating Zone State:** The heating loop shall maintain space temperature at the heating set point as follows:
 - .1 From 0 to 50%, the heating loop output shall reset the discharge air temperature set point from the current AHU SAT set point to the maximum above space temperature set point (30°F). The airflow setpoint shall be the heating minimum.
 - .2 From 51% to 100%, if the DAT is greater than the room temperature plus 3°C (5°F), the heating loop output shall reset the airflow set point from the heating minimum airflow set point to the heating maximum airflow set point.
 - .3 The heating coil shall be modulated to maintain the discharge air temperature set point.

.5 System Requests

.1 Cooling SAT reset requests

- .1 If the zone temperature exceeds the zone's cooling set point by 3°C (5°F) for 2 minutes, send 3 requests.
- .2 Else if zone temperature exceeds the zone's cooling set point by 2°C (3°F) for 2 minutes, send 2 requests.
- .3 Else if the cooling loop is greater than 95%, send 1 request until the loop is less than 85%.
- .4 Else if the cooling loop is less than 95%, send 0 requests.
- .5 Repress requests for 5 minutes after a reset to the SAT.

.2 Static Pressure reset requests

- .1 If the measured airflow is less than 50% of set point while set point is greater than zero and the damper position is greater than 95% for 1 minute, send 3 requests.
- .2 Else if the measured airflow is less than 70% of set point while set point is greater than zero and the damper position is greater than 95% for 1 minute, send 2 requests.
- .3 Else if the damper position is greater than 95%, send 1 request until the damper position is less than 85%.
- .4 Else if the damper is less than 95%, send 0 requests.
- .5 Repress requests for 5 minutes after a reset to the static pressure.

.3 Hot Water reset requests

- .1 If the DAT is 17°C (30°F) less than set point for 5 minutes, send 3 requests.
- .2 If the DAT is 8°C (15°F) less than set point for 5 minutes, send 2 requests.
- .3 Else if HW valve position is greater than 95%, send 1 request until the HQ valve position is less than 85%.
- .4 Else if the HW valve position is less than 95%, send 0 requests.
- .5 Repress requests for 5 minute after a reset to the hot water temperature.

.6 Alarms

.1 Low Airflow

- .1 Measured airflow is less than 70% of set point for 5 minutes (while set point is greater than 0).
- .2 Measured airflow is less than 50% of set point for 5 minutes (while set point is greater than 0).
- .3 If a zone has an importance-multiplier of 0 for it's static pressure reset control loop, low airflow alarms shall be suppressed.

- .2 Low-Discharge Air Temperature
 - .1 If heating plant is on, and DAT is 8°C (15°F) less than set point for 10 minutes.
 - .2 If heating plant is on, and DAT is 17°C (30°F) less than set point for 10 minutes.
 - .3 If a zone has an importance multiplier of 0 for it's hot water reset control loop, low discharge air temperature alarms shall be suppressed.
- .3 Airflow Sensor Calibration: If the fan serving the zone has been off for 10 minutes and the airflow sensor reading is above 10% of the cooling maximum airflow set point.
- .4 Leaking Damper: If the damper position is 0% and airflow sensor is above 10% of the cooling maximum airflow set point for 10 minutes while the fan serving the zone is on.
- .5 Leaking Valve: If the valve position is 0% for 15 minutes, DAT is above AHU SAT by 3°C (5°F) and the fan serving the zone is on.
- .7 Points List

Name	AI	AO	DI	DO
Damper Command		X		
Airflow Volume	X			
Discharge Air Temperature	X			
Temperature Control Valve Modulation		X		
Space Temperature	X			
Space Temperature Adjustment	X			

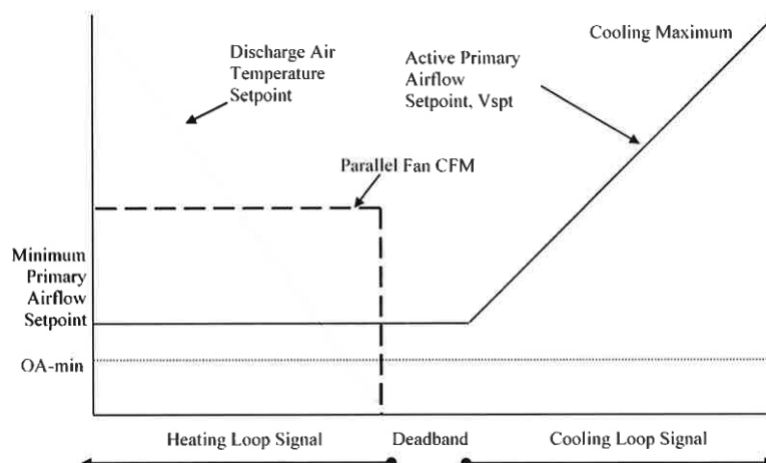
3.19 PARALLEL FLOW FAN POWERED VAV BOXES (Guideline 36 Version)

- .1 General
 - .1 Controls logic to be provided to meet ASHRAE Guideline 36, High-Performance Sequences of Operation for HVAC Systems. A summary of this standard follows, but BAS contractor remains responsible for the full implementation of the standard along with any additional notes indicated below.
 - .2 Design flow rates are indicated on the VAV Schedule on the drawings. Controls contractor shall calculate all required airflow settings as indicated elsewhere in this section. All settings shall be independently adjustable by the operator.
 - .3 Supply air temperature shall be monitored and displayed at the OWS.
 - .4 Supply air volume shall be monitored and displayed at the OWS.
 - .5 Space temperature sensors are equipped with a warm/cool adjust and occupancy override button. Warm/cool adjust shall be set point by 2° C. Override button will extend occupancy hours by two hours.

- .6 All set points shall be adjustable. Refer to schedules for maximum and minimum airflows in different operating modes.
- .7 Fan power boxes start from air handling unit dead stop.
- .2 Safeties and Limits
 - .1 The discharge air temperature shall be controlled to be no greater than 30 degrees F above the space set point.
 - .2 System Start/Stop. Not applicable. Refer to multizone AHU sequences of operation.
 - .3 Upon signal from the associated HVAC unit's leak detection system:
 - .1 Disable any electric reheat or other sources of ignition in the ductwork system.
 - .2 Fully open zone dampers within the ductwork system/close bypasses.
 - .3 Energize all fans within the duct system/general exhaust fans in area affected.
- .3 Control Strategy
 - .1 Active maximum and minimum primary air flow set points shall vary depending on the mode of the zone group the VAV is a part of.

Set Point	Occupied	Cool down	Warm-Up	Unoccupied
Cooling Maximum	Vcool-max	Vcool-max	0	0
Minimum	Vmin	0	0	0

- .2 Maximum and minimum airflows shall be set as follows:
 - .1 Vcool-max: Design airflow, plus 30%.
 - .2 Vmin: 30% of design airflow.
- .3 Control logic is depicted schematically in the figure below and described in the following sections.



- .4 Cooling Zone State: The cooling loop output shall be mapped to the airflow set point from the cooling minimum to the cooling maximum set points. Heating coil is disabled unless discharge air temperature is below the minimum set point. Note that if the supply air temperature from the air handler is greater than room temperature, cooling supply airflow set point shall be no higher than the minimum. Unit fan shall be off.
- .5 Deadband Zone State: The active airflow set point shall be the minimum airflow set point. Unit fan shall be off.
- .6 Heating Zone State: As the demand for heating increases, the SAT from the VAV box increases for the AHU SAT to the maximum allowable SAT. The heating coil valve is modulated to achieve the required temperature. When in this mode of operation, the fan is on. Primary airflow is maintained at the minimum setting.
- .7 System Requests
 - .1 Cooling SAT reset requests
 - .1 If the zone temperature exceeds the zone's cooling set point by 3°C (5°F) for 2 minutes, send 3 requests.
 - .2 Else if zone temperature exceeds the zone's cooling set point by 2°C (3°F) for 2 minutes, send 2 requests.
 - .3 Else if the cooling loop is greater than 95%, send 1 request until the loop is less than 85%.
 - .4 Else if the cooling loop is less than 95%, send 0 requests.
 - .5 Repress requests for 5 minutes after a reset to the SAT.
 - .2 Static Pressure reset requests
 - .1 If the measured airflow is less than 50% of set point while set point is greater than zero and the damper position is greater than 95% for 1 minute, send 3 requests.
 - .2 Else if the measured airflow is less than 70% of set point while set point is greater than zero and the damper position is greater than 95% for 1 minute, send 2 requests.
 - .3 Else if the damper position is greater than 95%, send 1 request until the damper position is less than 85%.
 - .4 Else if the damper is less than 95%, send 0 requests.
 - .5 Repress requests for 5 minutes after a reset to the static pressure.
 - .3 CO₂ Control
 - .1 Space CO₂ level shall be monitored. Reset minimum damper position from the value shown on the schedules to 50% of design airflow as CO₂ varies between 800 and 1000 ppm. Utilize reheat coil to maintain space temperature if necessary.

.8 Alarms

.1 Low Airflow

- .1 Measured airflow is less than 70% of set point for 5 minutes (while set point is greater than 0).
- .2 Measured airflow is less than 50% of set point for 5 minutes (while set point is greater than 0).
- .3 If a zone has an importance-multiplier of 0 for its static pressure reset control loop, low airflow alarms shall be suppressed.

.2 Low-Discharge Air Temperature

- .1 If heating plant is on, and DAT is 8°C (15°F) less than set point for 10 minutes.
- .2 If heating plant is on, and DAT is 17°C (30°F) less than set point for 10 minutes.
- .3 If a zone has an importance multiplier of 0 for it's hot water reset control loop, low discharge air temperature alarms shall be suppressed.

.3 Airflow Sensor Calibration: If the fan serving the zone has been off for 10 minutes and the airflow sensor reading is above 10% of the cooling maximum airflow set point.

.4 Leaking Damper: If the damper position is 0% and airflow sensor is above 10% of the cooling maximum airflow set point for 10 minutes while the fan serving the zone is on.

.5 Leaking Valve: If the valve position is 0% for 15 minutes, DAT is above AHU SAT by 3°C (5°F) and the fan serving the zone is on.

.6 Fan Command/Status mismatch after 1 minute.

.9 Points List

Name	AI	AO	DI	DO
Damper Command		X		
Airflow Volume	X			
Temperature Control Valve Command		X		
Space Temperature	X			
Space Temperature Adjustment	X			
Space CO ₂ Reading	X			
Fan Command		X		
Fan Status	X			
Discharge Air Temperatures	X			

3.20 HEAT PUMP UNIT CONTROL

- .1 General
 - .1 Heat pump supply air temperature shall be monitored
 - .2 **Space temperature sensors are equipped with a warm/cool adjust and override button. Warm/cool adjust shall adjust set point by 2 degrees C. Override button will extend occupied hours by 2 hours, except in unsupervised areas such as corridors. Sensor shall have a jack for BAS computer access.**
 - .3 Heat Pumps are controlled in conjunction with associated air handling unit and heat pump water loop. When a heat pump is in an occupied mode the air handling unit shall provide fresh air, and the heat pump loop pumps shall run. If the heat pump loop pumps do not run the heat pump compressors are shut down.
 - .4 Units shall have a staggered start delay programmed into them for start-up on power failure.
 - .5 Time delays on the digital outputs shall be used to prevent equipment short cycling.
 - .6 Heat pumps shall receive a signal upon heat pump loop failure that shall force all heat pump compressors off.
 - .7 **Heat pumps shall have a BAS controlled two position valve for variable speed pumping, complete with end switch.**
- .2 Safeties and Limits
 - .1 Two position valve shall be confirmed open prior to heat pump operation.
- .3 Start/Stop
 - .1 During occupied hours the supply fan shall run continuously.
 - .2 During unoccupied hours the supply fan shall cycle with the compressor to maintain set point.
- .4 Control Strategy
 - .1 The heating and cooling stages will be controlled, and the reversing valve adjusted to maintain the space temperature set point.
 - .2 **Integrate Occupancy Sensor control logic to provide occupied temperature set back for heat pumps as part of this project.**
 - .3 **Controller shall provide control of ECM motor control to meet space loads.**
- .5 Safeties and Alarms
 - .1 When a lock out alarm is received, the heat pump controller will increment the lock out counter by 1. When the lock out counter reaches 3, the BAS shall stop trying to start the compressor and will issue an alarm. The operator will be required to manually resetting the lockout via the workstation. A successful start of the compressor shall reset the counter to zero.
 - .2 The space temperature drops below 13° C.
 - .3 The space temperature drops below 18° C in occupied mode.
 - .4 The space temperature rises above 29° C in occupied mode.

- .5 If the heat pump has been in heating mode for 2 minutes, and SAT temperature is cooler than 30° C
- .6 If the heat pump has been in cooling mode for 2 minutes, and SAT temperature is warmer than 18° C.
- .7 The Room Stat shall flash a LED continuously if the heat pump is in an alarm state.

.6 Points List

Name	AI	AO	DI	DO
Space Temperature	X			
Space Temperature Adjustment	X			
Space Occupancy			X	
Fan Command				X
Fan Status	X			
Fan Speed Control		X		
Heat Pump Alarm (Lock Out)			X	
Compressor Hi/Lo Status			X	
Compressor Freezestat Temperature	X			
Supply Air Temperature	X			
Isolation Valve Command				X
Isolation Valve Position			X	
Compressor Command				X
Reversing Valve Command				X
Condensate Level	X			

3.21 FORCE FLOW HEATERS (UNIT HEATERS SIMILAR)

- .1 A temperature sensor energizes the fan to maintain setpoint. Fan status is monitored and alarms to BAS when it does not match command.
- .2 **Temperature sensor shall also modulate associated Temperature Control Valve**
- .3 The control system shall maintain the following temperatures:
- .4 Occupied mode 18°C for vestibules/stairwells.
- .5 Unoccupied mode: 13°C.
- .6 Provide alarm if space temperature is below 10°C.

.7 Points List

Name	AI	AO	DI	DO
Space Temperature	X			
Temperature Control Valve Modulation		X		
Fan Command				X
Fan Status	X			

3.22 CONVECTORS (RADIANT PANELS AND WALLFIN SIMILAR)

.1 Space Temperature Control

.1 Occupied Mode

Radiation valves shall be modulated to maintain space temperature.

.2 Unoccupied Mode

The heat setpoint shall be lowered to maintain space temperature.

.3 Points List

Name	AI	AO	DI	DO
Space Temperature	X			
Space Temperature Adjustment	X			
Temperature Control Valve Modulation		X		
Temperature Control Valve Command				X

3.23 PACKAGED HVAC (CONSTANT VOLUME)

.1 General

.1 The constant volume air handling units consists of a mixed air section with outdoor air and return air dampers, pre-filter, DX cooling coil, multiple-stage gas heat, and supply fan. The unit is DDC controlled using electric actuation.

.2 Some units will have remote ERVs that must be integrated into the sequences.

.2 Limits and Safeties

.1 Unit shall be equipped with a freeze stat.

.2 Mechanical cooling low temperature protection: If the outdoor air temperature falls below its Mechanical Cooling Lockout setpoint, it will prevent the mechanical cooling stages from being energized.

- .3 Monitor units' refrigeration leak detection system. Upon signal from system :
 - .1 Disable any electric reheat or other sources of ignition in the ductwork system.
 - .2 Fully open zone dampers within the ductwork system/close bypasses.
 - .3 Energize all fans within the duct system/general exhaust fans in area affected.
- .3 Unit Start/Stop
 - .1 Occupied Mode: unit fan runs continuously.
 - .2 Unoccupied Mode: unit fan is off unless there is requirement for space heating and cooling.
- .4 Control Strategy
 - .1 Space Temperature Control
 - .1 Room Temperature Control: The gas heat and DX cooling stage(s) will be activated appropriately to maintain the supply air temperature at its setpoint.
 - .2 Unoccupied Mode: When the room temperature falls below the unoccupied low limit setpoint, then the HVAC unit will start and continue to run until the room temperature rises by 3C°. If the room temperature rises above the unoccupied high limit setpoint, then the unit will start and continue to run until the room temperature falls by 3C°. Unit shall operate at full heat or cooling to bring space to setpoint as quickly as possible. Provide minimum run times as per Occupied mode. If supplemental heat is available, it shall be first stage heat.
 - .3 Morning Warm-up: When the HVAC unit starts-up after the unoccupied period and the return air temperature is below the warm-up mode setpoint, 20°C (adj.), the warm-up mode is in effect. The outdoor air damper will close fully and the gas valve will open until the return air temperature exceeds warm-up mode setpoint. Cooling stages will be locked-out during the warm-up mode.
 - .2 Supply Fan Shutdown Delay: If the fan system is shut down while heating or cooling stages are energized, the stages will immediately de-energize and the fan will continue to run for 60 sec. (heating mode, adj.) or 30 sec. (cooling mode, adj.) more, then shut down.
 - .3 Manual Override Timer: The supply fan will also be started if the manual override timer switch is activated. The fan will then run until the switch times out.
 - .4 Ventilation Control
 - .1 The ERV shall be enabled during all occupied hours and warm up periods to provide minimum ventilation rate. The ERV shall utilize free cooling when conditions are suitable.
 - .2 Provide CO₂ controls connected to the unit to override OA damper controls to allow more outside air to enter. Maintain CO₂ at 1000 ppm (adj). Limit outside air in order to prevent MAT falling below 13 degrees C.

- .3 Outside air damper shall be open to minimum position during occupied mode and closed in unoccupied mode.
- .5 Economizer:
 - .1 An economizer cycle shall be employed to return the outside air dampers to minimum position should the outside air temperature exceed the return air temperature.
- .5 Alarms
 - .1 Fan System Failure Alarm: An alarm is generated whenever the supply fan fails to respond to start-stop commands.
 - .2 Unit not cooling when commanded, as indicated by SAT (5 minute delay)
 - .3 Unit not heating when commanded, as indicated by SAT (5 minute delay)
 - .4 Supply air temperature above 35°C (5 minute delay)
 - .5 Unit is running and return air CO₂ levels are above 800 ppm (1 hour delay)
- .6 Points List
 - .1 **Where available, points may be integrated via BACNet. Any points not available via BACNet shall be provided by this contractor.**

Name	AI	AO	DI	DO
Space Temperature	X			
Space Temperature Adjustment	X			
Fan Command				X
Fan Status	X			
Gas Heat Stage 1				X
Gas Heat Stage 2				X
Cooling Stage 1				X
Cooling Stage 2				X
Mixed/OA damper Command		X		
Occupied/Unoccupied Command				X
Mix Air Temperature	X			
Supply Air Temperature	X			
Return Air CO ₂	X			
Return Air Temperature	X			
Freeze Stat Status			X	
Unit Alarm			X	

3.24 OUTDOOR AIR HANDLING UNITS (VAV DX, GAS, DISCHARGE AIR RESET)

.1 General

- .1 The variable volume air handling units consists of a mixed air section with outdoor air, exhaust air and return air dampers, filter, gas fired burner, packaged cooling, supply and return fans with variable frequency drives. The unit is DDC controlled using electric actuation. **A remote ERV is integrated into the sequences.**
- .2 Sequences are to meet ASHRAE Standard 36, High Performance Sequences of Operation for HVAC Systems. The BAS Contractor is responsible for full integration of the sequences, along with any additional requirements listed below.
- .3 Time delays shall be provided to prevent unit short cycling.
- .4 Fan status shall be reported.
- .5 Units shall have a staggered start delay programmed into them for start-up on power failure.

.2 Safeties and Limits

- .1 Freeze Protection: Provide programming to ASHRAE Guideline 36 standard. There are three levels of freeze protection to be programmed into the software:
 - .1 If supply air temperature drops below 4.4°C (40°F) for 5 minutes, enable heating plant, override outdoor air damper position/ERV operation to minimum, and modulate the heat to maintain a supply air temperature of at least 6°C (42°F). Disable this function once the supply air temperature rises above 7°C (45°F) for 5 minutes.
 - .2 If supply air temperature drops below 3.3°C (38°F) for 5 minutes, fully close both the economizer/outdoor air damper for 1 hour and set an alarm at the OWS. After 1 hour the unit shall resume minimum outdoor air ventilation and enter the previous stage of freeze protection.
 - .3 If supply air temperature drops below 3.3°C (38°F) for 15 minutes or below 1°C (34°F) for 5 minutes, shut down supply and return fans, close outdoor air damper, open both the chilled water valves and energize both pumping systems. Also ensure heating plant is enabled, and modulate the heating valve to maintain the higher of the supply air temperature or mixed air temperature at 27°C (80°F), and send an alarm to the OWS. The freeze protection shall remain in place until reset by a software switch at the OWS.
 - .4 Provide a hardwired freeze stat that must be manually reset as a final safety.

.3 System Start/Stop

- .1 The unit fan may run in any mode except for unoccupied mode.
- .2 The unit shall only run in setback mode if there is a perimeter zone without perimeter radiation, or after the perimeter radiation has failed to maintain set point for a minimum of 15 minutes.
- .3 Provide an override switch at the OWS to enable the unit for 3 hours.

- .4 Monitor units' refrigeration leak detection system. Upon signal from system:
 - .1 Disable any electric reheat or other sources of ignition in the ductwork system.
 - .2 Fully open zone dampers within the ductwork system/close bypasses.
 - .3 Energize all fans within the duct system/general exhaust fans in area affected.
- .4 Control Strategy
 - .1 Provide a summation of total airflow from the VAV boxes on the graphic for the unit.
 - .2 Determination of AHU Mode of Operation
 - .1 AHU system modes are the same as the zone groups served by the system. When zone groups served by an air-handling system are in different modes, the following hierarchy applies:
 - .1 Occupied mode
 - .2 Cool down mode
 - .3 Setup mode
 - .4 Warm-up mode
 - .5 Setback mode
 - .6 Freeze Protection setback mode
 - .7 Unoccupied mode
- .5 Static Pressure Control
 - .1 Static Pressure Reset. Provide static pressure reset using Trim and Respond Set-Point Logic to ASHRAE Standard 36, High-Performance Sequences of Operation. All parameters shall be adjustable by the operator at the OWS.
 - .2 BAS shall modulate the VFD of the supply and return fans to maintain the static pressure set point.
 - .3 The speed AO sent to the VFDs shall be configured such that 0% speed corresponds to 0 Hz, and 100% speed corresponds to maximum speed configured at the VFD. This does not necessarily correspond to 60 Hz.
- .6 Supply Air Temperature Control
 - .1 The Supply Air temperature control loop is enabled at all times that the supply air fan is proven on and disabled and output set to deadband (no heating, outdoor air damper closed) otherwise.
 - .2 Supply Air Temperature Set Point. Supply Air Temperature is to be reset and controlled to ASHRAE Guideline 36, using Trim and Respond logic. Design variables are as follows:
 - .1 Minimum Cooling Supply Air Temperature: 12°C (55°F)
 - .2 Maximum Cooling Supply Air Temperature: 18°C (65°F)
 - .3 OAT Minimum: 16°C (60°F)
 - .4 OAT Maximum: 21°C (70°F)
 - .3 Supply air temperature in heating mode shall be kept as low as possible so that heat can be delivered by the VAV reheat coils.

- .4 All Trim and Respond variables and set points shall be adjustable from the OWS.
- .5 During occupied mode and setup mode, the SAT set point shall be reset from Minimum Cooling Supply Air Temperature when the OAT is at OAT maximum and above, proportionally up to a maximum temperature, T-max when the outdoor air temperature is at OAT minimum and below.
- .6 T-max shall be reset using Trim and Respond Logic between the minimum cooling supply air temperature and the maximum cooling supply air temperature.
- .7 See controls diagram from ASHRAE Guideline 36 below:

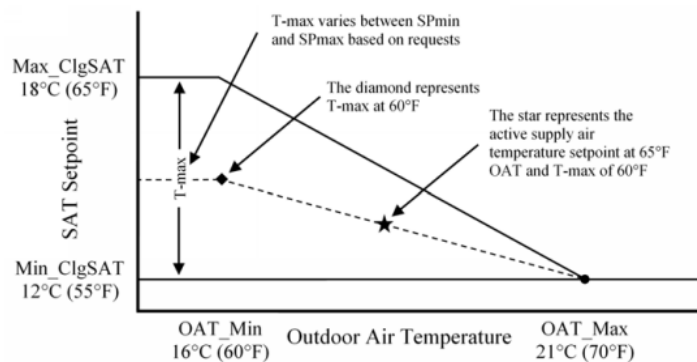


Figure 5.16.2.2 Example supply air temperature reset diagram.

- .8 During the cooldown mode, the set point shall be the minimum cooling supply air temperature.
 - .9 During the warm-up and setback modes the set point shall be:
 - .1 35°C (95°F) for systems with zones without reheat.
 - .2 21°C (70°F) for systems with VAV reheat or perimeter heat in all zones.
 - .10 Provide logic to allow the VAV unit to act as the primary heat source and increase supply air temperature to 32°C (90°F) in case of central plant failure of branch piping shut down.
 - .11 The supply air temperature shall be controlled to set point shall be sent to the AHU.
- .7 Minimum Outdoor Airflow Control
- .1 ASHRAE Guideline 36 logic shall be modified to allow for CO₂ demand control ventilation based on a CO₂ reading in the return air duct.
 - .2 The ERV shall be enabled during all occupied hours and represents the minimum ventilation rate. When in minimum ventilation rate, the AHUs OA damper shall be fully closed.
 - .3 The ERV shall be set to free cooling mode when conditions are appropriate.
 - .4 Provide a minimum outdoor air control loop which is enabled whenever the AHU is in operation and in occupied mode. Set output to zero otherwise. Provide an IAQ signal to the unit for internal operation of the dampers, return fan etc.

- .5 During occupied times:
 - .1 The outdoor air damper will remain closed until a preset value of 1000 ppm is reached. Beyond that value the damper shall modulate open until a minimum value of 800 ppm is reached.
 - .2 Reset the CO₂ setpoint up by 200 ppm with the mechanical cooling is in operation.
- .6 The demand for economizer operation shall override the outdoor air damper position and exhaust/return fan control.
- .7 Control loop mapping shall be as follows:
- .8 Air Side Economizer
 - .1 The unit shall control the air side economizer operation.
- .9 Return Fan and Building Pressure control
 - .1 Return fan shall operate whenever the associated supply fan is proven on, and shall be off otherwise.
 - .2 Return fan shall be controlled to maintain return fan discharge static pressure at set point.
 - .3 Exhaust dampers shall only be enabled when the associated supply and return fans are proven to be on, and the minimum outdoor air damper is open. The exhaust dampers shall be closed otherwise.
 - .4 The building static pressure shall be time averaged with a sliding 5-minute window to dampen fluctuations. The averaged value shall be that displayed and used for control.
 - .5 When exhaust dampers are enabled, a control loop shall modulate exhaust dampers in sequence with the return fan static pressure set point as indicated below to maintain the building pressure at a set point of 12 Pa (0.05 in. of water):
 - .1 From 0% to 50%, the building pressure control loop shall modulate the exhaust dampers from 0% to 100% open.
 - .2 From 51% to 100%, the building pressure control loop shall reset the return-fan discharge static pressure set point from its minimum to maximum. Static set points to be provided by the balancer.
- .10 Alarms
 - .1 Maintenance interval alarm once fan has operated for 1500 hrs.
 - .2 Supply fan status/command mismatch (1 minute delay)
 - .3 Return fan status/command mismatch (1 minute delay)
 - .4 Freeze stat alarms as listed under Limits and Safeties section.
 - .5 Supply air temperature above 35°C (5 minute delay)
 - .6 Return air temperature is more than 5 degrees from space set point (5 minute delay)
 - .7 Unit is running and return air CO₂ levels are above 800 ppm (1 hour delay)
 - .8 Heat wheel or other alarm is received from unit controller (immediate)
 - .9 Unit not cooling when commanded, as indicated by SAT (5 minute delay)

- .10 Unit not heating when commanded, as indicated by SAT (5 minute delay)
- .11 High Building Pressure (more than 25 Pa (0.10 in. of water)
- .12 Low Building Pressure (less than 0 Pa (0.0 in of water)
- .13 Provide software logic to shut down all fan systems AHU-1, AHU-2, and the RTUs upon fire alarm.

.11 Points List

- .1 **Where available, points may be integrated via BACNet. Any points not available via BACNet shall be provided by this contractor.**

Name	AI	AO	DI	DO
Supply Fan Command				X
Supply Fan Speed Modulation		X		
Supply Fan Status	X			
Supply Fan Alarm			X	
Supply Duct Static Pressure	X			
Return Fan Command				X
Return Fan Speed Modulation		X		
Return Fan Status	X			
Return Fan Alarm			X	
Discharge Air Setpoint		X		
Heating Lockout				X
Gas Burner Status	X			
Cooling Lockout				
DX Cooling Status	X			
Supply Air Flow Volume	X			
Supply Air Temperature	X			
Supply Air Humidity	X			
Return Air Temperature	X			
Return Air CO ₂	X			
Return Air Humidity	X			
Mixed Air Temperature	X			
Freeze Stat Status			X	
Unit Alarm			X	

3.25 EXHAUST FANS (GENERAL)

- .1 Start/stop exhaust fans on time of day schedule.
- .2 The DDC system uses a current switch to confirm fan operation. Provide a dual voltage relay adjacent to the BAS panel. DDC system generates an alarm if status deviates from DDC start/stop control.
- .3 Points List

Name	AI	AO	DI	DO
Exhaust Fan Command				X
Exhaust Fan Status	X			

3.26 EXHAUST FANS (WASHROOM)

- .1 Start/stop exhaust fans on time of day schedule.
- .2 The DDC system uses a current switch to confirm fan operation. Provide a dual voltage relay adjacent to the BAS panel. DDC system generates an alarm if status deviates from DDC start/stop control.
- .3 Points List

Name	AI	AO	DI	DO
Exhaust Fan Command				X
Exhaust Fan Status	X			

3.27 EXHAUST FANS (HEAT REJECTION)

- .1 Start/stop exhaust fans based on space temperature.
- .2 Space temperature shall be indicated on the BAS. Use of local reverse acting thermostats is not acceptable.
- .3 Exhaust fan shall operate with motorized dampers on the exhaust ductwork, and on the make up air ductwork if motorized dampers are indicated on the plans. Confirm dampers are open prior to sending fan command.
- .4 The DDC system uses a current switch to confirm fan operation. Provide a dual voltage relay adjacent to the BAS panel. DDC system generates an alarm if status deviates from DDC start/stop control.

.5 Points List

Name	AI	AO	DI	DO
Exhaust Fan Command				X
Exhaust Fan Status	X			
Space Temperature	X			
Motorized Damper Command				X
Motorized Damper Feedback			X	

3.28 ENERGY RECOVERY VENTILATORS

.1 General

.1 **ERV shall be integrated via Terminal Strip**

.2 ERV shall come with internal controller to control wheel modulation speed, fan status, free cooling and defrost cycles.

.2 Safeties and Limits

.1 Unit shall be prevented from short cycling by the BAS.

.2 Monitor units' refrigeration leak detection system. Upon signal from system:

.1 Disable any electric reheat or other sources of ignition in the ductwork system.

.2 Fully open zone dampers within the ductwork system/close bypasses.

.3 Energize all fans within the duct system/general exhaust fans in area affected.

.3 Start/Stop

.1 The unit shall be started and stopped by a time of day schedule.

.4 Control Strategy

.1 The unit shall utilize internal controls.

.5 Alarms

.1 Provide indication at OWS if unit is in alarm.

.2 If fan status does not match command. (10 minute delay)

.6 Points List

- .1 Where available, points may be integrated via BACNet. Any points not available via BACNet shall be provided by this contractor.

Name	AI	AO	DI	DO
Unit Command				X
Supply Fan Status	X			
Exhaust Fan Status	X			
Unit Alarm			X	
ERV Wheel Status	X			
ERV Wheel Entering Air Temp	X			
ERV Wheel Leaving Air Temp	X			

3.29 DOMESTIC WATER SYSTEM CONTROL (SIMPLE)

- .1 Provide supply temperature indication with strap on sensor on domestic hot water pipe for two (2) domestic hot water systems.
- .2 The recirculation pumps will be started/stopped on a time of day schedule.
- .3 Recirculation pump status shall be monitored.
- .4 Alarms shall be provided for the following:
- .1 Recirc pump start/stop/status mismatch (5 minute delay).
 - .2 Domestic hot water supply temperature rises above 62 degrees C for kitchen loop.
 - .3 Domestic hot water supply temperature rises above 45 degrees C for main building loop.

.5 Points List

Name	AI	AO	DI	DO
Supply Water Temperature	X			
Recirc Pump Command				X
Recirc Pump Status	X			

3.30 IT ROOM TEMPERATURE CONTROL

- .1 General
 - .1 The BAS shall control the IT room cooling system.
- .2 Limits and Safeties
 - .1 The discharge air temperature from the indoor fan coil unit shall be maintained above 10°C.
 - .2 **Monitor units' refrigeration leak detection system. Upon signal from system:**
 - .1 **Disable any electric reheat or other sources of ignition in the ductwork system.**
 - .2 **Fully open zone dampers within the ductwork system/close bypasses.**
 - .3 **Energize all fans within the duct system/general exhaust fans in area affected.**
- .3 Control Strategy
 - .1 The BAS shall provide a temperature and humidity set-point to the unit to maintain.
 - .2 Unit controls shall control unit operation to maintain set point. BAS contractor shall be responsible for commissioning and set up of equipment.
 - .3 Provide space temperature and humidity sensor that is separate from unit sensors.
 - .4 Provide graphic indicating status of all heating, cooling, fans, reheat and discharge air temperature and humidity.
- .4 Alarms
 - .1 Monitor all unit alarms.
 - .2 Alarm if space temperature rises 3°C above set point.
- .5 Points List
 - .1 **Where available, points may be integrated via BACNet. Any points not available via BACNet shall be provided by this contractor.**

Name	AI	AO	DI	DO
Unit Command				X
Space Temperature Set Point		X		
Space Humidity Set Point		X		
Unit Alarm			X	
Space Temperature	X			
Unit Fan Status	X			
Unit Heat/Cool/Reheat Status			X	
Unit Discharge Air Temperature	X			
Unit Discharge Air Humidity	X			

3.31 SERVICE ROOM TEMPERATURE CONTROL

.1 Room Temperature Control.

The room temperature control consists of a temperature sensor, a forced flow unit heater fan motor, modulating control valve, and an exhaust air fan and a supply air fan.

The DDC will control using electric actuation.

The controller monitors the room temperature sensor.

On a call for cooling the unit heater control valve is closed and the fan motor is off, controller will start exhaust and supply fan motor to maintain room temperature setpoint.

On a call for heating the exhaust fan motor is off, controller will modulate unit heater control valve and the unit heater fan motor is on to maintain room temperature setpoint.

The DDC system uses current switches to confirm fan operation. Provide a dual voltage relay adjacent to the BAS panel. DDC system generates an alarm if status deviates from DDC start/stop control.

.2 Points List

Name	AI	AO	DI	DO
Space Temperature	X			
Exhaust Fan Command				X
Exhaust Fan Status	X			
Supply Fan Command				X
Supply Fan Status	X			
Unit Heater Fan Command				X
Unit Heater Fan Status	X			
Heating Valve Modulation		X		

3.32 OUTDOOR TEMPERATURE AND HUMIDITY

.1 Provide new sensor for outdoor air temperature

.2 Provide new sensor for outdoor humidity

.3 Points List

Name	AI	AO	DI	DO
Outdoor Air Temperature	X			
Outdoor Air Humidity	X			

3.33 EXTERIOR LIGHTING CONTROL

- .1 The outdoor lighting consists of two lighting zones (parking lot poles and wall packs) and one astrological clock.
- .2 The DDC will control using electric actuation Start/stop of each lighting zone on time of day schedule. Photocell will override program turning lights on should outdoor elements reach a low illumination during program stop period.
- .3 The DDC system will monitor lighting zone operation and generates an alarm if status deviates from DDC start/stop control.
- .4 Points List

Name	AI	AO	DI	DO
Zone Command (multiple)				X
Photocell			X	
Astrological Clock			X	

3.34 SECURITY SYSTEM INTEGRATION

- .1 Monitor the armed/un-armed operation of the security system. Provide alarm indication at the OWS.
- .2 Use security setting to program exterior lighting on in the event of an armed signal, program to go off when system is disarmed.
- .3 Include readings in the graphics package.
- .4 Points List

Name	AI	AO	DI	DO
System Status			X	

3.35 FIRE ALARM INTEGRATION

- .1 The fire panel monitoring consists of one dry contact at fire alarm panel as supplied by panel manufacture.
- .2 The DDC will monitor fire panel contact and generate an alarm if contact closes.
- .3 The BAS/DDC system will enter fire alarm system mode as approved by local fire authority and mechanical engineer.

.4 Points List

Name	AI	AO	DI	DO
System Status			X	

3.36 ELECTRICAL/GAS/WATER METER INTEGRATION

- .1 Integrate electrical meters provided as part of switchboard into BAS to provide monitoring of instantaneous electrical load, as well as a variety of totalization and trending.
- .2 Provide meters to monitor gas and domestic water usage as indicated on drawings.
- .3 Co-ordinate exact method of integration with electrical trade.
- .4 Points List

Name	AI	AO	DI	DO
Electrical Use	X			
Gas Use	X			
Water Use	X			

3.37 INTERIOR LIGHTING INTEGRATION

- .1 The BAS shall provide occupied/unoccupied scheduling into the building's lighting control panel.
- .2 All downstream control will be programmed as part of the electrical lighting package.
- .3 Points List

Name	AI	AO	DI	DO
Building Occupation Status				X

- .4 The BAS shall enable/disable the receptacles identified on the electrical drawings based on a time of day schedule to meet the prescriptive requirements of ASHRAE 90.1 This contractor shall review the electrical drawings for locations and number of contacts.

.5 Points List

Name	AI	AO	DI	DO
Power Interruption				X

3.1 TRAP PRIMER STATIONS

- .1 Once per day the BAS shall operate the trap primer solenoid valves to provide a water to the trap primer header.
- .2 The injection shall be 6 seconds (adjustable by operator)
- .3 Alarm shall be provided to the operator if end switch is not confirmed.

Name	AI	AO	DI	DO
Valve command				X
Valve Endswitch			X	

3.2 WARRANTY

- .1 Warranty Start Date:
 - .1 Warranty period starts as of the date of Ready for Takeover.
 - .2 Warranty start dates based on shipment date, start up date, substantial completion date, etc. are not applicable.
- .2 Warranty Duration:
 - .1 One (1) year warranty period applies.
- .3 Warranty Coverage:
 - .1 Applies to parts and labour.

END OF SECTION

Division 26 Common Requirements for Electrical

26 00 11	Electrical Specification Index
	Common Contract Requirements for Electrical
26 01 13	Electrical Supplemental Tender Form
26 01 15	Electrical Allowances
26 01 16	Electrical Contract General Requirements
26 01 20	Integrated Testing of Fire Protection and Life Safety Systems
26 01 21	Electrical Occupancy Requirements
	Common Work Results for Electrical
26 05 19	Wires and Cables
26 05 20	Splitters, Junction, and Pull Boxes
26 05 21	Outlet Boxes, Conduit Boxes, and Fittings
26 05 22	Wire and Box Connectors – 0 –1000 V
26 05 26	Grounding Secondary
26 05 27	Seismic Restraint for Electrical Systems
26 05 33	Conduits, Conduit Fastenings, and Conduit Fittings
26 05 43	Installation of Cables in Trenches and Ducts
26 05 74	Short Circuit/Coordination Study Arc Flash Hazard Analysis
26 05 75	Auxiliary Systems
	Low-Voltage Transformers
26 22 13	Dry Type Transformers
	Switchboard and Panelboards
26 24 13	Service Entrance Board
26 24 16	Panelboards
26 24 17	Moulded Case Circuit Breakers
	Low-Voltage Distribution Equipment
26 27 26	Wiring Devices
	Low-Voltage Circuit Protective Devices
26 28 13	Fuses – Low Voltage
26 28 16	Disconnect Switches
	Low-Voltage Controllers
26 29 13	Starters and Contactors
	Electrical and Cathodic Protection
26 43 13	Surge Protective Devices
	Lighting
26 51 13	Lighting Equipment
26 51 16	Digital Occupancy and Daylight Control Systems

Division 28 Electronic Safety and Security

	Fire Detection and Alarm
28 31 26	Fire Alarm System (Renovation)

END OF SECTION

Part 1 General

1.1 INSTRUCTIONS TO BIDDERS

- .1 The Electrical Supplemental Tender Form must be submitted to the architect and consultant (admin@deiassociates.ca) within 2 hours after tender closing. Electrical contractors shall identify all sub-contractors he/she intends to use and must complete all information requested. The requisite information shall be given at the office of the Consultant. Contractor shall sign and date this page and initial and date each page thereafter.
- .2 Should the Electrical Supplemental Form not be submitted then the contractor shall use Basis of Design manufacturers as listed.

.3 CONTRACTOR

I/We certify that I/We have the authority to bind the company.

COMPANY NAME

AUTHORIZED SIGNATURE

ADDRESS

PRINTED SIGNATURE

CITY

TITLE

TELEPHONE NUMBER

DATE

FAX

.4 SUB-CONTRACTORS

The Contractor shall state below the name of the Public Address, Security, Co-ordination Study, Computer Network, Life Safety Systems Commissioning Agent, Seismic Restraint Engineer Sub-contractor he intends to use, which shall not be changed without the consent of the Consultant.

Co-ordination Study _____

Seismic Restraint Engineer _____

- .5 The Stipulated Bid Sum shall be for the basis of design manufacturer or supplier equipment only, unless otherwise indicated. Where a choice of this equipment is given, this Contractor shall indicate the supplier or manufacturer he intends to use. **Where no choice is indicated, the basis of design supplier or equipment shall be used.**

CONTRACTOR'S NAME: _____ DATE: _____

- .6 Equipment or materials manufactured by firms named in the following listing only shall be deemed equal to the equipment or material specified, provided the equipment or material will have capacity, performance, rating, construction, physical dimensions, accessories and features which, in the opinion of the Consultant, are equal to those of the specified equipment or material. The Electrical Contractor shall not indicate equipment, materials or suppliers which are not listed. If this is done, the base bid supplier shall be used.
- .7 Where modifications to the work of other trades are required as a result or part of the alternative offered, include the cost of said modifications in the work.
- .8 Submit the following list of basis of design and alternative suppliers in accordance with the bid requirements:

Spec. Reference Section	Equipment	Basis of Design	Acceptable Alternate Manufacturer	Indicate Manufacturer Or Supplier
26 29 13.13	Starters and Contactors	Schneider Electric	Allen Bradley Siemens Eaton Klockner-Moeller	
26 22 13.13	Dry –Type Transformers	Hammond	Rex Acme Delta Bemag	
26 24 13	Service Entrance Board	Schneider Electric	Siemens Eaton	
26 24 17	Molded Case Circuit Breakers	Schneider Electric	Siemens Eaton	
26 28 16	Disconnect Switches	Schneider Electric	Siemens Eaton	
26 24 16	Panelboards	Schneider Electric	Siemens Eaton	
26 28 13	Fuses – Low Voltage	Mersen	GEC Littlefuse	
26 05 75	Classroom Control Panels	Swift Path	Control Hub Olympic Tool & Die	

CONTRACTOR'S NAME: _____ DATE: _____

26 51 13	LED Interior	Cooper	Lithonia Signify	
26 51 13	LED Exterior	Cooper	Lithonia Signify	
26 51 13	Exit Lighting	Aimlite	Lumacell Stanpro	
26 51 13	Emergency Battery Units	Aimlite	Lumacell Stanpro	
26 51 13	Emergency Fixtures	Aimlite	Lumacell Stanpro	
26 43 13	Surge Protection Devices	Innosys	n/a	
28 31 25	Fire Alarm System (Addressable)	AutoCall	Existing – No Equals	

.9 LABOUR RATES

- .1 The following labour rates shall apply for calculating the cost of credit or extras on Change Notices. The rates shall include any employee benefits. The labour rates do not include overhead and profit.

Apprentice Electrician \$_____/hr

Journeymen Electrician \$_____/hr

1.2 ELECTRICAL TENDER PRICE (EXCLUDING HST)

- .1 Having carefully examined all Drawings and Specifications and the Addenda to the Drawings and Specifications, and having carefully examined the sites and all conditions affecting the work, we, the undersigned thereby offer to provide all plant, labour, materials and incidentals required to complete the work of all trades for: All the work specified for herein for

the Total Stipulated Price of: \$_____

 (in writing)

in lawful money of Canada; included in which are all applicable excise taxes, custom duties, freight, exchange, and all other charges. HST is not included.

END OF SECTION

CONTRACTOR'S NAME: _____ DATE: _____

Part 1 General

1.1 GENERAL INSTRUCTIONS

- .1 Comply with the General Conditions, Supplementary Conditions, and all of Division 1.
- .2 Allowances are indicated in Division 1 for this project. Refer to Division 1 to obtain allowance values.

1.2 CASH ALLOWANCE (HST EXCLUDED)

- .1 Refer to current CCDC requirement and Division 1 for CASH ALLOWANCES.
- .2 HST (Harmonized Sales Tax) is not included in cash allowance(s).
- .3 Allowances are stated in Division 1 of this project specification. It is the responsibility of the Electrical Contractor to review all allowances. If no allowances are identified, the Electrical Contract Price shall include all costs associated for the full scope of work and materials related to Electrical Contract Documents prepared by the Consultant.
- .4 Allowances shall be expended as the Owner directs through the Consultant. The Consultant will direct the Contractor(s) to **purchase** and perform work for which payment is made from an allowance.
- .5 Unless otherwise noted, the stated allowances for equipment purchase include initial distributor mark-up for the material components. The installation of these allowance items, along with required power connections, device boxes, conduit, controls, cabling, cable terminations with testing, making operable, and warranty must be included in the electrical tender price. Therefore, the Contractor shall include any overhead and profit on the allowance value in their tendered price and not from within the allowance value.
- .6 Where the actual cost of the Work under any cash allowance is less than the amount of the allowance, the Owner shall be credited for the unexpended portion of the cash allowance, but not for the Contractor's overhead and profit on such amount.
- .7 Where the allowance is insufficient to cover the actual cost the difference in value will be addressed as a change order.
- .8 The value of the work performed under a cash allowance is eligible to be included in progress payments.

1.3 EXPENDITURE OF CASH ALLOWANCES

- .1 Owner, through Consultant, will provide Contractor with documentation required to permit pricing of a cash allowance item.
- .2 Owner, through Consultant, may request Contractor to identify potential Suppliers or Subcontractors, as applicable, and to obtain at least three competitive prices for each cash allowance item.
- .3 Owner, through Consultant, may request the Contractor to disclose originals of all bids, quotations, and other price related information received from potential Suppliers or Subcontractors.

- .4 Owner, through Consultant, will determine by whom and for what amount each cash allowance item will be performed. Obtain Owner's prior written approval in the form of a Change Order before entering into a subcontract, amending an existing subcontract, or performing own forces work included in a cash allowance. Upon issuance of the Change Order, the Contractor's responsibilities for a cash allowance item shall be the same as for other work of the Contract.
- .5 Refer to CCDC 2 – 2020, GC4.1.4. Where the actual cost of the Work under any cash allowance exceeds the amount of the allowance, and unexpended amounts from other cash allowance shall be reallocated, at the Consultant's direction, to cover the shortfall, and, in that case, there shall be no additional amount added to the Contract Price for overhead and profit.
- .6 Only where the actual cost of the Work under all cash allowances exceeds the total amount of all cash allowances shall the Contractor be compensated for the excess incurred and substantiated, plus an amount for overhead and profit on the excess only, as set out in the Contract Documents.
- .7 Where the actual cost of all the Work under the cash allowances are less than the amount of the allowances, the Owner shall be credited for the unexpended portion of the cash allowances, but not for the Contractor's overhead and profit on such amount.

1.4 CASH ALLOWANCE CONTRACT REQUIREMENTS

- .1 The Contractor accepts to provide all contract requirements for the products supplied in the allowances, this includes providing supervision to include the product into the contract, shop drawing submission, coordinating installation, accepting warranty, accepting instruction to the Owner, providing as-builts, including product literature in maintenance manuals, etc.
- .2 All this work must be included in the Contractor's tender price.

Part 2 PRODUCTS

2.1 Not Used.

Part 3 EXECUTION

3.1 Not Used.

END OF SECTION

Part 1 General

1.1 GENERAL

- .1 This Section covers items common to Electrical Division 26, as well as Division 27 and Division 28.**
- .2 This section supplements requirements of Division 1.
- .3 Furnish labour, materials, and equipment necessary for completion of work as described in contract documents.

1.2 INTENT

- .1 Mention herein or indication on Drawings of articles, materials, operations, or methods requires: supply of each item mentioned or indicated, of quality, or subject to qualifications noted; installation according to conditions stated: and, performance of each operation prescribed with furnishing of necessary labour, equipment, and incidentals for electrical work.
- .2 Where used, words "Section" and "Division" shall also include other Subcontractors engaged on site to perform work to make building and site complete in all respects.
- .3 Where used, word "supply" shall mean furnishing to site in location required or directed complete with accessory parts.
- .4 Where used, word "install" shall mean secured in place and connected up for operation as noted or directed.
- .5 Where used, word "provide" shall mean supply and install as each is described above.

1.3 TENDERS

- .1 Complete Supplemental Tender Form including list of equipment and materials to be used on this project and forming part of tender documents.
- .2 Submit Supplemental Tender Form as noted.
- .3 Submit tender based on specified described equipment or Alternates listed.
- .4 State in Tender, names of all Subcontractors proposed for work under this Division.

1.4 LIABILITY INSURANCE

- .1 This contractor must maintain and produce at the request of the consultant proof of proper insurance to fully protect the owner, the consultant and the contractor from any and all claims due to accidents, misfortunes, acts of God, etc.

1.5 ELECTRICAL SAFETY AUTHORITY

- .1 The contractor is to determine general inspection fees with Electrical Safety Authority and include as part of tender.

- .2 A submission has been made (if required by this scope of project) by the consultant to the Electrical Safety Authority for review of this project. The payment of the required review costs will be coordinated by the consultant. A copy of the Electrical Safety Authority review report will be forwarded to the successful contractor for information and action. Contractor will not be responsible for these review costs.

1.6 DRAWINGS

- .1 Electrical Drawings do not show structural and related details. Take information involving accurate measurement of building from building drawings, or at building. Make, without additional charge, any necessary changes or additions to runs of conduits and ducts to accommodate structural conditions. Location of conduits and other equipment may be altered by the consultant without extra charge provided change is made before installation and does not necessitate major additional material.
- .2 As work progresses and before installing fixtures and other fittings and equipment which may interfere with interior treatment and use of building, provide detail drawings or obtain directions for exact location of such equipment and fitments.
- .3 Electrical drawings are diagrammatic. Where required work is not shown or only shown diagrammatically, install same at maximum height in space to conserve head room (minimum 2200 mm (88") clear) and interfere as little as possible with free use of space through which they can pass. Conceal wiring, conduits and ducts in furred spaces, ceilings and walls unless specifically shown otherwise. Install work close to structure so furring will be small as practical.
- .4 Before commencing work, check and verify all sizes, locations, grades, elevations, levels and dimensions to ensure proper and correct installation. Verify existing/municipal services.
- .5 Locate all electrical equipment in such a manner as to facilitate easy and safe access to and maintenance and replacement of any part.
- .6 In every place where there is indicated space reserved for future or other equipment, leave such space clear, and install services so that necessary installation and connections can be made for any such apparatus. Obtain instructions whenever necessary for this purpose.
- .7 Relocate equipment and/or material installed but not co-ordinated with work of other Sections as directed, without extra charge.
- .8 Where drawings are done in metric and product not available in metric, the corresponding imperial trade size shall be utilized.

1.7 INTERFERENCE AND CO-ORDINATION DRAWINGS

- .1 Prepare interference and equipment placing drawings to ensure that all components will be properly accommodated within the constructed spaces provided.
- .2 Prepare drawings to indicate co-ordination and methods of installation of a system with other systems where their relationship is critical. Ensure that all details of equipment apparatus, and connections are co-ordinated.
- .3 Ensure that clearances required by jurisdictional authorities and clearances for proper maintenance are indicated on drawings.

- .4 Upon consultant's request submit copies of interference drawings to the consultant.
- .5 Due to the nature of the building and the complexity of the building systems provide the following:
 - .1 Interference drawings, showing coordination of architectural, structural, mechanical, and electrical systems for the consultant's review prior to fabrication.
 - .2 Detailed equipment room drawings clearly showing all distribution equipment.
 - .3 Detailed layout drawings clearly showing conduit/feeder runs 78mm diameter or larger, including hangers or tray.
- .6 Provide CAD drawings (minimum file version AutoCAD 2013) in addition to hard copies.

1.8 QUALITY ASSURANCE

- .1 The installations of the division must conform to the latest edition of the Electrical Safety Code as well as its supplemental bulletins and instructions. Provide materials and labour necessary to comply with rules, regulations, and ordinances.
- .2 Complete underground systems in accordance with CSA C22.3 No. 7-94 except where specified otherwise.
- .3 Abbreviations for electrical terms: to CSA Z85-1983.
- .4 In case of differences between building codes, provincial laws, local ordinances, utility company regulations, and Contract Documents, the most stringent shall govern. Promptly notify consultant in writing of such differences.

1.9 ALTERNATES AND SUBSTITUTIONS

- .1 Throughout these sections are lists of "Alternate Equipment" manufacturers acceptable to consultant if their product meets characteristics of specified described equipment.
- .2 Each bidder may elect to use "Alternate Equipment" from lists of Alternates where listed. Include for any additional costs to suit Alternated used. Prices are not required in Tender for Alternates listed except where specifically noted as "Separate Price". Complete the Supplementary Tender Form.
- .3 When two or more suppliers/manufacturers are named in the Bid Documents, only one supplier/manufacture of the products named will be acceptable; however, it is the responsibility of this Division to ensure "Alternate Equipment" fits space allocated and gives performance specified. If an "Alternate Equipment" unit is proposed and does not fit space allotted nor equal specified product in consultant's opinion, supply of specified described equipment will be required without change in Contract amount. Only manufacturers listed will be accepted for their product listing. All other manufacturers shall be quoted as substitution stating conditions and credit amount.
- .4 If item of material specified is unobtainable, state in Tender proposed substitute and amount added or deducted for its use. Extra monies will not be paid for substitutions after Contract has been awarded.

1.10 EXAMINATION

- .1 Site Reviews
 - .1 Examine premises to understand conditions, which may affect performance of work of this Division before submitting proposals for this work.
 - .2 No subsequent allowance for time or money will be considered for any consequence related to failure to examine site conditions.
- .2 Drawings
 - .1 Electrical Drawings show general arrangement of fixtures, power devices, equipment, etc. Follow as closely as actual building construction and work of other trades will permit.
 - .2 Consider Architectural, Mechanical, and Structural Drawings part of this work insofar as these drawings furnish information relating to design and construction of building. These drawings take precedence over Electrical Drawings.
 - .3 Because of small scale of Drawings, it is not possible to indicate all offsets, fittings, and accessories, which may be required. Investigate structural and finish conditions affecting this work and arrange work accordingly, providing such fittings and accessories required to meet conditions.
- .3 Ensure that items to be furnished fit space available. Make necessary field measurements to ascertain space requirements including those for connections and furnish and install equipment of size and shape so final installation shall suit true intent and meaning of Contract Documents. If approval is received by Addendum or Change Order to use other than originally specified items, be responsible for specified capacities and for ensuring that items to be furnished will fit space available.

1.11 SEQUENCING AND SCHEDULING

- .1 It is understood that while Drawings are to be followed as closely as circumstances permit, this Division will be held responsible for installation of systems according to the true intent and meaning of Contract Documents. Anything not clear or in conflict will be explained by making application to consultant. Should conditions arise where certain changes would be advisable, secure consultant's approval of these changes before proceeding with work.
- .2 Coordinate work of various trades in installing interrelated work. Before installation of electrical items, make proper provision to avoid interferences in a manner approved by consultant. Changes required in work specified in these sections caused by neglect to do so shall be made at no cost to owner.
- .3 Arrange fixtures, conduit, ducts, and equipment to permit ready access to junction boxes, starters, motors, control components, and to clear openings of doors and access panels.

- .4 Furnish and install inserts and supports required by these sections unless otherwise noted. Furnish sleeves, inserts, supports, and equipment that are an integral part of other Divisions of the Work to Sections involved in sufficient time to be built into construction as the Work proceeds. Locate these items and see that they are properly installed. Expense resulting from improper location or installation of items above shall be borne by the electrical trade.
- .5 Adjust locations of ducts, conduits, equipment, fixtures, etc., to accommodate work from interferences anticipated and encountered. Determine exact route and location of each conduit and duct prior to installation.
 - .1 Make offsets, transitions, and changes in direction of ducts, and electrical raceways as required to maintain proper head room and pitch of sloping lines whether or not indicated on Drawings.
 - .2 Supply and install pull boxes, etc., as required to affect these offsets, transitions, and changes in direction.

1.12 REQUEST FOR INFORMATION (RFI) PROCEDURES

- .1 RFIs shall be submitted to the consultant minimum two (2) weeks prior to answer being required. Failure to submit and RFI in a timely manner will forfeit delay claims and schedule extension requests by the contractor.
- .2 All RFIs will be submitted with the following information:
 - .1 RFI number
 - .2 Name of project
 - .3 Date of initiation
 - .4 Date response required by (minimum two (2) weeks)
 - .5 Subject
 - .6 Submitter's name
 - .7 Drawing/specification reference
 - .8 Photograph of the issue (if applicable)
 - .9 Description of the issue
 - .10 Contractor's proposed resolution

1.13 DRAW BREAKDOWN

- .1 This contractor **MUST** submit a breakdown of the tender price into classifications to the satisfaction of the consultant, with the aggregate of the breakdown totaling the total contract amount. **Each item must be broken out into material and labour costs.** Progress claims, when submitted are to be itemized against each item of the draw breakdown. This shall be done in table form showing contract amount, amount this draw, total to date, % complete and balance.
- .2 Breakdown shall be as follows:
 - .1 Permits and fees
 - .2 Mobilization (maximum 1%)
 - .3 Switchboard

- .4 Panelboards and miscellaneous distribution equipment
- .5 Ductbank primary
- .6 Ductbank secondary
- .7 Secondary cables
- .8 Feeder conduits
- .9 Branch conduits
- .10 Feeder cables
- .11 Branch wiring
- .12 Lighting fixtures (interior)
- .13 Emergency lighting
- .14 Exterior lighting
- .15 Lighting Controls Installation
- .16 Fire alarm system
- .17 Classroom control panels
- .18 Starters, contactors, and control devices
- .19 Electric heating
- .20 Wiring for mechanical equipment
- .21 Wiring for owner's equipment
- .22 Commissioning (minimum 3%)
- .23 Electrical contractor closeout requirements (minimum of 3% but not less than \$5,000.00)
- .3 The breakdown must be approved by the consultant prior to submission of the first draw.
- .4 Breakdowns not complying to the above will not be approved.
- .5 Breakdown must indicate total contract amount.
- .6 **Mobilization amount may only be drawn when all required shop drawings have been reviewed by the consultant.**

1.14 SHOP DRAWINGS AND PRODUCT DATA

- .1 General
 - .1 Furnish complete catalog data for manufactured items of equipment to be used in the work to consultant for review within 14 days after award of Contract.
 - .2 Upon receipt of reviewed shop drawing, product is to be ordered immediately.
 - .3 Provide a complete list of shop drawings to be submitted prior to first submission.

- .4 Before submitting to the consultant, review all shop drawings to verify that the products illustrated therein conform to the Contract Documents. By this review, the contractor agrees that it has determined and verified all field dimensions, field construction criteria, materials, catalogue numbers, and similar data and that it has checked and coordinated each shop drawing with the requirements of the work and of the Contract Documents. The contractor's review of each shop drawings shall be indicated by stamp, date and signature of a qualified and responsible person possessing by the appropriate authorization.
- .5 If material or equipment is not as specified or submittal is not complete, it will be rejected by consultant.
- .6 Additional shop drawings required by the contractor for maintenance manuals, site copies etc., shall be photocopies of the "reviewed" shop drawings. All costs to provide additional copies of shop drawings shall be borne by the contractor.
- .7 **Submit all shop drawings for the project as a package. Partial submittals will not be accepted.**
- .8 Catalog data or shop drawings for equipment, which are noted as being reviewed by consultant or his engineer shall not supersede Contract Documents.
- .9 Review comments of consultant shall not relieve this Division from responsibility for deviations from Contract Documents unless consultant's attention has been called to such deviations in writing at time of submission, nor shall they relieve this Division from responsibility for errors in items submitted.
- .10 Check work described by catalog data with Contract Documents for deviations and errors.
- .11 Shop drawings and product data shall show:
 - .1 Mounting arrangements.
 - .2 Operating and maintenance clearances. e.g. access door swing spaces.
- .12 Shop drawings and product data shall be accompanied by:
 - .1 Detailed drawings of bases, supports, and anchor bolts.
 - .2 Manufacturer test data where requested.
 - .3 Manufacturer to certify as to current model production.
 - .4 Certification of compliance to applicable codes.
- .13 State sizes, capacities, brand names, motor HP, accessories, materials, gauges, dimensions, and other pertinent information. List on catalog covers page numbers of submitted items. Underline applicable data.
- .14 **If a shop drawing is returned "reviewed as noted" this contractor must provide written indication that the comments have been complied with.**
- .15 A partial list of shop drawings includes:
 - .1 High voltage equipment
 - .2 Switchboards, panelboards and transformers
 - .3 Fire alarm system
 - .4 Luminaires and drivers
 - .5 Emergency battery units, exit signs, and fixtures

- .6 Electrical heaters
 - .7 Classroom control panels
 - .8 Heat loss replacement cabling equipment
 - .9 Starters, contactors, and control devices
 - .10 Firestopping materials
 - .11 Hand dryers
 - .12 Wiring devices
 - .13 Cable management hangers
 - .14 Cable management system
 - .15 Lighting controls
 - .16 Digital time switch
 - .17 Disconnect switches and fuses
 - .18 Surge protection devices
 - .19 Grounding system components
 - .20 Destratification fans and associated controls
 - .21 Roof cone
 - .22 Miscellaneous enclosures
 - .23 Co-ordination study and arc flash hazard analysis
 - .24 Seismic restraint study
- .2 Submissions shall be submitted electronically as per the following directions:
- .1 Electronic Submissions:
 - .1 Electronically submitted shop drawings shall be prepared as follows:
 - .1 Use latest software to generate PDF files of submission sheets.
 - .2 Scanned legible PDF sheets are acceptable. Image files are not acceptable.
 - .3 PDF format shall be of sufficient resolution to clearly show the finest detail.
 - .4 PDF page size shall be standardized for printing to letter size (8.5"x11"), portrait with no additional formatting required by the consultant. Submissions requiring larger detail sheets shall not exceed 11"x17".
 - .5 Submissions shall contain multiple files according to section names as they appear in Specification.
 - .6 File names shall include consultant project number and description of shop drawing section submitted.
 - .7 Each submission shall contain an index sheet listing the products submitted, indexed in the same order as they appear in the Specification. Include associated PDF file name for each section.
 - .8 On the shop drawing use an "electronic mark" to indicate what is being provided.

.9 Each file shall bear an electronic representation of the “company stamp” of the contractor. If not stamped the file submission will not be reviewed.

- .2 Email submissions shall include subject line to clearly identify the consultants’ project number and the description of the shop drawings submitted.
- .3 Electronic attachments via email shall not exceed 10MB. For submissions larger than 10MB, multiple email messages shall be used. Denote related email messages by indicating “1 of 2” and “2 of 2” in email subject line for the case of two messages.
- .4 Electronic attachments via web links (URL) shall directly reference PDF files. Provide necessary access credentials within link or as username/password clearly identified within body of email message.
- .5 On site, provide one (1) copy of the “reviewed” shop drawings in a binder as noted above.
- .6 Contractor to print copies of “reviewed” shop drawings and compile into maintenance manuals in accordance with requirements detailed in this section.

1.15 CARE, OPERATION AND START-UP

- .1 Instruct consultant and operating personnel in the operation, care and maintenance of equipment.
- .2 Arrange and pay for services of manufacturer's factory service engineer to supervise start-up of installation, check, adjust, balance and calibrate components.
- .3 Provide these services for such period, and for as many visits as necessary to put equipment in operation and ensure that operating personnel are conversant with all aspects of its care and operation.

1.16 VOLTAGE RATINGS

- .1 Operating voltages: to CAN3-C235-83.
- .2 Motors, electric heating, control and distribution devices and equipment to operate satisfactorily at 60 Hz within normal operating limits established by above standard. Equipment to operate in extreme operating conditions established in above standard without damage to equipment.

1.17 PERMITS, FEES, AND INSPECTION

- .1 A submission has been made (if required by this scope of project) by the consultant to the Electrical Safety Authority for review of this project. The payment of the required review costs will be co-ordinated by the consultant. A copy of the Electrical Safety Authority review report will be forwarded to the successful contractor for information and action.
- .2 The contractor is required to include in his tender all required inspection costs by the Electrical Safety Authority. Permit application is the responsibility of the contractor.
- .3 Reproduce drawings and specifications required by Electrical Safety Authority at no cost.

- .4 Notify consultant of changes required by Electrical Safety Authority prior to making changes.
- .5 Furnish Certificates of Acceptance to consultant from Electrical Safety Authority and other authorities having jurisdiction upon completion of work.
- .6 This contractor must furnish any certificates required to indicate that the work completed conforms with laws and regulations of authorities having jurisdiction.

1.18 ADDITIONAL INSTALLED EQUIPMENT

- .1 The electrical contractor is to review all specification sections forming part of the electrical bid documents and include additional equipment or components, as well as all associated installation costs and testing costs as noted, in the electrical bid price.

1.19 MATERIALS AND EQUIPMENT

- .1 Equipment and material to be CSA certified. Where there is no alternative to supplying equipment which is not CSA certified, obtain special approval from Electrical Safety Authority.
- .2 Factory assemble control panels and component assemblies.

1.20 ELECTRIC MOTORS, EQUIPMENT, AND CONTROLS

- .1 Supplier and installer responsibility is indicated in the Equipment Wiring Schedule on electrical drawings.
- .2 Control wiring and conduit is specified in the Electrical specifications except for conduit, wiring and connections below 50 V, which are related to control systems specified in the Mechanical specifications.

1.21 FINISHES

- .1 Shop finish metal enclosure surfaces by application of rust resistant primer inside and outside, and at least two coats of finish enamel.
 - .1 Paint outdoor electrical equipment "equipment green" finish.
 - .2 Paint indoor switchgear and distribution enclosures light grey.
- .2 Clean and touch up surfaces of shop-painted equipment scratched or marred during shipment or installation, to match original paint.
- .3 Clean and prime exposed non-galvanized hangers, racks, fastenings, and conduits etc. to prevent rusting.

1.22 EQUIPMENT IDENTIFICATION

- .1 Identify electrical equipment with nameplates as follows:
- .2 Nameplates:
 - .1 Lamicoid 3 mm (1/8") thick plastic engraving sheet, black face, white core, mechanically attached with self tapping screws.

NAMEPLATE SIZES

Size 1	9 mm x 50 mm (3/8" x 2")	1 line	3 mm (1/8") high letters
Size 2	12 mm x 70 mm (1/2" x 2 1/2")	1 line	5 mm (3/16") high letters
Size 3	12 mm x 70 mm (1/2" x 2 1/2")	2 lines	3 mm (1/8") high letters
Size 4	20 mm x 90 mm (3/4" x 3 1/2")	1 line	9 mm (3/8") high letters
Size 5	20 mm x 90 mm (3/4" x 3 1/2")	2 lines	5 mm (3/16") high letters
Size 6	25 mm x 100 mm (1" x 4")	1 line	12 mm (1/2") high letters
Size 7	25 mm x 100 mm (1" x 4")	2 lines	6 mm (1/4") high letters

- .3 Wording on nameplates labels to be approved by consultant prior to manufacture.
- .4 Allow for average of twenty-five (25) letters per nameplate.
- .5 Identification to be English.
- .6 Nameplates for terminal cabinets and junction boxes to indicate system and/or voltage characteristics.
- .7 Nameplates for disconnects, starters and contactors must indicate equipment being controlled and voltage.
- .8 Nameplates for transformers must indicate transformer label as indicated and capacity, primary, and secondary voltages.

1.23 WIRING IDENTIFICATION

- .1 Identify wiring with permanent indelible identifying markings, either numbered or coloured plastic tapes, on both ends of phase conductors of feeders and branch circuit wiring.
- .2 Maintain phase sequence and colour coding throughout.
- .3 Colour code: to CSA C22.1.
- .4 Use colour coded wires in communication cables, matched throughout system.

1.24 CONDUIT AND CABLE IDENTIFICATION

- .1 Colour code conduits, boxes and metallic sheathed cables.
- .2 Code with plastic tape or paint at points where conduit or cable enters wall, ceiling, or floor, and at 15 m (45') intervals.

- .3 Colour bands must be 25 mm (1") wide.

	<u>Prime</u>
Up to 208 V	yellow
209 to 600 V	white
Voice system	green
Data system	orange
Security	brown
Public address	black
Cable TV	blue
Fire alarm	red

- .4 This contractor must paint all system junction boxes and covers in conformance with the above schedule.

1.25 PROTECTION OF OPENINGS

- .1 Protect equipment and systems openings from dirt, dust, and other foreign materials with materials appropriate to system.

1.26 WIRING TERMINATIONS

- .1 Lugs, terminals, screws used for termination of wiring to be suitable for either copper or aluminum conductors.

1.27 MANUFACTURERS AND CSA LABELS

- .1 All labels must be visible and legible after equipment is installed.

1.28 WARNING SIGNS

- .1 To meet requirements of Electrical Safety Authority and consultant.
.2 Provide porcelain enamel signs, with a minimum size of 175 mm x 250 mm (7" x 10").

1.29 LOCATION OF OUTLETS

- .1 Do not install outlets back-to-back in wall; allow minimum 150 mm (6") horizontal clearance between boxes.
.2 Change location of outlets at no extra cost or credit, providing distance does not exceed 3 m (10'), and information is given before installation.
.3 Locate light switches on latch side of doors. Locate disconnect devices in mechanical and elevator machine rooms on latch side of door.

1.30 MOUNTING HEIGHTS

- .1 Mounting height of equipment is from finished floor to centreline of equipment unless specified or indicated otherwise. Coordinate with block coursing (if applicable).
.2 If mounting height of equipment is not specified or indicated, verify before proceeding with installation.

.3 Install electrical equipment at following heights unless indicated otherwise.

- .1 Local switches: 1100 mm (43.3").
- .2 Wall receptacles:
 - .1 General: 400 mm (16").
 - .2 Above top of continuous baseboard heater: 200 mm (8").
 - .3 Above top of counters or counter splash backs: 100 mm (4").
 - .4 In mechanical rooms: 1200 mm (48").
- .3 Panelboards: as required by Code or 1400 mm (56").
- .4 Voice/Data outlets: At height of adjacent outlet or at 400 mm (16").
- .5 Fire alarm stations: 1200 mm (3'-11").
- .6 Fire alarm visual and signal devices: 2250 mm (88 ½").
- .7 Television outlets: 400 mm (16").
- .8 Thermostat: 1200 mm (3'-11").
- .9 Clocks: 2100 mm (84").
- .10 Heaters: 200 mm (8" AFF) to bottom of heater.
- .11 Emergency call switches and/or pushbuttons: 900 mm (36").

1.31 LOAD BALANCE

- .1 Measure phase current to panelboards with normal loads (lighting) operating at time of acceptance. Adjust branch circuit connections as required to obtain best balance of current between phases and record changes.
- .2 Measure phase voltages at loads and adjust transformer taps to within 2% of rated voltage of equipment.
- .3 Submit, at completion of work, report listing phase and neutral currents on panelboards, dry-core transformers and motor control centres, operating under normal load. State hour and date on which each load was measured, and voltage at time of test.

1.32 CONDUIT AND CABLE INSTALLATION

- .1 Install conduit and sleeves prior to pouring of concrete. Sleeves through concrete shall be schedule 40 steel pipe, sized for free passage of conduit, and protruding 50 mm (2") beyond either side.
- .2 Install cables, conduits and fittings to be embedded or plastered over, neatly and close to building structure so furring can be kept to minimum.

1.33 FIELD QUALITY CONTROL

- .1 Conduct and pay for following tests:
 - .1 Power distribution system including phasing, voltage, grounding, and load balancing.
 - .2 Circuits originating from branch distribution panels.
 - .3 Lighting and its control.

- .4 Motors, heaters and associated control equipment including sequenced operation of systems where applicable.
- .5 Systems: fire alarm system, communications, security.
- .2 Furnish manufacturer's certificate or letter confirming that entire installation as it pertains to each system has been installed to manufacturer's instructions.
- .3 Insulation resistance testing.
 - .1 Megger circuits, feeders and equipment up to 350 V with a 500 V instrument.
 - .2 Megger 350-600 V circuits, feeders and equipment with a 1000 V instrument.
 - .3 Check resistance to ground before energizing.
- .4 Carry out tests in presence of consultant.
- .5 Provide instruments, meters, equipment and personnel required to conduct tests during and at conclusion of project.
- .6 Submit test results for consultant's review.

1.34 EQUIPMENT NAMEPLATE DATA

- .1 Refer to the Equipment Wiring Schedule, Distribution Diagram(s) and Panel Schedules for information regarding the designed electrical connections for all equipment to be connected to the electrical distribution system.
- .2 Refer to the shop drawing submissions of all project divisions and coordinate with all trades and equipment manufacturers throughout the construction period for equipment connection requirements.
- .3 This electrical trade shall be responsible to coordinate any discrepancies on equipment minimum circuit ampacity, maximum overcurrent protection, voltage and phase, between the equipment manufacturer published literature, the equipment shop drawing submission, the project design drawings equipment wiring schedule, and the nameplate data on the equipment. The contractors installing and connecting all equipment shall be responsible for the coordination of this data through the construction period.
- .4 Equipment shall not be connected where the specified maximum overcurrent protection and minimum circuit ampacity values do not meet the requirements of the equipment nameplate data on site.
- .5 Electrical distribution equipment shop drawings shall not be submitted prior to approval of equipment to be connected including, but not limited to, mechanical units, pumps, elevators, etc. Electrical distribution equipment shall not be released into production until all connected equipment requirements are confirmed and included in approved shop drawings.
- .6 Where nameplate data of equipment on site varies from that data listed in the approved equipment shop drawings, the consultant shall be notified in writing, and the equipment shall not be connected until the equipment connection details are confirmed. The final installation must meet the nameplate data of the equipment on site.

- .7 No subsequent allowance for time or money for changes to breakers, wiring and conduit, or equipment sizes will be considered for any consequence related to failure by the electrical trade to coordinate final equipment connection requirements with nameplate data and electrical distribution equipment shop drawings.

1.35 CO-ORDINATION OF PROTECTIVE DEVICES

- .1 Ensure circuit protective devices such as overcurrent trips, relays and fuses are installed to required values and settings as indicated on drawings or as determined from co-ordination study.
- .2 Electrical connections to all equipment requiring connection to the electrical distribution system as part of this electrical tender have been specified according to the anticipated equipment manufacturer electrical requirements and the applicable sections of the OESC. This contractor must coordinate electrical connections to all equipment specified to be connected as part of this electrical tender.
- .3 Prior to submitting electrical distribution shop drawings to the consultant, review all shop drawings for all equipment specified for connection to the electrical distribution system to verify that the product electrical connection requirements listed by the manufacturer conform to the equipment electrical connections specified on the electrical design drawings and specifications. Make necessary revisions to breaker ratings associated with the review of all product shop drawings and identify such changes as part of the electrical distribution equipment shop drawing submission.
- .4 Prior to making final equipment connections, this electrical contractor shall examine equipment nameplates at the project site to confirm voltage and phase requirements, minimum circuit ampacity and maximum overcurrent protection values, and bring to the attention of the consultant in writing any connection requirements which may vary from the designed connections or approved electrical distribution shop drawings. No subsequent allowance for time or money for changes to breaker or wire and conduit sizes will be considered for any consequence related to failure to examine site conditions.

1.36 GUARANTEE AND WARRANTY

- .1 At ready for takeover of this project this Contractor must provide a written guarantee indicating that any defects, not due to ordinary wear and tear or improper use which occur within the first year from the date of ready for takeover will be corrected at the contractor's expense.
- .2 **If the electrical sub-contractor's office is 50 kilometers (30 miles) or more from the project site, the sub-contractor is to provide a service/warranty work agreement for warranty period with a local electrical sub-contractor approved by consultant. Include copy of service/warranty agreement in warranty section of operation and maintenance manual.**
- .3 Warranty period shall start from date of ready for takeover completion.
- .4 Refer to individual specification sections for information on any special manufacturer's equipment warranties.

1.37 SYSTEM START UP

- .1 Provide consultant with written notice verifying all equipment operation and installation is complete prior to scheduled start-up period.
- .2 Start up shall be in presence of the following: owner or representative, contractor, and manufacturer's representative. Each person shall witness and sign off each piece of equipment. Consultant's attendance will be determined by consultant.
- .3 Arrange with all parties and provide 72 hours notice for start up procedure.
- .4 Simulate system start up and shut down and verify operation of each piece of equipment.
- .5 These tests are to demonstrate that the systems and equipment installed are operational as specified.
- .6 The contractor must describe during the start up session the required maintenance for each piece of equipment according to the manufacturer.
- .7 The contractor must provide all necessary tools (including a digital multimeter) to successfully complete the start up procedure.

1.38 OPERATION AND MAINTENANCE MANUAL

- .1 Provide operation and maintenance data for incorporation into manual as specified in other Sections of this Division.
- .2 Operation and maintenance manual to be approved by, and final copies deposited with, consultant before final inspection.
 - .1 Submit one (1) copy of Operation and Maintenance Manual to consultant for review and approval. Submission of individual data will not be accepted unless so directed by consultant. Submission can be done electronically in PDF format or as a hard copy.
 - .1 Electronic submission/PDF file is required to be bookmarked. Any submission received without bookmarking will be immediately returned as unacceptable.
 - .2 Hard copy submission shall be in a three-ring binder (minimum 50 mm (2") ring) and labelled as 'Operation and Maintenance Manual' with project name and location. Dividers are to be used for binder organization.
 - .2 Make changes as required and re-submit as directed by consultant.
- .3 Each manual must include (in "tabbed" sections) the following:
 - .1 Index
 - .2 List of General, Mechanical, Electrical Contractors and all associated sub-contractor names, addresses and contact numbers.
 - .3 List of suppliers and equipment wholesalers local to the project.
 - .4 Letter of contractor's warranty and guarantee for all parts, equipment and workmanship.
 - .5 List of manufacturers, spare parts list and source.

- .6 Copy of typewritten schedules for all new and renovated panels.
- .7 Copy of all substantial performance final certificates.
- .8 Copy of electrical shop drawings which have been stamped and reviewed by consultant.
- .9 Electrical As-built drawings including contractor company's as built stamp.
- .10 Coordination study/Arc flash hazard study shop drawings
- .11 Any special warranties on equipment required (i.e. LED lighting, digital lighting control, SPDs, power generation).
- .12 Certificate of completion from all associated sub-contractors.
- .13 Cable test results and floor plans containing address labels.
- .14 System commissioning certificate and report.
- .4 Final Submittals:
 - .1 Upon acceptance of Operation and Maintenance Manual by the consultant, provide the following:
 - .1 Provide one (1) copy of final Operation and Maintenance Manuals, as well as a PDF file of the entire approved manual on a USB stick. Only one (1) USB stick is to be provided containing both the approved manual and as-built drawings.

1.39 AS-BUILT DRAWINGS

- .1 Site records:
 - .1 Contractor shall provide two (2) sets of reproducible electrical drawings. Provide sets of white prints as required for each phase of the work. Mark thereon all changes as work progresses and as changes occur. This shall include field and contract changes to electrical systems.
 - .2 On a weekly basis, transfer information to reproducibles, revising reproducibles to show all work as actually installed.
 - .3 Use different colour waterproof ink for each service.
 - .4 Make available for reference purposes and inspection at all times.
- .2 As-built drawings submittal for review:
 - .1 Identify **each drawing** in lower right-hand corner in letters at least 3 mm (1/8") high as follows: - "AS-BUILT DRAWINGS: THIS DRAWING HAS BEEN REVISED TO SHOW ELECTRICAL SYSTEMS AS INSTALLED" (Company Name) (Signature of Contractor) (date).
 - .2 Submit copy to consultant for approval. When returned, make corrections (if any) as directed.
- .3 As-built drawings final submittal:
 - .1 Once approved, submit completed, reproducible paper as-built drawings as well as a scanned PDF file copy on USB stick with Operation and Maintenance Manuals.

1.40 DEMONSTRATION AND OPERATING AND MAINTENANCE INSTRUCTIONS

- .1 Supply tools, equipment and personnel to demonstrate and instruct operating and maintenance personnel in operating, controlling, adjusting, trouble-shooting and servicing of all systems and equipment during regular work hours, prior to acceptance.
- .2 Manufacturers or their representatives are to provide demonstrations and instructions.
- .3 Use operation and maintenance manual, As-built drawings, audio visual aids, etc. as part of instruction materials.
- .4 Instruction duration time requirements as specified in appropriate sections.
- .5 Where deemed necessary, consultants may record these demonstrations on video tape for future reference.

1.41 READY FOR TAKEOVER

- .1 Complete the following to the satisfaction of the consultant prior to request for ready for takeover.
 - .1 As-built Drawings
 - .2 Maintenance Manuals
 - .3 System Start up
 - .4 Instructions to Owners
 - .5 Coordination Study / Arc Flash Hazard (including photos of each breaker)
 - .6 Lighting Control System
 - .7 Auxiliary Systems (A/V systems, SPDs, etc.)
 - .8 **Outlet cover circuit labels**

1.42 TRIAL USAGE

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

1.43 REVISION TO CONTRACT

- .1 Provide the following for each item in a given change notice:
 - .1 Itemized list of material with associated costs.
 - .2 Labour rate and itemized list of labour for each item.
 - .3 Copy of manufacturers/suppliers invoice if requested.

1.44 EQUIPMENT SUPPORTS

- .1 Equipment supports supplied by equipment manufacturer: shall be installed by the electrical contractor.
- .2 Equipment supports not supplied by equipment manufacturer: fabricate from structural grade steel meeting requirements of - Structural Steel Section. Submit structural calculations with shop drawings if necessary.

- .3 Mount base mounted equipment on chamfered edge housekeeping pads, minimum of 100 mm (4") high and 150 mm (6") larger than equipment dimensions all around. This installation of this pad shall be the responsibility of the electrical contractor.
- .4 This contractor shall be responsible for providing all anchor bolts and associated formed concrete bases for lighting standards as detailed.

1.45 SLEEVES

- .1 Pipe sleeves: at points where pipes pass through masonry, concrete, or fire rated assemblies and as indicated.
- .2 Schedule 40 steel pipe.
- .3 Sleeves with annular fin continuously welded at midpoint:
 - .1 Through foundation walls.
 - .2 Where sleeve extends above finished floor.
- .4 Sizes: minimum 6 mm (1/4") clearance all around, between sleeve and conduit.
- .5 Terminate sleeves flush with surface of concrete and masonry walls, concrete floors on grade and 25 mm (1") above other floors.
- .6 Through foundation walls PVC sleeves are acceptable.
- .7 Fill voids around pipes:
 - .1 Caulk between sleeve and pipe in foundation walls and below grade floors with waterproof fire retardant non-hardening mastic.
 - .2 Where sleeves pass through walls or floors, provide space for firestopping. Where pipes/ducts pass through fire rated walls, floors and partitions, maintain fire rating integrity.
 - .3 Fill future-use sleeves with easily removable filler.

1.46 FIRESTOPPING

- .1 Firestopping material and installation within annular space between conduits, ducts, and adjacent fire separation.
- .2 Provide materials and systems capable of maintaining effective barrier against flame, smoke, and gases.
- .3 Comply with the requirements of CAN4-S115-M35, and do not exceed opening sized for which they have been tested.
- .4 Systems to have an F or FT rating (as applicable) not less than the fire protection rating required for closures in a fire separation.

- .5 Provide "firewrap" blanket around services penetrating firewalls. Extent of blanket must correspond to ULC recommendations. In general wrap individual conduits with approved firewrap materials on each side of firewall. Refer to architectural drawings for FT ratings. Provide 1 and/or 2 layers of firewrap with transverse and longitudinal seams overlapped and/or butted (second layer offset from first layer). Cut edges are to be sealed with aluminum foil tape. Provide 50 mm stainless steel banding at 200 mm intervals. Install firewrap to manufacturers' recommendations for proper FT rating. Acceptable manufacturers are 3M Firemaster ductwrap or approved equal.
- .6 The firestopping materials are not to shrink, slump or sag and be free of asbestos, halogens and volatile solvents.
- .7 Firestopping materials are to consist of a component sealant applied with a conventional caulking gun and trowel.
- .8 Firestop materials are to be capable of receiving finish materials in those areas, which are exposed and scheduled to receive finishes.
- .9 Firestopping shall be inspected and approved by local authority prior to concealment or enclosure.
- .10 Install material and components in accordance with ULC certification, manufacturers instructions and local authority.
- .11 **Submit product literature and installation material on firestopping in shop drawing and product data manual.**
- .12 Acceptable manufacturers:
 - .1 Rectorseal Corporation (Metacaulk)
 - .2 Proset Systems
 - .3 3M
 - .4 Hilti
 - .5 STI Firestop

Note: Fire stop material must conform to requirements of local authorities having jurisdiction. Contractor to confirm prior to application and ensure material used is compatible with that used by other trades on site.

1.47 PAINTING

- .1 Refer to Section Interior Painting and specified elsewhere.
- .2 Apply at least one coat of corrosion resistant primer paint to ferrous supports and site fabricated work.
- .3 Prime and touch up marred finished paintwork to match original.
- .4 Restore to new condition, or replace equipment at discretion of consultant, finishes which have been damaged too extensively to be merely primed and touched up.

1.48 ACCESS DOORS

- .1 Supply access doors to concealed electrical equipment for operating, inspecting, adjusting and servicing.

- .2 Flush mounted 600 mm x 600 mm (24" x 24") for body entry and 300 mm x 300 mm (12" x 12") for hand entry unless otherwise noted. Doors to open 180°, have rounded safety corners, concealed hinges, screwdriver latches, and anchor straps.
- .3 Material:
 - .1 Special areas such as tiled or marble surfaces: use stainless steel with brushed satin or polished finish as directed by consultant.
 - .2 Remaining areas: use prime coated steel.
 - .3 Fire rated areas: provide ULC listed access doors
- .4 Installation:
 - .1 Locate so that concealed items are accessible.
 - .2 Locate so that hand or body entry (as applicable) is achieved.
 - .3 Installation is specified in applicable sections.
- .5 Acceptable materials:
 - .1 Le Hage
 - .2 Zurn
 - .3 Acudor
 - .4 Nailor Industries Inc.

1.49 DELIVERY STORAGE, AND HANDLING

- .1 Follow Manufacturer's directions in delivery, storage, and protection, of equipment and materials. Contractor to include all costs associated with delivery storage and handling in tender price.
- .2 Deliver equipment and material to site and tightly cover and protect against dirt, water, and chemical or mechanical injury, but have readily accessible for inspection. Store items subject to moisture damage (such as controls) in dry, heated space.

1.50 REPAIR, CUTTING, CORING AND RESTORATION

- .1 Be responsible for required digging, cutting, and patching incident to work of this Division and make required repairs afterwards to satisfaction of consultant. Cut carefully to minimize necessity for repairs to existing work. Do not cut beams, columns, or trusses.
- .2 Patch and repair walls, floors, ceilings, and roofs with materials of same quality and appearance as adjacent surfaces unless otherwise shown. Surface finishes shall exactly match existing finishes of same materials.
- .3 Each Section of this Division shall bear expense of cutting, patching, repairing, and replacing of work of other Sections required because of its fault, error, tardiness, or because of damage done by it.
- .4 Cutting, patching, repairing, and replacing pavements, sidewalks, roads, and curbs to permit installation of work of this Division is responsibility of Section installing work.

- .5 Slots, cores and openings through floors, walls, ceilings, and roofs shall be provided by this contractor but performed by a trade specializing in this type of work. This Division shall see that they are properly located and do any cutting and patching caused by its neglect to do so.

1.51 CLEANING

- .1 Clean interior and exterior of all electrical equipment provided including light fixture lenses.
- .2 In preparation for final acceptance, clean and refurbish all equipment and leave in operating condition.

1.52 OWNER SUPPLIED EQUIPMENT

- .1 Connect to equipment supplied by the owner and make operable.
- .2 Design drawings are diagrammatic and do not necessarily indicate all specific final connection requirements. For the purposes of bidding, electrical trade shall include but not be limited to provision of a junction box to connect equipment wiring tail, provision of suitable disconnecting means, and flexible connection directly to equipment.

1.53 ENCLOSURES

- .1 This contractor must ensure that all electrical equipment mounted in sprinklered areas is provided with an enclosure in conformance with the Electrical Safety Code.

1.54 ELECTRICAL SYSTEMS COMMISSIONING

- .1 This electrical contractor shall work with the building commissioning agent to perform commissioning of all electrical systems.

Part 2 Not Used

Part 3 Not Used

END OF SECTION

Part 1 General

1.1 WORK INCLUDED

- .1 Section 21 02 51 – FIRE PROTECTION GENERAL REQUIREMENTS and DIVISION 1
- .2 Section 21 12 13 – FIRE SUPPRESSION STANDPIPE SYSTEM
- .3 Section 21 13 13 – WET PIPE FIRE SUPPRESSION
- .4 Section 21 22 11 – CLEAN AGENT FIRE SUPPRESSION SYSTEM and DIVISION 1
- .5 Section 23 02 52 – HVAC GENERAL REQUIREMENTS and DIVISION 1
- .6 Section 23 33 17 – SMOKE CONTROL DAMPERS
- .7 Section 26 01 16 – ELECTRICAL GENERAL REQUIREMENTS and DIVISION 1
- .8 Section 26 51 13 – LIGHTING EQUIPMENT
- .9 Section 26 51 16 – DIGITAL OCCUPANCY & DAYLIGHT CONTROL SYSTEMS
- .10 Section 28 31 25 – FIRE ALARM SYSTEM (ADDRESSABLE)
- .11 Applicable building systems in item 1.3.10 and as included in all project DIVISIONS.

1.2 REFERENCES

- .1 OBC-2024, Ontario Building Code Compendium.
- .2 CAN/ULC-1001, Integrated System Testing of Fire Protection and Life Safety Systems.
- .3 CAN/ULC-S524, Installation of Fire Alarm Systems.
- .4 CAN/ULC-S537, Verification of Fire Alarm Systems.
- .5 CAN/ULC-S573, Installation of Ancillary Devices Connected to Fire Alarm Systems
- .6 CAN/ULC-S561, Installation and Service for Fire Signal Receiving Centres and Systems
- .7 CAN/ULC-S112, Standard Method of Fire Test of Fire Damper Assemblies
- .8 NFPA 13, Fire Sprinkler Systems
- .9 NFPA 17A, Standard for Wet Chemical Extinguishing Systems
- .10 NFPA 92, Standard for Smoke Control Systems
- .11 NFPA 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

1.3 OVERVIEW

- .1 All work shall be performed in accordance with CAN/ULC-1001 Integrated System Testing of Life Safety and Fire Protection Systems, latest edition.
- .2 The Building Code has adopted CAN/ULC-1001 as the standard to comply with Integrated System Testing of Life Safety and Fire Protection Systems. The scope of this project shall follow the strict guidelines laid out in CAN/ULC-1001 for Integrated Testing Planning, review, and implementation.

- .3 The Integrated Testing Plan (ITP) will provide a full overview of all integration points of life safety and fire protection systems. The ITP will be submitted for review to the design professionals and Authority Having Jurisdiction (AHJ). Upon the successful completion of the ITP and all the respective systems, the Integrated Testing Coordinator (ITC) will provide a schedule to the design professionals, the AHJ, and all required participating members for the ITP to be conducted.
- .4 The ITC will review all drawings, specifications, sequence of operations, and methodology prepared by the design professionals, complete with the contractor's shop drawings and manufacture requirements.
- .5 The ITP shall be coordinated with all sub-contractors and suppliers as outlined in item 1.1.
- .6 The ITC will conduct the ITP and will sign each integrated test form, complete with signatures from each participating member of the integrated systems.
- .7 The ITC shall witness all integrations and not rely on the CAN/ULC-S537 Verification Inspection Report for fire protection system integration testing; however, the ITC may attend the verification to validate the testing.
- .8 The ITC will provide all work and ITP including functional documentation, prescribed in CAN/ULC-1001. Such testing and documentation have been deemed to satisfy OBC 2024 Sentence 3.2.9.
- .9 The ITC will provide PDF and digital media copy of the buildings ITP and Integrated System Report (ITR) for the building owner's use, re-testing, and reproduction purpose.
- .10 The systems applicable to the function testing include but not limited to:
 - .1 Fire Alarm System (including sequence of operations) and Monitoring
 - .2 Elevators
 - .3 Sprinkler Systems (wet, dry, window, garbage chute, standpipe)
 - .4 Kitchen Fire Suppression Systems
 - .5 Fixed Fire Suppression Systems
 - .6 Magnetic Door Holds
 - .7 Fire Curtain or Fire Shutter Release
 - .8 Smoke and CO Alarms
 - .9 Smoke Damper Assemblies
 - .10 HVAC Shutdown
 - .11 A/V System Mute/Shutdown
 - .12 HVLS Fan Shutdown

Part 2 Products

2.1 TESTING AND PLANNING

- .1 The Integrated Testing Process must include following:
 - .1 Planning phase by the testing coordinator.
 - .2 Integrated testing plan review by the design professionals.
 - .3 Integrated testing plan review by the AHJ.
 - .4 Review of sequence of operations.
 - .5 System documentation.
 - .6 Integrated System Testing Plan consisting of:
 - .1 Project description.
 - .2 Project contacts including applicable project responsibilities.
 - .3 Overview and description of each integrated system.
 - .4 System integrations and functional objective of each integrated system.
 - .5 Integration matrix of all integrated system complete with integration type, normal mode and off-normal mode.
 - .6 Test protocols and procedures of each integrated system,
 - .7 Notifications.
 - .8 Personnel safety.
 - .9 Phased occupancies.
 - .10 Pre-testing documentation checklist.
 - .11 Pre-testing documentation acknowledgement forms.
 - .12 Testing forms.
 - .13 Ongoing integrated system testing forms.
 - .14 Integrated system testing completion form.
 - .15 Integrated testing notes.

2.2 RESPONSIBILITIES

- .1 General Contractor:
 - .1 General Contractor to employ the services of the ITC firm as a sub-contractor and include in bid price. Refer to item 2.6.
 - .2 Coordinate with the ITC for schedule and witness testing.
 - .3 Coordinate all responsible sub-contractors.
 - .4 Confirm all respective systems listed in item 1.3.10 are complete and fully operational, prior to the ITC commencing the functional testing.
 - .5 Provide reports for respective systems such as, but not limited to; TSSA elevator inspection reports, start-up reports, commissioning reports, verification reports.
 - .6 Participate in the ITP and provide function testing of equipment within the mechanical, electrical, and fire protection contract packages.
 - .7 Allow for any cost associated to re-testing of the ITP due to failures or insufficient work.

- .8 Allow for any cost associated with phased occupancy and phased Integrated Testing work.
- .2 HVAC Contractor:
 - .1 The HVAC Contractor shall confirm all mechanical systems listed in item 1.3.10 are complete and fully operational, prior to the ITC commencing the functional testing.
 - .2 Provide system reports such as, but not limited to; air balancing reports, TSSA inspection reports, start-up reports, commissioning reports, verification reports. The Mechanical Contractor shall further provide written confirmation that all mechanical systems are installed and operating as intended by the contract documents and sequence of operations.
 - .3 Participate in the ITP and provide function testing of equipment within the mechanical contract package.
 - .4 Allow for any cost associated to re-testing of the ITP due to failures or insufficient work.
 - .5 Allow for any cost associated with phased occupancy and phased Integrated Testing work.
- .3 Fire Protection Contractor:
 - .1 The Fire Protection Contractor shall confirm all fire protection systems listed in item 1.3.10 are complete and fully operational, prior to the ITC commencing the functional testing.
 - .2 Provide system reports such as, but not limited to; NFPA 13 letter, NFPA 20, letter, above ground sprinkler piping letter, below ground sprinkler letter, system designer letter, start-up reports, commissioning reports, verification reports. The Fire Protection Contractor shall further provide written confirmation that all fire protection systems are installed and operating as intended by the contract documents and sequence of operations.
 - .3 Participate in the ITP and provide function testing of equipment within the fire protection contract package.
 - .4 Allow for any cost associated to re-testing of the ITP due to failures or insufficient work.
 - .5 Allow for any cost associated with phased occupancy and phased Integrated Testing work.
- .4 Electrical Contractor:
 - .1 The electrical contractor shall confirm all electrical systems listed in item 1.3.10 are complete and fully operational, prior to the ITC commencing the functional testing.
 - .2 Provide system reports such as, but not limited to; ESA Inspection Certificate, Fire Alarm Verification, TSSA Inspection, Generator Start-up report, commissioning reports, and verification reports. The Electrical Contractor shall further provide written confirmation that all electrical systems are installed and operating as intended by the contract documents and sequence of operations.

- .3 Participate in the ITP and provide function testing of equipment within the electrical contract package.
- .4 Allow for any cost associated to re-testing of the ITP due to failures or insufficient work.
- .5 Allow for any cost associated with phased occupancy and phased Integrated Testing work.
- .5 Equipment Manufacturers:
 - .1 Where required, shall confirm all respective systems listed in item 1.3.10 are complete and fully operational, prior to the ITC commencing the functional testing.
 - .2 Participate in the ITP and provide function testing of equipment within the respective contract package.
- .6 Design Professionals:
 - .1 The design professional shall include, but not be limited to, the project Architect, Electrical and Mechanical Consultants, Fire Protection Engineer, Elevator Consultant, etc.
 - .2 Shall review the ITP, and upon review, accept the ITP as the agreed ITP for implementation.
 - .3 The design professionals are responsible for design. Upon an unsuccessful test, the failure will be documented and provided to the respective design professionals for review and action.

2.3 NOTIFICATION OF TESTING PLANNING PROCESS

- .1 The ITC shall work with the General Contractor, Owner, sub-contractors, design professionals, and the AHJ to provide a schedule for the implementation of the ITP.
- .2 The ITC shall obtain contact names, contact details, and system responsibilities for all project design professionals.
- .3 The ITC shall provide notification to the integrated testing participants seven (7) days prior to the date and time for the implementing of the ITP.
- .4 Prior to testing, the ITC shall obtain written acknowledgement for acceptance and understanding of the ITP by all project design professionals and contractors per 1001 Section 5 and Appendix B. Include ITP Review & Acceptance acknowledgement sheet in the ITR. **Refer to Figure 1.**
- .5 Prior to testing, the ITC shall obtain written acknowledgement for acceptance testing of site readiness from all project design professionals and contractors per 1001 Section 5 and Appendix B. Failure to obtain acknowledgement prior to implementation of integrated testing may invalidate the results and could result in delays by the design professionals issuing conformance. Include ITP Acceptance Testing acknowledgement sheet in the ITR. **Refer to Figure 2 and Figure 3.**
- .6 In the event of building occupants, the ITC shall provide at a minimum, forty-eight (48) hour notice of the implementation of the integrated testing. Notification shall be provided via written notices posted at each building entrance.

- .7 Partial occupancies shall employ this process for each individual occupancy and shall clearly identify the extent of to which the partial occupancy applies when obtaining written confirmations.
- .8 Figures 1 through 3 of this specification section are indicated as informative and are for information only regarding the intent for required written acknowledgement gathering by the ITC. All designers and trades listed may not apply to all projects. The ITC shall be responsible for determining all required designers and contractors for the project based on the contact information from the ITP.

2.4 TESTING IMPLEMENTATION PROCESS

- .1 Implementation of the integrated test shall follow all job site and personnel safety requirements set out in the contract and General Contractors requirements.
- .2 The ITC shall define:
 - .1 Personnel safety protocols
 - .2 Special hazards
 - .3 Team communications
 - .4 Occupant notification of emergencies
- .3 The integrated system test shall follow the methodology and process outlined in CAN/ULC-1001 as the requirement for this project.
 - .1 Provide the final ITP to the Consultant fourteen (14) days prior to scheduled implementation and test.
- .4 The respective contractors and manufactures are responsible to start-up and function test their respective systems, for observation and witnessing by the ITC. The ITC will record the results, and the respective contractor and manufacture will restore the system to a normal condition. Upon successful testing the contractor and manufacture will initial the respective integrated testing from adjacent to their respective test.
- .5 Upon a failure of a test, the ITC will document the failure and continue with the testing of other integrations. The respective contractor and manufacture will document the failure, notify they design professional, and correct the failure under the direction of the design professional.
 - .1 The ITC will re-test the unsuccessful integration after the correction has been documented and verified.
- .6 Upon a failure of a device (such as a smoke detector), the contractor may immediately replace the device, and the ITC may continue to test the integration. The device failure maybe documented but shall not result in a failed integrated test.
- .7 The ITC shall include in quote costs associated with site testing of all integrated devices. ITPs and testing procedures which include only for a sampling of devices will not be accepted. ITPs and testing procedures which rely solely on inspection reports, start-up reports, commissioning reports, or verification reports, etc. will not be accepted.
- .8 Partial occupancies shall employ this process for each individual occupancy and shall clearly identify the extent to which the partial occupancy applies when obtaining written confirmations.

- .9 Upon successfully completing the ITP, the ITC shall provide the ITR to the design professionals and building owner.

2.5 QUALITY CONTROL

- .1 The ITC must meet the following criteria to be considered acceptable for this project:
 - .1 Firms regular engaged with contractors in function testing, fire alarm verification, sprinkler system testing, annual inspections and maintenance of fire and life safety systems.
 - .2 Firms knowledgeable and experience of the respective Codes and Standards of the particular project, including but not limited to; Building Codes, Fire Codes, ULC Standards, CSA Standards, and NFPA Standards.
 - .3 Firms must be a member in good standing of the Canadian Fire Alarm Association (CFAA).
 - .4 Vendors must be a 3rd party and independent from the fire protection and life safety system installation company present on the project in accordance with ULC Certification Bulletin 2020-08.
 - .5 Firms must maintain operations in the province of Ontario for at least five years.
 - .6 Vendors must be a ULC Listed Integrated Systems Testing Service Provider and posses a ULC Integrated Fire Protection and Life Safety Certification. The ULC Certificate must be valid from the date of project award until the completed Integrated Testing Report. The ULC certification level shall be that which is applicable to the building life safety systems level of complexity for the project.
 - .1 Submit the ULC Certificate upon project award to the Consultant's office complete with Applicant ID Number.

2.6 QUALIFIED INTEGRATED TESTING COORDINATOR

- .1 Bidders may choose from the experienced ITC Firms listed below or local branches of these companies noted in the vicinity of this project and are acceptable as a sub-contractor to the Electrical Contractor:
 - .1 Lonergan Engineering
Aurora, Ontario L4G 3V5
 - .2 Great Lakes Fire Consulting & Engineering Group
Windsor, Ontario
- .2 Other experienced ITC Firms must submit in writing, to the Consultant's office, confirmation of the items listed in the Quality Control criteria above, prior to tender close to be considered as an acceptable bidder.

END OF SECTION

Figure 1 – Example Pre-Test ITP Acknowledgement (Typical Design Professionals): Informative

INTEGRATED SYSTEMS WRITTEN ACKNOWLEDGEMENT REVIEW AND ACCEPTANCE OF INTEGRATED TEST PLAN (EXAMPLE)			
Per Item 5.2.8 and Section B9.1 of CAN/ULC S1001 (latest version), the respective design professionals shall indicate written confirmation to the Testing Coordinator acceptance of the Integrated systems Test Plan according to the intent of the project design documents.			
List of Design Professionals		Company/Representative	Design Responsibility
Architect	Company Name:		
	Designer Name:		
	Signature		
Electrical Engineer	Company Name:		
	Designer Name:		
	Signature		
Mechanical Engineer	Company Name:		
	Designer Name:		
	Signature		
Fire Protection Engineer (sprinkler)	Company Name:		
	Designer Name:		
	Signature		
(typical responsible consultant on project)	Company Name:		
	Designer Name:		
	Signature		

Figure 2 – Example Pre-Test Trade Site Ready Acknowledgement (Typical Project Trades): Informative

PRE-TESTING INTEGRATED SYSTEMS WRITTEN ACKNOWLEDGEMENT (EXAMPLE)			
Per Item 5.3.1.(B) and Section B8.1 of CAN/ULC S1001 (latest version), the respective installing contractors shall indicate written confirmation to the Testing Coordinator that their respective life safety systems have been installed in accordance with the design are ready for integrated testing as outlined within the Integrated Systems Testing Plan.			
List of Installing Trades		Company/Representative	System Responsibilities
General Contractor	Company Name:		
	Name:		
	Signature		
Electrical Contractor	Company Name:		
	Name:		
	Signature		
Mechanical Contractor	Company Name:		
	Name:		
	Signature		
Sprinkler Contractor	Company Name:		
	Name:		
	Signature		
Elevator Contractor	Company Name:		
	Name:		
	Signature		
(typical responsible trade on project)	Company Name:		
	Name:		
	Signature		

Figure 3 – Example Pre-Test Designer Site Ready Acknowledgement (Typical Design Professionals):
 Informative

PRE-TESTING INTEGRATED SYSTEMS WRITTEN ACKNOWLEDGEMENT (EXAMPLE)			
Per Item 5.3.1.(A) and Section B8.1 of CAN/ULC S1001 (latest version), the respective design professionals shall indicate written confirmation to the Testing Coordinator that the site is ready for integrated systems testing per the descriptions and integrations outlined within the Integrated Systems Testing Plan.			
List of Design Professionals		Company/Representative	Design Responsibility
Architect	Company Name:		
	Designer Name:		
	Signature		
Electrical Engineer	Company Name:		
	Designer Name:		
	Signature		
Mechanical Engineer	Company Name:		
	Designer Name:		
	Signature		
Fire Protection Engineer (sprinkler)	Company Name:		
	Designer Name:		
	Signature		
(typical responsible consultant on project)	Company Name:		
	Designer Name:		
	Signature		

Part 1 General

1.1 GENERAL

.1 **This Section covers items common to Electrical Division 26, as well as Division 27 and Division 28.**

.2 This section supplements requirements of Division 1.

1.2 OCCUPANCY REQUIREMENTS

.1 The contractor shall provide the following documentation to the consultant's satisfaction prior to receiving occupancy. Failure to provide the proper documentation will result in the occupancy not being granted. List of required documentation:

- .1 Final Certificates (required prior to consultant's release of conformance letter).
 - .1 Electrical Safety Authority.
 - .2 Emergency Lighting.
 - .3 Smoke Alarm and Carbon Monoxide Detector Alarm.
 - .4 Testing of Integrated Fire Protection and Life Safety Systems Report.
 - .5 Electrical Seismic Restraint Engineers' Letter.
 - .6 Fire Alarm Verification Certificate.

Part 2 PRODUCTS

2.1 Not Used.

Part 3 EXECUTION

3.1 Not Used.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 CSA C22.2 No.0.3-92, Test Methods for Electrical Wires and Cables.
- .2 CAN/CSA-C22.2 No.131-M89(R1994), Type TECK 90 Cable.

1.2 PRODUCT DATA

- .1 Submit product data in accordance with Electrical General Requirements Section.

Part 2 Products

2.1 BUILDING WIRES

- .1 Conductors: stranded for 10 AWG and larger.
- .2 Minimum size: 12 AWG.
- .3 Copper conductors: size as indicated, with 600 V insulation of chemically cross-linked thermosetting polyethylene material 90°C (194°F) rated T90 for indoor above grade installations and RW90 for below grade installations.

2.2 TECK CABLE

- .1 Cable: to CAN/CSA-C22.2 No.131.
- .2 Conductors:
 - .1 Grounding conductor: copper.
 - .2 Circuit conductors: copper, size as indicated.
- .3 Inner jacket: polyvinyl chloride material.
- .4 Armour: aluminum.
- .5 Overall covering: polyvinyl chloride material.
- .6 Fastenings:
 - .1 One hole steel zinc straps to secure surface cables 50 mm (2") and smaller. Two hole steel straps for cables larger than 50 mm (2").
 - .2 Channel type supports for two or more cables at 1500 mm (60") centres.
 - .3 Threaded rods: 6 mm (1/4") diameter to support suspended channels.
- .7 Connectors must be suitable for:
 - .1 Installed environment and approved for use with TECK cable.

2.3 ARMoured CABLES

- .1 Conductors: insulated, copper minimum size as indicated above.
- .2 Type: AC90 (minimum size 12 AWG).

- .3 Armour: interlocking type fabricated from aluminum strip.
- .4 Connectors must be suitable for installed environment and approved for use with armoured cable.

Part 3 Execution

3.1 INSTALLATION OF BUILDING WIRES

- .1 Install wiring from source to load through raceways as specified.
- .2 Provide separate neutral conductors for all lighting circuits and circuits originating from surge protected panels. Size raceways accordingly.

3.2 INSTALLATION OF TECK CABLE 0 - 1000 V

- .1 Group cables wherever possible on channels.
- .2 Terminate cables in accordance with Wire and Box Connectors - 0 - 1000 V Section.

3.3 INSTALLATION OF MINERAL INSULATED CABLES

- .1 Run cable exposed, securely supported by straps and hangers.
- .2 Support 2 h fire rated cables at 1 m (39") intervals.
- .3 Make cable terminations by using factory-made kits.
- .4 At cable terminations use thermoplastic sleeving over bare conductors.
- .5 Where cables are buried in cast concrete or masonry sleeve for entry and exit of cables.
- .6 Do not splice cables.

3.4 INSTALLATION OF ARMoured CABLES

- .1 Group cables wherever possible.
- .2 Terminate cables in accordance with Wire and Box Connectors - 0 - 1000 V Section.
- .3 These cables are to be installed in concealed locations only. These concealed locations are considered to be stud walls and "drops" to stud walls, lighting fixtures, and ceiling mounted devices.
- .4 **These "drops" shall not be permitted to exceed 2.4 m (8'-0"). To limit these "drops" to lengths noted above provide additional branch wiring in conduit.**

END OF SECTION

Part 1 General

1.1 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data for cabinets in accordance with Electrical General Requirements Section.

Part 2 Products

2.1 MATERIALS

- .1 Splitters must conform to CSA C22.2 No. 76 (latest edition).
- .2 Junction and pull boxes must conform to CSA C22.2 No. 40 (latest edition)

2.2 SPLITTERS

- .1 Sheet metal enclosure, welded corners and formed hinged cover suitable for locking in closed position.
- .2 Main and branch lugs to match required size and number of incoming and outgoing conductors as indicated.
- .3 At least three spare terminals on each set of lugs in splitters less than 400 A.
- .4 Splitter length must match arrangement of equipment unless indicated otherwise.

2.3 JUNCTION AND PULL BOXES

- .1 Welded steel construction with screw-on flat covers for surface mounting.
- .2 Covers with 25 mm (1") minimum extension all around, for flush-mounted pull and junction boxes.

Part 3 Execution

3.1 SPLITTER INSTALLATION

- .1 Install splitters and mount plumb, true and square to the building lines on 21 mm (3/4") painted plywood backboards.

3.2 JUNCTION AND PULL BOXES INSTALLATION

- .1 Install pull boxes in inconspicuous but accessible locations.
- .2 Install junction and pull boxes so as not to exceed 30 m (100') of conduit run between pull boxes and in conformance with the Electrical Safety Code.

3.3 IDENTIFICATION

- .1 Provide equipment identification in accordance with General Electrical Requirements Section.
- .2 Install size 2 identification labels indicating system name, voltage and phase.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 Outlet boxes, conduit boxes, and fittings must conform to CSA C22.2 No. 18 (latest edition).

Part 2 Products

2.1 OUTLET AND CONDUIT BOXES GENERAL

- .1 Size boxes in accordance with CSA C22.1.
- .2 102 mm (4") square or larger outlet boxes as required for special devices.
- .3 Gang boxes where wiring devices are grouped.
- .4 Blank cover plates for boxes without wiring devices.
- .5 347 V outlet boxes for 347 V switching devices.
- .6 Combination boxes with barriers where outlets for more than one system are grouped.

2.2 SHEET STEEL OUTLET BOXES

- .1 Electro-galvanized steel single and multi gang flush device boxes for flush installation, minimum size 76 mm x 50 mm x 64 mm (3" x 2" x 2½") or as indicated. 102 mm (4") square outlet boxes when more than one conduit enters one side with extension and plaster rings as required. Iberville 1104 Series.
- .2 Electro-galvanized steel utility boxes for outlets connected to surface-mounted EMT conduit **in utility rooms**, minimum size 102 mm x 57 mm x 38 mm (4" x 2¼" x 1½"). Iberville 1110 Series.
- .3 102 mm (4") square or octagonal outlet boxes for lighting fixture outlets.
- .4 102 mm (4") square outlet boxes with extension and plaster rings for flush mounting devices in finished tile walls.

2.3 MASONRY BOXES

- .1 Electro-galvanized steel masonry single and multi gang boxes for devices flush mounted in exposed block walls.

2.4 CONCRETE BOXES

- .1 Electro-galvanized sheet steel concrete type boxes for flush mount in concrete with matching extension and plaster rings as required.

2.5 FLOOR BOXES

- .1 Flush floor boxes where indicated shall be complete with the following features:
 - .1 Four (4) independent wiring compartments.
 - .2 Flexible activation cover.

- .3 Fully adjustable.
- .4 Sixteen (16) Kos 12.7 mm (½ ") – 32 mm (1 ¼ ").
- .5 Stamped steel construction (concrete-tight).
- .2 Manufacturers:
 - .1 Wiremold Cat# RFB4-DTB-2-2T-RAKM11- flush floor box complete with two duplex receptacle brackets, 2 dual RJ brackets, and recessed activation with carpet trim plate.
Approved alternates:
 - .1 Hubbell Cat. #LCFBSS complete with LCFB XX (colour by architect), flush cover and internal faceplate to suit devices noted on the drawings.
 - .2 Wellmark Electric Inc. Cat. #400B-1-YY-XX-CRL.

2.6 CONDUIT BOXES

- .1 Cast FS or FD feraloy boxes with factory-threaded hubs and mounting feet for surface wiring of switches and receptacle **in areas (other than utility rooms) where surface conduit is used.**

2.7 FITTINGS- GENERAL

- .1 Bushing and connectors with nylon insulated throats.
- .2 Knock-out fillers to prevent entry of debris.
- .3 Conduit outlet bodies for conduit up to 32 mm (1- 1/4") and pull boxes for larger conduits.
- .4 Double locknuts and insulated bushings on sheet metal boxes.

Part 3 Execution

3.1 INSTALLATION

- .1 Support boxes independently of connecting conduits.
- .2 Fill boxes with paper, sponges or foam or similar approved material to prevent entry of debris during construction. Remove upon completion of work.
- .3 For flush installations mount outlets flush with finished wall using plaster rings to permit wall finish to come within 6 mm (1/4") of opening.
- .4 Provide correct size of openings in boxes for conduit, mineral insulated and armoured cable connections. Reducing washers are not allowed.
- .5 Outlets if unwired are to be provided with blank coverplates to suit related sections of this specification.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 CSA C22.2 No.65-1956(R1965) Wire Connectors.

Part 2 Products

2.1 MATERIALS

- .1 Pressure type wire connectors: with current carrying parts of copper sized to fit copper conductors as indicated.
- .2 Fixture type splicing connectors: with current carrying parts of copper sized to fit copper conductors 10 AWG or less.
- .3 Clamps or connectors for armoured cable, mineral insulated cable, and flexible conduit, as required.

Part 3 Execution

3.1 INSTALLATION

- .1 Remove insulation carefully from ends of conductors and:
 - .1 Apply coat of zinc joint compound on aluminum conductors prior to installation of connectors.
 - .2 Install mechanical pressure type connectors and tighten screws with appropriate compression tool recommended by manufacturer. Installation shall meet secureness tests in accordance with CSA C22.2 No.65.
 - .3 Install fixture type connectors and tighten. Replace insulating cap.

END OF SECTION

Part 1 General

1.1 Not Applicable.

Part 2 Products

2.1 MATERIALS

- .1 Grounding equipment must conform to CSA C22.2 No 41 (latest edition).

2.2 EQUIPMENT

- .1 Clamps for grounding of conductor: size as required to electrically conductive underground water pipe and electrically conductive metal gas piping.
- .2 Rod electrodes: copper clad steel 19 mm (3/4") diameter by 3 m (10') long.
- .3 Plate electrodes: galvanized steel, surface area 0.2 m², minimum 1.6 mm thick.
- .4 Insulated grounding conductors: green with insulation type that matches specified phase conductors. Gauge shall be in conformance with the latest edition of the Electrical Safety Code to suit required installation conditions.
- .5 Ground bus: copper, size as indicated, complete with insulated supports, fastenings, connectors.
- .6 Non-corroding accessories necessary for grounding system, type, size, material as indicated, including but not necessarily limited to:
 - .1 Grounding and bonding bushings.
 - .2 Protective type clamps.
 - .3 Bolted type conductor connectors.
 - .4 Thermit welded type conductor connectors.
 - .5 Bonding jumpers, straps.
 - .6 Pressure wire connectors.

Part 3 Execution

3.1 INSTALLATION GENERAL

- .1 Install complete permanent, continuous grounding system including, electrodes, conductors, connectors, accessories. **Where EMT is used, run ground wire in conduit.**
- .2 Install connectors in accordance with manufacturer's instructions.
- .3 Protect exposed grounding conductors from mechanical injury.
- .4 Make buried connections, and connections to conductive water main, electrodes, using copper welding by thermit process inspectable wrought copper compression connectors to ANSI/IEEE 837.

- .5 Make bonding connection to gas piping from electrical service ground at each location it enters a building, including multiple entries.
- .6 Use mechanical connectors for grounding connections to equipment provided with lugs.
- .7 Soldered joints not permitted.
- .8 Install bonding wire for flexible conduit, connected at both ends to grounding bushing, solderless lug, clamp or cup washer and screw. Neatly cleat bonding wire to exterior of flexible conduit.
- .9 Install separate ground conductor to outdoor lighting standards.
- .10 Ground pad mounted transformers as detailed on the drawings.

3.2 ELECTRODES

- .1 Make ground connections to continuously conductive underground water pipe on street side of water meter. This shall apply to the installation or replacement of building water service.
- .2 Install water meter shunt.
- .3 Make ground connections to continuously conductive metal gas piping system. This shall apply to installation or replacement of gas appliances, as well as installation or modification of a building gas piping system.
- .4 Corrugated metal tubing shall not be used as a bonding means for the gas piping system.
- .5 Install concrete encased electrodes in building foundation footings, with terminal connected to grounding network.
- .6 Install rod or plate electrodes and make grounding connections.
- .7 Bond separate, multiple electrodes together.
- .8 Use #2/0 copper conductors for connections to electrodes. Size in conformance with the Electrical Safety Code.

3.3 EQUIPMENT GROUNDING

- .1 Install grounding connections to typical equipment included in, but not necessarily limited to following list. Electrical Service equipment, electrically conductive underground water pipe, electrically conductive metal gas piping, transformers, switchgear, duct systems, frames of motors, motor control centres, starters, control panels, building steel work, generators, elevators and escalators, distribution panels, and outdoor lighting.

3.4 COMMUNICATION SYSTEMS

- .1 Install grounding connections for telephone, sound, fire alarm, computer network systems as follows:
 - .1 Telephones: make telephone grounding system in accordance with telephone company's requirements.
 - .2 Sound, fire alarm, computer network systems as indicated.

3.5 FIELD QUALITY CONTROL

- .1 Perform tests in accordance with Electrical General Requirements Section.
- .2 Perform ground continuity and resistance tests using method appropriate to site conditions and to approval of local authority having jurisdiction over installation.
- .3 Perform tests before energizing electrical system.
- .4 Disconnect ground fault indicator during tests.

END OF SECTION

Part 1 General

1.1 APPLICATION

- .1 Seismic restraint is becoming more prominent with improved soil testing equipment. Seismic requirement is not site specific by geographical area but determined by site soil conditions.
- .2 Where the structural engineer or architect documents have $I_e \cdot S_a(0.2) \cdot F_a < 3.5$ seismic is not required on the electrical systems.
- .3 Where the structural engineer or architect documents have $I_e \cdot S_a(0.2) \cdot F_a \geq 3.5$ seismic is required on the electrical systems.
- .4 Seismic will always be required on fire protection systems when required by NFPA codes.
- .5 Seismic will always be required on any "Disaster Relief Building." For example, hospitals, police stations, ambulance building, etc.
- .6 When it is unclear in the tender documents request information from the structural engineer or architect for clarification.

1.2 SECTION INCLUDES

- .1 Seismic Requirements for free standing equipment and other similar systems.
- .2 Seismic Requirements for single rod hanger supports for conduit, and other similar systems.
- .3 Seismic Requirements for trapeze type supports for bus tray, conduit, and other similar systems.

1.3 REFERENCES

- .1 Building Officials and Code Administrators National Building Code (BOCA) (latest edition).
- .2 Ontario Building Code (OBC), (latest edition).

1.4 QUALITY ASSURANCE

- .1 The contractor shall provide pre-engineered seismic restraint systems to meet total design lateral force requirements for support and restraint of free standing electrical equipment, conduit, cable trays and other similar suspended systems and equipment as determined by seismic restraint designer.
- .2 System Supports/Restraints: Firms regularly engaged in the manufacture of products of the types specified in this section, whose products have been in satisfactory use in similar service for not less than 5 years.
- .3 Bolted framing channels and fittings shall have the manufacturers name, part number, and material heat code identification number stamped in the part itself for identification. Material certification sheets and test reports must be made available by the manufacturer upon request.

- .4 Only companies experienced in performing the work of this section shall do the installation.
- .5 All seismic restraint installations shall be independently reviewed by the Owner's representatives for compliance with project specifications.

1.5 SUBMITTALS

- .1 Submit seismic force calculations according to forces chart located on structural engineer of record's drawings. Submit pre-approved restraint selections and installation details from acceptable manufacturer specified in this section or engineer approved equal.
- .2 Restraint selection and installation details shall be pre-approved by a professionally licensed engineer with at least 5 years of experience in the design of seismic restraints.
- .3 Submit manufacturer's product data on strut channels including, but not limited to, types, materials, finishes, gauge thickness, and hole patterns.
- .4 Contractor to retain services of Professional Engineer, designated in local jurisdiction and submit stamped drawings. The same engineer shall provide periodic field review and final certification upon completion of the project.

The following companies are provided for information purposes:

- .1 Tecoustics Limited - 1-888-714-9596
- .2 Lampkin Structural Services – 613-830-6875
- .3 Vibro Acoustics – 1-800-565-8401
- .4 Tecoustics Vibration Control & Seismic Restraint – 905-681-6077
- .5 Gerrits Engineering 705-737-3303
- .5 All fees and associated costs for the engineering shall be the responsibility of this contractor.

1.6 SEISMIC BRACING AND SUPPORT DESIGN REQUIREMENTS

- .1 Seismic restraint designer shall co-ordinate all attachments with the structural engineer of record.
- .2 Design analysis shall include force calculations according to forces chart listed on the structural engineer of record's drawings and capacity of materials utilized for the connection of the equipment or system to the structure.
- .3 Analysis shall detail anchoring methods, bolt diameter, and embedment depth.
- .4 All seismic restraint devices shall be designed to accept without failure the calculated forces as per the applicable Building Code.

1.7 DELIVERY, STORAGE, AND HANDLING

- .1 Deliver strut systems, pipe hangers and components carefully to avoid breakage, denting, and scoring finishes. Do not install damaged equipment.
- .2 Store strut systems, pipe hangers and components in original cartons and in clean dry space; protect from weather and construction traffic.

1.8 WORK FURNISHED BUT NOT INSTALLED

- .1 The materials and systems specified in this section shall be purchased by the electrical contractor from a single seismic snubber restraint materials manufacturer to assure sole source responsibility for the performance of the seismic restraints used.
- .2 The materials and systems specified in this section can, at the contractor's option, be installed by the subcontractor who installs the electrical equipment.

1.9 COORDINATION

- .1 Coordinate size, shape, reinforcement and attachment of all housekeeping pads supporting seismically rated equipment. Concrete shall have a minimum compressive strength of 3,000 psi or as specified by the consultant.
- .2 Coordinate with seismic restraint manufacturer to locate and size structural supports underneath seismically restrained equipment (e.g. switchboards, motor control centres, transformers, and other similar equipment).

1.10 DESCRIPTION OF SYSTEM

- .1 It shall be understood that the requirements of this seismic restraint section are in addition to other requirements as specified elsewhere for the support and attachment of equipment and electrical services, and for the vibration isolation of same equipment. Nothing on the project drawings or specifications shall be interpreted as justification to waive the requirements of this seismic restraint section.
- .2 The work under this section shall include furnishing all labour, materials, tools, appliances, and equipment, and performing all operations necessary for the complete execution of the installation of seismic snubber restraint assemblies as shown, detailed, and/or scheduled on the drawing and/or specified in this section of the specifications.
- .3 All seismic snubber restraint assemblies shall meet the following minimum requirements:
 - .1 The snubber/restrained isolator for isolated equipment shall include a resilient element that will ensure that no un-cushioned shock can occur (this does not include cable restraints).
 - .2 It shall be possible to visually inspect the resilient material for damage and allow for replacement, if necessary.
 - .3 All snubbers are to include a maximum air gap of 0.25" (6 mm).
 - .4 Seismic restraint systems shall be designed to offer seismic restraint in all directions, unless otherwise noted.
 - .5 Seismic restraint capacities to be verified by an independent test laboratory or certified by a registered Professional Engineer to ensure that the design intent of this specification is realized. Verification shall be by one of the following methods:
 - .1 An NRTL (National Recognized Testing Laboratory), or laboratory recommended by VISCMA.

- .2 Certified by a Professional Engineer with at least 5 years of experience, using industry standard methods of analysis, which employ common engineering practices. Adherence to the ratings standard within ASHRAE SPC171 and VISCMA 102-2007 is required.
- .3 By a nationally recognized agency, such as VISCMA, that has reviewed and approved the restraint.

1.11 SYSTEM DESIGN

- .1 Seismic restraint manufacturer shall be responsible for the structural design of attachment hardware as required to attach snubbers/restraints to both the equipment and supporting structure on vibration isolated equipment, or to directly attach equipment to the building structure for non-isolated equipment.
- .2 The contractor shall furnish, to the seismic restraint manufacturer, a complete set of approved shop drawings of all equipment that is to be restrained, from which the selection and design of seismic restraint devices and/or attachment hardware will be completed. The shop drawings furnished shall include, at a minimum, basic equipment layout, length, and width dimensions, and installed operating weights of the equipment to be restrained.
- .3 All conduit etc. is to be restrained to meet code requirements. At a minimum, the seismic restraint manufacturer shall provide documentation on maximum restraint spacing for various restraint sizes and anchors, as well as "worst case" reaction loads for each restraint and/or anchor size.
- .4 The contractor shall ensure that all housekeeping pads used are adequately reinforced and are properly dowelled to the building structure, so as to withstand calculated seismic forces. In addition, the size of the housekeeping pad is to be coordinated with the seismic restraint manufacturer to ensure that adequate edge distances exist in order to obtain the desired equipment anchor capacities.

1.12 ALTERNATE SYSTEMS

- .1 Provisions of the General Conditions and Supplemental Conditions of the specifications shall govern the use of alternate systems to those specified.
- .2 Manufacturers not listed as approved in "Part 2 Materials" of this section must secure approval to bid a minimum of ten (10) days prior to the project bid date.
- .3 Uncertified internal equipment seismic restraint systems are disallowed for use on this project.

1.13 INSTALLATION

- .1 Installation of all seismic restraint materials specified herein shall be accomplished following the manufacturer's written instructions. Installation instructions shall be submitted to the engineer for approval prior to the beginning of the work.

Part 2 Products

2.1 ACCEPTABLE MANUFACTURERS

- .1 Cooper B-Line.
- .2 Unistrut Building Systems.
- .3 Kinetics Noise Control Inc.
- .4 Mason Industries.
- .5 Engineer approved equal.

2.2 SEISMIC BRACING COMPONENTS

- .1 Steel strut and bracing components shall be utilized in combinations as required to meet designed load capacities.
- .2 Fittings and accessories: Products shall be of the same manufacturer as strut and designed for use with that product.

2.3 BUILDING CODE REQUIREMENTS

- .1 Seismic Zone Factors and coefficients shall be according to geographical area information table located on structural engineer of record's drawings.

2.4 SEISMIC SNUBBER TYPES

- .1 GENERAL

(Isolator/Snubber Types contained herein are per ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.) Handbook, HVAC Applications, Seismic and Wind Restraint Design)

- .2 Type J, Cable Restraints for Suspended Conduit and Trapeze
 - .1 Seismic wire rope cable restraints shall consist of steel wire strand cables, sized to resist project seismic loads, arranged to offer seismic restraint capabilities for conduit, trapeze assemblies, and suspended equipment in all lateral directions.
 - .2 Building and equipment attachment brackets at each end of the cable shall be designed to permit free cable movement in all directions up to a 45-degree misalignment. Protective thimbles shall be used at sharp connection points as required to eliminate potential for dynamic cable wear and strand breakage.
 - .3 Restraints shall be sized to the capacity of the cable or to the capacity of the anchorage, whichever is lesser.
 - .4 Seismic wire rope connections shall be made using overlap wire rope "U" clips or seismically rated tool-less wedge insert lock connectors.
 - .5 Vertical suspension rods shall be braced as required to avoid potential for buckling due to vertical "up" forces. Braces shall be structural steel angle uniquely selected to be of sufficient strength to prevent support rod bending. Brace shall be attached to the vertical suspension rod by a series of adjustable straps. Clips shall be capable of securely locking brace to suspension rod without the need for hand tools.

- .6 Where clevis hanger brackets are used for seismic restraint attachment, they will be fitted with clevis internal braces to prevent buckling of the hanger brackets.
- .7 Seismic cable shall be as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed.
- .8 Seismic cable building and equipment attachment brackets shall be Model KSCA, KSCU, or KSCC as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed.
- .9 Seismic cable concrete anchor bolts shall be Model KCAB Wedge, Model KCCAB Cracked Concrete, or Model KUAB Undercut, as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed.
- .10 Seismic wire rope connectors shall be (Model KWRC - 'U' clamp) / (Model KWGC - Tool-less wedge lock) as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed.
- .11 Seismic vertical suspension stiffener rod clips shall be Model KHRC as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed.
- .12 Clevis Internal Braces shall be Model KCHB as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as listed.

Part 3 Execution

3.1 INSTALLATION

- .1 All seismic restraint systems shall be installed in strict accordance with the manufacturer's seismic restraint guidelines manual and all certified submittal data.
- .2 Installation of seismic restraints shall not cause any change in position of equipment or piping, resulting in stresses or misalignment.
- .3 No rigid connections between equipment and the building structure shall be made that degrade the noise and vibration isolation system specified.
- .4 Do not install any equipment, piping, duct, or conduit that makes connections with the building unless isolation is not specified.
- .5 Prior to installation, bring to the architect's/engineer's attention any discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection.
- .6 Bracing may occur from flanges of structural beams, upper truss cords of bar joists, cast in place inserts, or wedge-type concrete anchors. Consult structural engineer of record.
- .7 Overstressing of the building structure shall not occur from overhead support of equipment. Bracing attached to structural members may present additional stresses. The contractor shall submit loads to the structural engineer of record for approval in this event.
- .8 Brace support rods when necessary to accept compressive loads. Welding of compressive braces to the vertical support rods is not acceptable.

- .9 Provide reinforced clevis bolts where required.
- .10 Seismic restraints shall be mechanically attached to the system. Looping restraints around the system is not acceptable.
- .11 Do not brace a system to two independent structures such as a ceiling and wall.
- .12 Provide appropriately sized openings in walls, floors, and ceilings for anticipated seismic movement. Provide fire seal systems in fire-rated walls.
- .13 Torque anchor bolts according to anchor manufacturer's written instructions to resist seismic forces.
- .14 Do not install any seismic restraint for equipment, cable trays or conduit that compromises isolation specified.
- .15 Hold down clamps must be used to attach conduits and/or cables to all trapeze members before applying restraints.
- .16 Conduit crossing building seismic or expansion joints, passing from building to building, or supported from different portions of the building shall be installed to allow differential support displacements without damaging the conduit, equipment connections, or support connections. Conduit offsets, loops, anchors, and guides shall be installed as required to provide specified motion capability and limit motion of adjacent piping.
- .17 Coring is not permitted for the installation of concrete anchors. Use ground penetrating radar or equivalent method of embedment item detection to locate all embed items including reinforcing steel and electrical conduits. Concrete reinforcing steel and electrical conduits shall not be cut or damaged under any circumstances.

3.2 EXECUTION

- .1 Install vertical braces to stiffen hanger rods and prevent buckling per seismic restraint manufacturer's design. Clamp vertical brace to hanger rods. Requirements apply equally to hanging equipment. Do not weld vertical braces to hanger rods.
- .2 If mounting hole diameter exceeds bolt diameter by more than 0.125" (3 mm), reduce clearance in hole with epoxy grout, flanged elastomeric bushings or welded washer.
- .3 Housekeeping Pads must be adequately reinforced and adequately sized for proper installation of equipment anchors. Refer to seismic restraint manufacturer's written instructions.

3.3 INSPECTION

- .1 The contractor shall notify the local representative of the seismic restraint materials manufacturer prior to installing any seismic restraint devices. The contractor shall seek the representative's guidance in any installation procedures with which he/she is unfamiliar.
- .2 Upon completion of the installation of all seismic restraint devices herein specified, the local representative of the seismic restraint manufacturer shall, at the contractor's request, inspect the completed system and report in writing any installation errors, improperly selected snubber devices, or other fault in the system which could affect the performance of the system.

- .3 The installing contractor shall submit a report upon request to the building architect and/or engineer, including the manufacturer's representative's final report, indicating that all seismic restraint material has been properly installed, or steps that are to be taken by the contractor to properly complete the seismic restraint work as per the specifications.

3.4 CONDUIT

- .1 Seismically restrain all electrical conduit. Use Type J Cable Restraints for all conduit supported by vibration isolation hanger assemblies. Brace all conduit to code requirements (IBC or TI-809-04) or in conformance with SMACNA (Sheet Metal and Air Conditioning Contractors National Association, Inc.) "Seismic Restraint Manual Guidelines for Mechanical Systems", Second Edition (Remaining Codes).

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 Canadian Standards Association (CSA)
 - .1 CAN/CSA C22.2 No.18-92, Outlet Boxes, Conduit Boxes, and Fittings.
 - .2 CSA C22.2 No.45-M1981(R1992), Rigid Metal Conduit.
 - .3 CSA C22.2 No.56-1977(R1977), Flexible Metal Conduit and Liquid-Tight Flexible Metal Conduit.
 - .4 CSA C22.2 No.83-M1985(R1992), Electrical Metallic Tubing.
 - .5 CSA C22.2 No.211.2-M1984(R1992), Rigid PVC (Unplasticized) Conduit.
 - .6 CAN/CSA C22.2 No.227.1, Nema TC-13, Flexible Nonmetallic Tubing.

Part 2 Products

2.1 CONDUITS

- .1 Rigid metal conduit: to CSA C22.2 No.45, aluminum threaded.
- .2 Epoxy coated conduit: to CSA C22.2 No.45, with zinc coating and corrosion resistant epoxy finish inside and outside.
- .3 Electrical metallic tubing (EMT) with couplings: to CSA C22.2 No.83.
- .4 Rigid PVC conduit: to CSA C22.2 No.211.2.
- .5 Flexible metal conduit: to CSA C22.2 No.56, aluminum and liquid-tight flexible metal.
- .6 Flexible PVC conduit: to CAN/CSA C22.2 No.227.1 and Nema TC-13, Electrical nonmetallic tubing (ENT).

2.2 CONDUIT FASTENINGS

- .1 One hole steel straps to secure surface conduits 53 mm (2") and smaller. Two hole steel straps for conduits larger than 53 mm (2").
- .2 Beam clamps to secure conduits to exposed steel work.
- .3 Channel type supports for two or more conduits at 1.5 m (5'-0") oc.
- .4 Threaded rods, 6 mm (1/4") diameter, to support suspended channels.

2.3 CONDUIT FITTINGS

- .1 EMT fittings shall be set screw style (zinc alloy).
- .2 Flexible metal conduit fittings shall be screw-in type.
- .3 Liquid type flexible metal conduit fittings shall be sealtite type.
- .4 PVC fittings shall be PVC type complete with PVC adaptors at all boxes.
- .5 Rigid conduit and mineral insulated conduit fittings shall be threaded type.

- .6 Coating: same as conduit.
- .7 Factory "ells" where 90° bends are required for 27 mm (1") and larger conduits.
- .8 Where bushings are noted to be provided they must be "screwed" type fastened to a conduit connector. Push-fit or glued in place bushings will NOT be accepted.

2.4 FISH CORD

- .1 Nylon twine.

Part 3 Execution

3.1 INSTALLATION

- .1 Install conduits to conserve headroom in exposed locations and cause minimum interference in spaces through which they pass.
- .2 Conceal conduits except in mechanical/ electrical service rooms and in unfinished areas.
- .3 Where devices are to be installed on existing walls in finished area, which cannot be "fished", install feeds in a surface metal raceway equal to Wiremold V700 series. Coordinate surface installations with Consultant prior to rough-in, unless otherwise noted.
- .4 **Use electrical metallic tubing (EMT) for all branch circuits unless specified otherwise.**
- .5 Electrical nonmetallic tubing (ENT) may be used only for branch circuits in non-combustible buildings, in framed wall construction for residential suites, within block walls, and in precast or cast in place walls and floors. **Use of ENT for direct burial, plenum ceilings, or outdoor environments will not be accepted.**
- .6 Use rigid aluminum threaded conduit where specified and up to 2.1 m (7'-0") above finish floor where exposed to mechanical injury.
- .7 Use rigid PVC conduit underground and in kitchen areas.
- .8 Use flexible metal conduit for connection to motors in dry areas, connection to recessed fixtures without a prewired outlet box, connection to surface or recessed fixtures, work in movable metal partitions.
- .9 Use liquid tight flexible metal conduit for connection to motors or vibrating equipment in damp, wet or corrosive locations and for connections to kitchen equipment.
- .10 Conduits terminating at electrical equipment in sprinklered areas are to be provided rain-tight insulated compression style connectors.
- .11 **Minimum conduit size for branch circuits shall be 21 mm (3/4").** Single drops from ceiling mounted junction boxes down to a light switch or duplex receptacle may be reduced to 16 mm (1/2").
- .12 Bend conduit cold. Replace conduit if kinked or flattened more than 1/10th of its original diameter.
- .13 Mechanically bend steel conduit over 27 mm (1") diameter.
- .14 Field threads on rigid conduit must be of sufficient length to draw conduits up tight.

- .15 Install fish cord in empty conduits.
- .16 Run 2- 27 mm (1") spare conduits up to accessible ceiling space from each flush panel. Terminate these conduits in 152 mm x 152 mm x 102 mm (6" x 6" x 4") junction boxes in ceiling space.
- .17 Remove and replace blocked conduit sections. Do not use liquids to clean out conduits.
- .18 Dry conduits out before installing wire.
- .19 Do not install, store, or handle ENT in cold temperatures below -20°C(-4°F). Do not store ENT outside.

3.2 SURFACE CONDUITS

- .1 Run parallel or perpendicular to building lines.
- .2 Locate conduits behind infrared or gas fired heaters with 1.5 m (5') clearance.
- .3 Run conduits in flanged portion of structural steel.
- .4 Group conduits wherever possible on suspended or surface channels.
- .5 Do not pass conduits through structural members except as indicated.
- .6 Do not locate conduits less than 75 mm (3") parallel to steam or hot water lines with minimum of 25 mm (1") at crossovers.
- .7 **Do not fasten surface conduit to roof deck. Provide standoffs or supports as manufactured by Caddy or use Unistrut trapeze fastened to structure.**

3.3 CONCEALED CONDUITS

- .1 Do not install horizontal runs in masonry walls.
- .2 Do not install conduits in terrazzo or concrete toppings.

3.4 CONDUITS IN CAST-IN-PLACE CONCRETE

- .1 Locate to suit reinforcing steel. Install in centre one third of slab.
- .2 Protect conduits from damage where they stub out of concrete.
- .3 Install sleeves where conduits pass through slab or wall.
- .4 Provide oversized sleeve for conduits passing through waterproof membrane, before membrane is installed. Use cold mastic between sleeve and conduit.
- .5 Do not place conduits in slabs in which slab thickness is less than 4 times conduit diameter.
- .6 Encase conduits completely in concrete with minimum 27 mm (1") concrete cover.
- .7 Organize conduits in slab to minimize cross-overs.

3.5 CONDUITS IN CAST-IN-PLACE SLABS ON GRADE

- .1 Run conduits 27 mm (1") and larger 300 mm (12") below slab (measured from top of slab to bottom of conduit) and encased in 78 mm (3") sand envelope.

3.6 CONDUITS UNDERGROUND

- .1 Slope conduits to provide drainage.

END OF SECTION

Part 1 General

1.1 GENERAL PROVISIONS

- .1 Conform to the General Provisions of Division 1 and Electrical General Requirements Section.

1.2 PRODUCT DATA

- .1 Submit product data in accordance with Electrical General Requirements Section.

Part 2 Products

2.1 MATERIALS

- .1 Rigid PVC ducts must conform to CSA C22.2 No. 211.0, 211.1 and 211.2 (latest edition).
- .2 Ducts and/or cables must be excavated, bedded, reinforced, encased and backfilled as per details on the drawings.

2.2 DUCT

- .1 Ducts indicated for encasement in concrete must be type DB-2. Ipex "Super Duct" or approved equal.
- .2 Ducts indicated for direct burial must be type SCEPTER. Ipex "Scepter" rigid PVC duct or approved equal.

2.3 DUCT FITTINGS

- .1 Fittings required to provide a complete continuous ductbank installation shall include but not be limited to, couplings, bell end fitting, caps, adapters, base and intermediate spacers.
- .2 Small or large angle couplings will be required where noted on the drawings.
- .3 Expansion joints are to be provided when running ducts in concrete across expansion joints and where exposed on roofs or exterior of buildings.

Part 3 Execution

3.1 BASIC INSTALLATION

- .1 Excavate trench along route as indicated and at a depth to suit cables and/or ducts as detailed.
- .2 If required, trench is to be pumped to maintain excavation free of water.
- .3 Import granular fill and place in bottom of trench. Compact to provide a firm level base.
- .4 Quantity and arrangement of ducts must be provided according to drawing details.
- .5 When ducts terminate at buildings or precast bases provide bell end fittings.

- .6 **When ducts enter buildings below grade they shall be sealed inside and out at the building foundation and service entrance equipment with a suitable duct sealing compound to prevent the entrance of moisture or gases.**
- .7 When terminating a ductbank for future extension terminate each duct with a coupling. If ducts are encased in concrete set coupling flush with end of concrete.
- .8 Attach ducts to spacers using non-metallic materials.
- .9 Provide concrete as detailed. Pour concrete down sides of ductbank to ensure spaces around and under ducts are filled first.
- .10 Concrete must obtain 50% of its specified strength prior to backfilling.
- .11 **Backfilling must be imported granular 'A' material.**
- .12 Backfill must be placed as 150 mm (6") compacted lifts.
- .13 Excess excavated material must be removed from site by this contractor.
- .14 Ensure ducts indicated to be installed along a curb line are installed at least 600 mm (24") from that curb line.

3.2 DIRECT BURIAL OF DUCTS

- .1 After sand bed specified is in place, lay ducts maintaining 75 mm (3") clearance from each side of trench to nearest duct. Do not pull cable into trench.
- .2 Provide offsets for thermal action and minor earth movements. Offset ducts 150 mm (6") for each 60 m (200') run, maintaining minimum duct separation and bending radius requirements.
- .3 Underground cable splices not acceptable.
- .4 Duct separation:
 - .1 Provide separation of ducts in conformance with the details in the Electrical Safety Code.

3.3 CABLE INSTALLATION IN DUCTS

- .1 Install cables as indicated in ducts.
- .2 Do not pull spliced cables inside ducts.
- .3 Install multiple cables in duct simultaneously.
- .4 Use CSA approved lubricants of type compatible with cable jacket to reduce pulling tension.
- .5 To facilitate matching of colour coded multi-conductor control cables reel off in same direction during installation.
- .6 Before pulling cable into ducts and until cables are properly terminated, seal ends of cables with moisture seal tape.
- .7 After installation of cables, seal duct ends with duct sealing compound.

3.4 FIELD QUALITY CONTROL

- .1 Perform tests using qualified personnel. Provide necessary instruments and equipment.
- .2 Check phase rotation and identify each phase conductor of each feeder.
- .3 Check each feeder for continuity, short circuits and grounds. Ensure resistance to ground of circuits is not less than 50 mega ohms.
- .4 Pre-acceptance tests.
 - .1 After installing cable but before terminating, perform insulation resistance test with 1000 V megger on each phase conductor.
- .5 Provide Consultant with list of test results showing location at which each test was made, circuit tested and result of each test.
- .6 Remove and replace entire length of cable if cable fails to meet any of test criteria.
- .7 The Consultant requires a minimum of 48 hours notice to inspect at his discretion the following; ductbank excavation, bedding and duct placement, pouring and/or placement of ductbank encasement.**

END OF SECTION

Part 1 General

1.1 GENERAL REQUIREMENTS

- .1 The studies must be submitted to the Consultant prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment for manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval from the Consultant may be obtained for a preliminary submittal of sufficient study data to ensure that the selection of device ratings and characteristics will be satisfactory.
- .2 The studies shall include all portions of the electrical distribution system from the normal power source or sources down to and including the smallest adjustable trip circuit breaker in the distribution system, **as well as mechanical unit equipment**. Normal system connections and those, which result in maximum fault conditions, shall be adequately covered in the study.
- .3 The firm should be currently involved in high- and low-voltage power system evaluation. The study must be performed, stamped and signed by a registered professional engineer in the Province of Ontario. Credentials of the individual(s) performing the study and background of the firm shall be submitted to the Consultant for approval prior to start of the work. A minimum of five (5) years experience in power system analysis is required for the individual in charge of the project.
- .4 The firm performing the study should demonstrate capability and experience to provide assistance during start up as required.

1.2 DATA COLLECTION FOR THE STUDY

- .1 The Contractor shall provide the required data for preparation of the studies. The Consultant performing the system studies shall furnish the Contractor with a listing of the required data immediately after award of the contract.
- .2 The Contractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to release of the equipment for manufacturing.
- .3 Data collected for the study, including correspondence with local utility, shall be included with study report.

Part 2 Products

2.1 SHORT CIRCUIT AND PROTECTIVE DEVICE EVALUATION AND COORDINATION STUDY

- .1 The short-circuit study shall be performed with the aid of a digital computer program and shall be in accordance with the latest applicable IEEE and ANSI standards.

- .2 In the short-circuit study, provide calculation methods and assumptions, the base per unit quantities selected, one-line diagrams, source impedance data including power company system characteristics, typical calculations, tabulations of calculation quantities and results, conclusions, and recommendations. Calculate short-circuit interrupting and momentary (when applicable) duties for an assumed 3-phase bolted fault at each supply switchgear lineup, unit substation primary and secondary terminals, low-voltage switchgear lineup, switchboard, motor control center, distribution panelboard, pertinent branch circuit panelboard, and other significant overcurrent protective device locations throughout the system. Provide a ground fault current study for the same system areas, including the associated zero sequence impedance data. Include in tabulations fault impedance, X to R ratios, asymmetry factors, motor fault contribution, short circuit kVA, and symmetrical and asymmetrical fault currents.
- .3 In the protective device coordination study, provide time-current curves graphically indicating the coordination proposed for the system, centered on conventional, full-size, log-log forms. Include with each curve sheet a complete title and one-line diagram with legend identifying the specific portion of the system covered by that particular curve sheet. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics. Tabulate recommended device tap, time dial, pickup, instantaneous, and time delay settings.
- .4 Include on the curve sheets power company relay and fuse characteristics, medium-voltage equipment protective relay and fuse characteristics, low-voltage equipment circuit breaker trip device characteristics, pertinent transformer characteristics, pertinent motor and generator characteristics, and characteristics of other system load protective devices. In addition, include all devices down to the largest branch circuit and largest feeder circuit breaker in each motor control center, and main breaker in branch panelboards.

Include all adjustable settings for ground fault protective devices. Include manufacturing tolerance and damage bands in plotted fuse characteristics. Show transformer full load currents, transformer magnetizing inrush, ANSI transformer withstand parameters, and significant symmetrical fault currents. Terminate device characteristic curves at a point reflecting the maximum symmetrical fault current to which the device is exposed.
- .5 Select each primary protective device required for a delta-wye connected transformer so that its characteristic or operating band is within the transformer characteristics, including a point equal to 58 percent of the ANSI withstand point to provide secondary line-to-ground fault protection. Separate transformer primary protective device characteristic curves from associated secondary device characteristics by a 16 percent current margin to provide proper coordination and protection in the event of secondary line-to-line faults. Separate medium-voltage relay characteristic curves from curves for other devices by at least a 0.4-second time margin.
- .6 Include complete fault calculations as specified herein based on contract documents.
- .7 Submit qualifications of individual(s) who will perform the work for approval prior to commencement of the studies. Provide studies in conjunction with equipment submittals to verify equipment ratings required. Submit the study to Consultant for review prior to delivery of the study to the Owner. Make all additions or changes as required by the reviewer.

- .8 Utilize equipment load data for the study obtained by the Contractor from contract documents, including contract addendums issued prior to bid openings.
- .9 Include fault contribution of all motors in the study. Notify the Consultant in writing of circuit protective devices not properly rated for fault conditions.
- .10 When emergency generator is provided, include phase and ground coordination of the generator protective devices. Show the generator decrement curve and damage curve along with the operating characteristic of the protective devices. Contractor shall obtain the information from the generator manufacturer and include the generator actual impedance value, time constants and current boost data in the study. Do not use typical values for the generator.
- .11 Evaluate proper operation of the ground relays in 4-wire distributions with more than one main service circuit breaker, or when generators are provided, and discuss the neutral grounds and ground fault current flows during a neutral to ground fault.
- .12 For motor control circuits, show the MCC full-load current plus symmetrical and asymmetrical of the largest motor starting current and time to ensure protective devices will not trip during major or group start operation.
- .13 **Evaluate proper rating of applicable mechanical unit equipment based on available fault at unit connection. Mechanical unit equipment in study shall include packaged assemblies identified as, but not limited to, AHUs, MUAs, DOAS, Chillers, and Cooling Towers.**

2.2 ARC FLASH HAZARD ANALYSIS

- .1 The contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E – Standard for Electrical Safety in the Workplace, reference Article 130.3 and Annex D and CSA Z462-(latest edition).
- .2 The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2004, Annex D.
- .3 When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Alternative methods shall be presented in the proposal.
- .4 The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where work could be performed on energized parts.
- .5 The Arc-Flash Hazard Analysis shall include all significant locations in 240 volt and 208 volt systems fed from transformers equal to or greater than 125 kVA.
- .6 Safe working distances shall be specified for calculated fault locations based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm².
- .7 The Arc Flash Hazard analysis shall include calculations for maximum and minimum contributions of fault current magnitude. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume a minimum motor load. Conversely, the maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

- .8 Arc Flash computation shall include both line and load side of main breaker calculations, where necessary.
- .9 Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-latest edition section B.1.2.
- .10 Arc Flash computation shall include arc flash current magnitude at each circuit breaker 1200A or higher (ARMS capable) to allow the Arc Flash Reduction Maintenance System pickups to be set based on multiples of the per unit secondary arc current monitored by the trip unit.

2.3 STUDY REPORT

- .1 The results of the power system study shall be summarized in a final report. Submit report in accordance with Electrical General Requirements Section as a shop drawing.
- .2 The report shall include the following sections:
 - .1 Descriptions, purpose, basis, and scope of the study.
 - .2 Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short-circuit duties, and commentary regarding same.
 - .3 **Tabulations of mechanical unit equipment ratings as identified on equipment shop drawings versus calculated short-circuit, and commentary regarding same. Short-circuit calculations for mechanical equipment shall be based on unit MCA with conductor sizes as identified on electrical design drawings and not based on equipment MOCP.**
 - .4 Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip settings, fuse selection, and commentary regarding same.
 - .5 Fault current calculations including a definition of terms and guide for interpretation of computer printout.
 - .6 Incident energy and flash protection boundary calculations
 - .1 Arcing fault magnitude
 - .2 Device clearing time
 - .3 Duration of arc
 - .4 Arc flash boundary
 - .5 Working distance
 - .6 Incident energy
 - .7 Hazard Risk Category
 - .8 Recommendations for arc flash energy reduction
 - .9 **Recommendations for Personal Protection Equipment (PPE) level.**

Part 3 Execution

3.1 POWER COMPANY APPROVAL

- .1 Copies of the final report must be submitted to the power company for their review and approval. Approved copies of the report shall be submitted to the Consultant.

3.2 FIELD SETTINGS

- .1 The Contractor shall perform field adjustments of the protective devices as required to place the equipment in final operating condition. The settings shall be in accordance with the approved short-circuit study, protective device evaluation study, and protective device coordination study.
- .2 Necessary field settings of devices and adjustments and minor modifications to equipment to accomplish conformance with the approved short-circuit and protective device coordination study shall be carried out by the Contractor at no additional cost to the Owner.
- .3 At the completion of the project, configure settings and install equipment labels. On company letterhead, the contractor is to prepare a certification letter indicating at minimum:
 - .1 project
 - .2 date
 - .3 device designation
 - .4 certification of correct settings
 - .5 certification of correct device labels
 - .6 certification of arc flash hazard equipment labels
 - .7 digital image of each breaker indicating final settings and placement of labels

3.3 ARC FLASH WARNING LABELS

- .1 The vendor shall provide a 3.5 in. x 5 in. thermal transfer type label of high adhesion polyester for each work location analyzed.
- .2 The label shall have an orange header with the wording, "WARNING, ARC FLASH HAZARD", and shall include the following information:
 - .1 Location designation
 - .2 Nominal voltage
 - .3 Flash protection boundary
 - .4 Hazard risk category
 - .5 Incident energy
 - .6 Working distance
 - .7 Personal Protection Equipment (PPE) level
 - .8 Engineering report number, revision number and issue date.
- .3 Labels shall be machine printed, with no field markings.

- .4 Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.
 - .1 For each 600, 480 and applicable 208 volt panelboards, one arc flash label shall be provided.
 - .2 For each motor control center, one arc flash label shall be provided.
 - .3 For each low voltage switchboard, one arc flash label shall be provided.
 - .4 For each switchgear, one flash label shall be provided.
 - .5 For medium voltage switches one arc flash label shall be provided
- .5 **Labels shall be field installed by the firm providing the Arc Flashing Hazard Analysis.**

3.4 SERIES RATING LABELS

- .1 Provide Iamcooid labels where recommended by study. **Labels for series rating with panelboards or equipment shall be indicated on feeder breaker as "SERIES RATING BREAKER" and at the panelboard or equipment as "SERIES RATING EQUIPMENT". Refer to section 26 24 16.**

3.5 ACCEPTABLE TESTING FIRMS

- .1 MVA Engineering (519) 668-4698
- .2 GT Woods (905) 272-1696
- .3 Brosz & Associates (905) 472-6660
- .4 K-Tek Electro-services Ltd. (905) 640-0660 ext. 228

END OF SECTION

Part 1 General

1.1 SHOP DRAWINGS

- .1 Submit shop drawings for each system in Conformance with The Electrical General Requirements Section.

1.2 PRODUCT/MAINTENANCE DATA

- .1 Submit product/maintenance data for each system for inclusion in maintenance manual conforming to The General Electrical Requirements Section.

1.3 SCOPE

- .1 The scope of this Section will include the following systems.
 - .1 Surface mounted raceway.
 - .2 Hand dryers.
 - .3 Cable management hangers.
 - .4 Cable management system.
 - .5 Auxiliary systems rough-in.
 - .6 Security and access control rough-in.
 - .7 Telecommunication network system rough-in.
 - .8 Miscellaneous clocks.
 - .9 Destratification fans and controls.
 - .10 Classroom control panels.
 - .11 Public address system rough-in.
 - .12 Digital time switch.
 - .13 Photocontrol switch.
 - .14 Line voltage power packs and low voltage occupancy sensors.

Part 2 Products

2.1 SURFACE MOUNTED RACEWAY

- .1 The two compartment surface raceway shall be complete with the following features:
 - .1 Surface non-metallic raceway is to be utilized in dry interior locations only.
 - .2 The surface non-metallic raceway system specified herein for branch circuit wiring and/or data network, voice, video and other low-voltage wiring shall be the 5400 System as manufactured by the Wiremold Company.
 - .3 The raceway and all system components must be UL Listed, and exhibit non-flammable self-extinguishing characteristics tested to comparable specifications of UL94V-0. The raceway base and cover shall be manufactured by rigid compound, available in ivory or white colours (Architect Selection).

- .4 The raceway shall be a two-piece design with a base and a snap-on cover. Total width shall be 133 mm (5¼") by 44.5 mm (1¾") deep with an approximate thickness of 2.4 mm (1/12"). The base and cover shall be available in 2.4 m (8') lengths. The raceway shall be available with two multiple wiring channels formed by integral barriers in the base.
- .5 The cover shall span the entire width of the base concealing all of the wiring channels.
- .6 A full complement of fittings must be available including, but not limited to flat, internal and external elbows, tees entrance fittings, cover clips and end caps. They shall be manufactured of a rigid PVC compound. The fittings shall have a matte texture, in ivory or white colours to match the base and cover. They shall overlap the cover and base to hide uneven cuts. All fittings shall be supplied with a base where applicable to eliminate mitring. A transition fitting shall be available to adapt to other Wiremold series raceways.
- .7 Device brackets shall be available for mounting standard devices in-line with the raceway. Faceplates shall match and fit flush in the device plate. They shall be manufactured of rigid PVC compound. They shall be ivory or white colours to match raceway base cover (Architect selection). Contractor is to provide devices as noted.
- .8 The raceway manufacturer will provide a complete line of connectivity outlets and modular inserts for UTP (including Category 5e and 6), STP (150 ohm) Fibre Optic, Coaxial and other cabling types with face plates and bezels to facilitate mounting. The electrical contractor is to provide adapter plates for faceplates to be provided by the voice/data sub-contractor. The recommended plate is a Deco adapter 3-port plate style, confirm with voice/data sub-contractor.
- .2 Acceptable alternate manufacturers include:
 - .1 Hubbell Base Trak
 - .2 Panduit Pan-Way

2.2 HAND DRYERS

- .1 Hand dryers where noted on the drawings are to be supplied and installed by this Division with the following features:
 - .1 Surface mounting.
 - .2 Fixed nozzle.
 - .3 White finish with automatic activation.
Final finish selection by owner/architect.
 - .4 Rating of 1800 W at 120 V.
 - .5 Cat. #NOVA 5-0212
 - .1 World Dryer Cat. #XA5-2-974.

2.3 CABLE MANAGEMENT HANGERS

- .1 Hangers where noted are to be complete with the following features:
 - .1 Approximately 150 mm (6") high by 80 mm (3¼") protrusion.
 - .2 Constructed from 5 mm (3/16") x 20 mm (3/4") flat steel bar and formed to resemble the letter "G".
 - .3 Seven 6 mm (1/4") diameter mounting holes are to be provided around the hanger perimeter.
 - .4 Matte black finish.
 - .5 Suitable for wall or suspended mounting.
 - .6 Acceptable Manufacturers:
 - .1 EMF Cat. #H-533-S
 - .7 Manufacturer Contact:
Electron Metal Fabricators Inc.
2160 Dagenais Boulevard West
Laval, Quebec
H7L 5X9
Phone: 450-625-8064 or 1-800-267-8064
Fax: 450-625-8004
 - .8 Acceptable Alternate:
Wiremold Cat. #GH030406
Mono System Cat. # The Hook H-433
Cablofil Cat. #CSGH-3-4-6
Eaton Cat. #B-Line
- .2 **As an alternate to the hanger system detailed the contractor may**
 - a) **Use as an equal one run of 50 mm (2") x 150 mm (6") wire mesh cable management system equal to Cablofil Cat. #CF 54/150 EZ complete with Cat. #FAS L 150 universal wall bracket where noted to be wall mounted and Cat. # FAS C 200 where noted to be hung. The hangers are to be installed at intervals as recommended by the manufacturer but no greater than 2.4 m (8'-0") on centre.**

2.4 CABLE MANAGEMENT SYSTEM

- .1 The system where noted shall be a continuous, rigid, welded steel wire mesh cable management system with the following features:
 - .1 Permits continuous ventilation of cable and maximum dissipation of heat.
 - .2 Continuous safety edge T-welded wire lip.
 - .3 Welded at all intersections.
 - .4 Straight sections 4" x 12" (100 mm x 300 mm) in configurations noted on the drawings.
 - .5 Constructed of carbon steel wire, ASTM A 510, grade 1008. Wire welded, bent, and surface treated after manufacture.

- .6 Post fabrication finish of electro-plated zinc galvanizing: ASTM B 633, Type III, SC-1.
- .7 Fittings: Field fabricated in accordance with manufacturer's instructions from straight sections.
- .2 The support system shall be Cablofil FAS CH hanger.
- .3 The necessary hardware, including splice connectors and support components furnished by manufacturer.
- .4 The product shall be Cablofil Cat. #CF105/300EZ complete with Cat. #FAS P300 CH at intervals as recommended by the manufacturer.
- .5 The manufacturer shall be:
 - .1 Cablofil Inc.
Local representation by:
Cablofil
533 Galway Drive
Burlington, Ontario
L7L 2S6
Ph: 905-681-5380
Fax: 905-681-2206
- .6 Approved equals:
 - .1 Eaton B-Line FT4x12x10 complete with 12 CTR HGR
Intralec Electrical Products Ltd.
1200 Cardiff Blvd.
Mississauga, Ontario
L5S 1P6
Phone: 905-670-0970

2.5 AUXILIARY SYSTEMS ROUGH-IN

- .1 Outlets where noted shall be single gang boxes unless specified otherwise.
- .2 Outlets if unwired are to be provided with blank coverplates to suit related sections of this specification.
- .3 Coordinate final outlet locations, quantities, etc. with respective system vendor and owner's representative.
- .4 Auxiliary systems installation such as CATV, A/V, etc., may be provided by owner's approved vendor as part of cash allowance. Rough-ins only for system devices shall be included in electrical bid price.

2.6 SECURITY AND ACCESS CONTROL ROUGH-IN

- .1 Provide conduit from device and outlet locations to cable management systems as noted on drawings.

- .2 Outlets if unwired are to be provided with blank coverplates to suit related sections of this specification.
- .3 Provide grounding of equipment as noted on drawings.
- .4 Security and access control systems installation shall be by Owner's approved vendor as part of separate tender.

2.7 TELECOMMUNICATION NETWORK SYSTEM ROUGH-IN

- .1 Outlets where noted shall be single gang flush mounted in wall or surface raceways.
- .2 Outlets if unwired are to be provided with blank coverplates to suit related sections of this specification.
- .3 Provide a #6 insulated green ground conductor from main service ground to voice equipment backboard located on drawings.
- .4 Telecommunication Network installation shall be by Owner's approved vendor as part of separate tender.

2.8 MISCELLANEOUS CLOCKS

- .1 Room and/or office clocks shall be surface mounted 300 mm (12") round style, battery operated. Finish to suit Architect.
- .2 Library and general purpose room clocks shall be surface mounted 375 mm (15") round style, battery operated. General purpose room clocks must be provided with wire guard. Finish to suit Architect.
- .3 Manufacturers shall be as follows:
 - .1 300 mm (12"):
 - Edwards Cat. #2941-2B
 - Simplex Cat. #BAT Series
 - American Time Cat. #E56BASD304
 - .2 355 mm (14")
 - La Crosse Technology Cat.#WT-3143A
 - .3 375 mm (15"):
 - Edwards Cat. #2942-2B
 - Simplex Cat. # BAT Series
 - American Time Cat. # E66BADD304
 - .4 Wireguard for 375 mm (15") clock:
 - Edwards Cat. #2091A
 - Simplex Cat. # BAT Series
 - American Time Cat. #G2366

2.9 DESTRATIFICATION FANS AND CONTROLS

- .1 General purpose fans in the gym to be provided with the following features:
 - .1 Metal construction.
 - .2 Baked white enamel.
 - .3 Down-blowing single direction.
 - .4 1400 mm (56") diameter blade combination.
 - .5 Minimum 400 mm (16") suspension with ball aligner and canopy.
 - .6 Suitable for 120V/1/60Hz operation.
 - .7 Provided with wire cage when installed in general purpose rooms.
 - .8 Manufacturer:
 - .1 Banvil Cat. #60F9-10 (FG60C where noted).
- .2 Single fan variable speed controller shall be Banvil Cat. #100P c/w colour and coverplate to suit this specification.
- .3 Multiple fan variable speed controller shall be Banvil Cat. [#105F (up to 4 fans), 150F (up to 8 fans), or 200F (up to 12 fans)] c/w colour and coverplate to suit this specification.
- .4 Approved equal:
 - .1 Pleasantaire
- .5 Decorative fans as indicated are to be provided with the following features:
 - .1 Metal construction.
 - .2 Blade, downrod and motor finish as directed by Architect.
 - .3 Down-blowing single direction.
 - .4 1300 (52") diameter blade combination.
 - .5 Minimum 400 mm (16") suspension with ball aligner and canopy.
 - .6 Suitable for 120V/1/60 Hz operation.
 - .7 Manufacturer: Big Ass Fans Cat. #K3127-A2-XX-XX-XX-03-C complete with multi-button wall mounted controller.

2.10 CLASSROOM CONTROL PANELS

- .1 Provide surface mounted Classroom Hub Control Panels as detailed on the drawings.
- .2 Modular control panels shall be constructed of structurally sound 6063 T5 alloy satin anodized aluminum frame .08mm thick with high pressure plastic laminate faced panels of lightweight particle core and 0.5mm thick plastic laminate backing sheet. Plastic laminate colour as selected by the Architect from Arborite or Formica, furniture finish, from manufacturer's standard colour range. Complete assembly to meet flame spread ratings in areas used.
- .3 Units to be complete with backboxes fabricated from heavy gauge satin coat steel with suitable barriers and continuous knockouts. Satin anodized faceplates shall be pre-punched to accept detailed components.
- .4 All panels shall be vandal resistant and removable with special tools for service access.

- .5 Fabricate units in accordance with reviewed shop drawings with extruded aluminum frames and solid plastic laminated face panels.
- .6 Panels to be removable from aluminum frames with rounded profile edging.
- .7 Front panels to have colour finish as selected by the Architect.
- .8 Panels to have all openings, mounting hardware, etc. for services as required for installation of mechanical and electrical services.
- .9 Units to be full height from 200 mm off floor to underside of ceiling panels. Standard unit dimensions are 16" in width, 4" deep.
- .10 Acceptable Manufacturer (basis of design):
 - .1 Swift Path Solutions.
- .11 Acceptable Alternates (no other alternates accepted):
 - .1 Control Hub Solutions Inc.
 - .2 Olympic Tool & Die Inc.

2.11 PUBLIC ADDRESS SYSTEM ROUGH-IN

- .1 Provide conduit from device and outlet locations to cable management systems as noted on drawings.
- .2 Outlets if unwired are to be provided with blank coverplates to suit related sections of this specification.
- .3 Provide grounding of equipment as noted on drawings.
- .4 Public address system installation shall be by Owner's approved vendor as part of separate tender.

2.12 DIGITAL TIME SWITCH

- .1 Supply and install a digital time switch with 40 Amp SPST contacts.
- .2 Unit shall be capable of 20 set points.
- .3 Unit shall repeat the same schedule each day.
- .4 Unit shall have automatic Daylight Savings Time and Leap Year compensation.
- .5 Unit shall program in AM/PM format.
- .6 Unit shall have LCD display.
- .7 Unit shall have permanent schedule retention.
- .8 Unit real time clock shall be retained by super capacitor for 100 hours in a power failure.
- .9 Unit shall be capable of manual override ON and OFF either to the next scheduled event or permanently.
- .10 Unit shall have a NEMA 3R indoor/outdoor plastic enclosure.
- .11 Unit shall have Load Status indication.
- .12 Unit shall have Power Failure indication.

- .13 Acceptable Manufacturer:
Tork Cat. #EW/EWZ Series
Use EW for control of indoor devices and EWZ for control of outdoor devices.

2.13 PHOTOCONTROL SWITCH

- .1 Supply and install photo control with rating of;
 - .1 (1000, 1800, 2000) Watts
 - .2 (8.33, 14, 16.6) amperes tungsten at 120Volts
 - .3 50 to 60 Hz. AC
- .2 Sealed cadmium sulphide photocell operates in temperature range of:
 - .1 -34°C. (-30°F) to 60°C. (140°F)
- .3 Lights switching on/off:
 - .1 On at (1.5, 2, 3) footcandles.
 - .2 Off at (4.5, 10) footcandles.
- .4 Diecast aluminum enclosure, gasketed for maximum weatherproofing.
- .5 Thermal inertia gives minimum time delay of fifteen (15) seconds to prevent false or nuisance switching due to light from vehicles, lightning etc.
- .6 Control to have standard threaded pipe nipple.
- .7 Control to have manually adjustable lever slide.
- .8 Acceptable manufacturers:
 - .1 Paragon Cat. #CW201-00 Series.
 - .2 Tork Cat. #2101 Series.

2.14 LINE VOLTAGE POWER PACKS AND LOW VOLTAGE OCCUPANCY SENSORS

- .1 Line voltage power packs and occupancy sensors shall be one manufacturer throughout the project.
- .2 Line Voltage Power packs shall be provided to match the room lighting load, control requirements, and lighting voltage. Power packs shall have the following features:
 - .1 Mount to standard junction box.
 - .2 Simple replacement. It shall be capable to replace the unit without requiring any configuration or set-up.
 - .3 Plenum rated
 - .4 120VAC or 347V, 60HZ operation.
 - .5 Acceptable materials:
 - .1 Sensorswitch Cat. #PP20 Series
 - .2 Legrand Cat. #BZ-250 Series
 - .3 Greengate Cat. #SP15 Series

- .3 Low voltage / analog occupancy sensors shall be complete with the following features:
 - .1 Coverage pattern to suit room ceiling height.
 - .2 Suitable to detect minor and medium motion patterns within rooms less than 2000 sq. ft.
 - .3 Mount to standard junction box.
 - .4 Simple replacement. It shall be capable to replace the unit without requiring any configuration or set-up.
 - .5 Relays shall not be integrated within the occupancy sensor. Relays shall be provided within separate power pack.
 - .6 Acceptable materials
 - .1 Sensorswitch Cat. #CM-PDT Series
 - .2 Legrand Cat. #CI-205
 - .3 Greengate Cat. #OAC-DT-2000

Part 3 Execution

3.1 SURFACE MOUNTED RACEWAY

- .1 Raceway is to be supplied and installed complete with all necessary fittings, hardware and device brackets for configuration as noted in the drawings for a complete functional installation.
- .2 Install conduit system, wiring and devices as indicated.
- .3 Ensure raceway is installed as per manufacturer recommendations.
- .4 Where the raceway ends at a wall install end cap.

3.2 HAND DRYERS

- .1 Install and connect hand dryers in conformance with manufacturer's recommendations.
- .2 Hand dryers are to be mounted at a height to suit age of expected users. Unless otherwise noted confirm height with manufacturer, owner, Architect, and/or consultant prior to rough-in.
- .3 Once installed this contractor is to caulk the joint between dryer and wall surface with a bead of clear silicone.

3.3 CABLE MANAGEMENT HANGERS

- .1 Install hangers as per details in configuration noted.
- .2 Prior to installation co-ordinate location with other services within the ceiling space.
- .3 Co-ordinate with noted sub-contractors to install cables noted to be utilizing these hangers. Cables are to be installed such that the maximum sag between hangers does not exceed 25 mm (1"). This electrical contractor is to coordinate.
- .4 **Attaching cable to any T-bar support rods is not acceptable.**

3.4 CABLE MANAGEMENT SYSTEM

- .1 Install cable management system at locations indicated on the drawings and in accordance with manufacturer's instructions.
- .2 Support system every 2.4 m (8'-0") unless system is used within a telecommunication room. In that situation support every 1.5 m (5'-0").
- .3 Cut wires in accordance with manufacturer's instructions.
- .4 Cut wires with side action bolt cutters to ensure integrity of galvanic protective layer. Cut using side action bolt cutters (Cablofil Cat. #Coupfil).
- .5 Cut each wire with 1 clean cut to eliminate grinding or touch-up.
- .6 Install cable management system using hardware, splice connectors, support components, and accessories furnished by manufacturer.
- .7 Suspend from structure or intermediate Unistrut channel spanning across the corridor where access to structure is not available due to the concentration of mechanical ductwork and/or piping.
- .8 Ground cable tray with continuous ground per O.E.S.C. and manufacturer instructions. Test to ensure minimum 5 ohms resistance.
- .9 Locate cable management system minimum 9" from EMI sources including but not limited to fluorescent lights, transformers, motors, and power cables.

3.5 AUXILIARY SYSTEMS ROUGH-IN

- .1 Provide backboard for each system use as noted complete with ground buss connection as specified.
- .2 Outlets are to be installed complete with minimum 21 mm (3/4") conduit to accessible ceiling space or as otherwise detailed.
- .3 Conduits terminated into ceiling spaces must be within 3 m (10') of zone conduits when noted.
- .4 Provide insulated bushings on all conduits terminated in ceiling space.
- .5 Ensure specified zone or riser conduits are installed back to equipment backboard.

3.6 SECURITY AND ACCESS CONTROL ROUGH-IN

- .1 Outlets are to be provided for devices with conduit as detailed on drawings.
- .2 Conduits terminated into ceiling spaces must be within 1m of cable management of tray.

3.7 TELECOMMUNICATION NETWORK SYSTEM ROUGH-IN

- .1 Install incoming service ducts and terminate as noted.
- .2 Provide backboard as noted complete with ground connection to main service ground.
- .3 Conduits terminated into ceiling spaces must be within 3 m (10') of zone conduits (if applicable).
- .4 Ensure specified zone conduits are installed back to service backboard.

- .5 Outlets are to be installed complete with 25 mm (1") conduit to corridor ceiling space or nearest zone conduit (if applicable).
- .6 Provide insulated bushings on all conduits terminated in ceiling space.
- .7 A 25 mm (1") conduit is to be installed from elevator machine room to voice service backboard.
- .8 Refer to Telecommunication Network Installations Section for additional requirements.

3.8 MISCELLANEOUS CLOCKS

- .1 Ensure clocks are installed where noted complete with batteries and all necessary mounting hardware.
- .2 Set clocks to proper time of day and ensure all are operational at the time of final inspection.

3.9 DESTRATIFICATION FANS AND CONTROLS

- .1 Ensure fans and controls are installed in conformance with manufacturer recommendations.
- .2 Where noted install wireguards to be level. Fasten wireguards to structure NOT roof deck. Provide intermediate Unistrut supports to suit.
- .3 Demonstrate fan operation at the time of final inspection.
- .4 Contractor is to remove manufacturer's label prior to installation.

3.10 CLASSROOM CONTROL PANELS

- .1 Electrical trade to supply and install units in accordance with manufacturers' recommendations and reviewed shop drawings complete with all frames, cut outs, face panels, etc., to provide a complete installation.
- .2 It is the electrical trade's responsibility to coordinate complete installation of all mechanical, electrical and miscellaneous services in all control panels. Components within control panels will vary from room to room.

3.11 PUBLIC ADDRESS SYSTEM ROUGH-IN

- .1 Conduits terminated into ceiling spaces must be within 1m (10') of cable management tray.
- .2 Outlets are to be installed complete with 25 mm (1") conduit to corridor ceiling space or nearest cable management tray.
- .3 Provide insulated bushings on all conduits terminated in ceiling space.
- .4 Electrical contractor shall obtain speaker back boxes from School Board vender for installation into ceiling tiles, block walls, etc.

3.12 DIGITAL TIME SWITCH

- .1 Install electromechanical lighting controls as indicated and in accordance with manufacturer's instructions.
- .2 Coordinate with owner's representative and install 'trippers' to suit.

3.13 PHOTOCONTROL SWITCH

- .1 Turns photo-initiated controls on at dusk.
- .2 Turns lights on at dusk and off at dawn.
- .3 Install photoelectric controls as indicated and in accordance with manufacturer's instructions on suitable weatherproof junction box.

3.14 LINE VOLTAGE POWER PACKS AND LOW VOLTAGE OCCUPANCY SENSORS

- .1 Install power packs in accessible maintenance areas.
- .2 Provide access doors if power packs are installed above drywall ceilings.
- .3 Install sensors in gym where noted on plan at mid height of wall.
- .4 Sensors installed in areas of high abuse shall be complete with wire guards.
- .5 It shall be the contractor's responsibility to locate and aim sensors in the correct location required for complete and proper coverage within the range of coverage as per the manufacturer's recommendations. The locations and quantities of sensors shown on the drawings are diagrammatic and indicate only the rooms which are to be provided with sensors. The contractor shall provide additional sensors if required to properly and completely cover the respective rooms.
- .6 It is the contractor's responsibility to arrange a pre-installation meeting with the manufacturer's factory authorized representative, at the facility, to verify placement to sensors and installation criteria.
- .7 The contractor shall also provide the on-site training necessary to familiarize the owner's personnel with the operation, use, adjustment and problem solving diagnosis of the occupancy sensing devices systems.
- .8 Upon completion of the installation, the system shall be completely commissioned by the manufacturer's factory authorized technician who will verify all adjustments and sensor placement to ensure a trouble-free occupancy-based lighting control. Submit commissioning report with closeout documents.
- .9 **All lighting controls shall be provided with functional testing and documentation conforming to Ashrae 90.1, latest adoption. This cost shall be included in the Tender Price.**

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 Dry type transformers must conform to CSA C22.2 No.47 and C9 (latest edition).
- .2 **Dry type transformers must conform to CSA C802 (latest edition).**
- .3 **Dry type transformers must be in accordance with Ontario Green Energy Act 2018 (NRCan 2018) DOE 2016.**

1.2 PRODUCT DATA

- .1 Submit product data in accordance with Electrical General Requirements Section.

Part 2 Products

2.1 TRANSFORMERS

- .1 Transformers to be of one manufacturer throughout project.
- .2 Ratings and characteristics shall be as indicated on riser diagrams.
- .3 Aluminum winding.
- .4 Transformers are to be ventilated dry type style with 4-2½% taps (2 F.C.B.N. and 2 F.C.A.N.)
- .5 Maximum permissible sound levels shall be as follows:

Transformer Rating (KVA)	Sound Level (dBA)
≤50	45
51 to 150	50
151 to 300	55
301 to 500	60

- .6 **All transformers with a K factor of 4 or above must be electro-static shielded.**
- .7 **Transformers with a K-factor of 4 or above must include a secondary neutral bus that is sized at twice the rated secondary phase current.**
- .8 Transformer enclosure shall be EEMAC/NEMA 3R ventilated complete with removable front panel.

- .9 Provide vibration isolators equal to Korfund R series, Mason ND-B, or approved equal. "Colour" of vibration isolators shall be based on weight of transformers.

Transformer Weight (lbs)	Approximate Rating	Colour (Korfund)
540	15 – 75 kVA	Blue (RD2)
680	112.5 kVA	Black (RD2)
960	150 kVA	Red (RD2)
1,520	300 kVA	Green (RD2)
2,200	500 kVA	Gray (RD3)

2.2 EQUIPMENT IDENTIFICATION

- .1 Provide equipment identification in accordance with Electrical General Requirements Section.
- .2 Label must indicate:
- .1 transformer "tag" as per riser diagram
 - .2 primary and secondary voltage and phase.

2.3 ACCEPTABLE MANUFACTURERS:

- .1 Acceptable manufacturers are as follows:
- .1 Hammond
 - .2 Rex
 - .3 Delta
 - .4 Acme
 - .5 Bemag

Part 3 Execution

3.1 INSTALLATION

- .1 Primary and secondary feeders are to be connected using flexible conduit.
- .2 Transformers with a rating up to and including 75 KVA are permitted to be wall mounted provided mounting method is a suitably sized angle iron frame secured to structure (i.e. masonry wall, steel columns, etc. NOT metal siding).
- .3 The above rating of transformers may also be suspended from **structure only** on a unistrut trapeze as detailed.
- .4 Transformers above 75 KVA must be floor mounted.

- .5 Floor mounted transformers are to be mounted/secured to a concrete pad suitably sized to suit the transformer. This pad is the responsibility of this contractor and must be provided in conformance with the standard of Division 1 specifications for poured in place concrete.
- .6 All transformers must be mounted on vibration isolators selected based on transformer weight.
- .7 Ensure adequate clearance around transformer for ventilation as per the Electrical Safety Code.
- .8 Loosen isolation pad bolts until no compression is visible.
- .9 Install transformers in level upright position.
- .10 Remove shipping supports only after transformer is installed and just before putting into service.
- .11 Make primary and secondary connections in accordance with wiring diagram.
- .12 Energize transformers after installation is complete.

END OF SECTION

Part 1 General

1.1 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with Electrical General Requirements Section.
- .2 Indicate on shop drawings.
 - .1 Floor anchoring method and foundation template.
 - .2 Dimensioned cable entry and exit locations.
 - .3 Dimensioned positions and size of bus.
 - .4 Overall length, height and depth.
 - .5 Dimensioned layout of internal and front panel mounted components.

1.2 MAINTENANCE DATA

- .1 Provide maintenance data for service entrance board for incorporation into manual specified in the Electrical General Requirements Section.
- .2 Submit 5 copies of maintenance data for complete assembly including components.

1.3 MAINTENANCE MATERIALS

- .1 Include:
 - .1 One can of touch-up paint.

1.4 SOURCE QUALITY CONTROL

- .1 Consultant to witness final factory tests if requested.
- .2 Notify Consultant in writing 5 days in advance that service entrance board is ready for testing.
- .3 Submit 5 copies of certified test results.

Part 2 Products

2.1 SERVICE ENTRANCE BOARD

- .1 Service entrance board must conform to CSA C222 No. 31 (latest edition).
- .2 Rating: 600V, 3 phase, 4 wire, 800A, short circuit current (kA rms symmetrical) as noted on distribution riser.
- .3 Cubicles: wall-mounted/free standing, dead front, size as indicated, hinged access panels with captive knurled thumbscrews (front access only), EEMAC2 rating (sprinkler hood).

- .4 Main section to contain:
 - Breakers as noted complete with kA interrupting capacity to match mains.
 - Barriered section for supply authority metering components.
 - Digital metering unit as specified.
 - NOTE: Refer to Moulded Case Circuit Breakers section for specifications regarding the required breakers.
- .5 Distribution section to contain breakers as noted complete with kA interrupting capacity to match mains.
 - NOTE: Refer to Moulded Case Circuit Breakers section for specifications regarding the required breakers.
- .6 Bus bars and main connections: aluminum.
- .7 Bus bars from load terminals of main device through metering section to distribution section.
- .8 Bus bars are to have identified colour coded phases.

2.2 GROUNDING

- .1 Aluminum ground bus extending full width of cubicles and located at bottom.
- .2 Lugs at each end for grounding cable. Contractor to size lug.

2.3 POWER SUPPLY AUTHORITY METERING

- .1 Separate compartment and rigid metal raceway for exclusive use of power supply authority metering.
- .2 Mounting accessories and wiring for metering supplied by power supply authority:
 - .1 3 current transformers.

2.4 FINISHES

- .1 Apply finishes in accordance with the Electrical General Requirements Section.
 - .1 Service entrance board exterior: grey.

2.5 EQUIPMENT IDENTIFICATION

- .1 Provide equipment identification in accordance with Electrical General Requirements Section.
- .2 Nameplates:
 - .1 Black plate, white letters, and size 7.
 - .2 Complete board labeled: 347/600V.
 - .3 Main disconnect labeled: Main Breaker
 - .4 Branch disconnects labeled: as indicated.

2.6 ACCEPTABLE PRODUCTS

- .1 Maximum 1200A (up to 65kA bracing and interrupting rating)
 - .1 Eaton Cat# CMP Series
 - .2 Siemens Cat# SMP
 - .3 Schneider Electric Cat# MDS
- .2 Maximum 6000A (up to 200kA bracing and interrupting rating)
 - .1 Eaton Cat# POW-R-LINE-C
 - .2 Siemens Cat# SB
 - .3 Schneider Electric Cat# QED
- .3 Digital Metering Units
 - .1 Eaton Cat# IQ 260 (MOD BUS) or Power Xpert 2000 Series (BACnet)
 - .2 Siemens Cat# PAC 4200
 - .3 Schneider Electric Cat# PM-5563RD.
- .4 Digital metering units shall be complete with MOD BUS (BACnet) communication module for interface of monitored parameters to BAS. Coordinate output with BAS contractor.
- .5 Manufacturer is to include for representative to visit the site to fully commission the meter.

Part 3 Execution

3.1 INSTALLATION

- .1 Locate service entrance board and fasten to wall/housekeeping pad.
- .2 Connect main secondary service to line terminals of main device.
- .3 Connect load terminals of distribution devices to feeders.
- .4 Check factory made connections for mechanical security and electrical continuity.
- .5 Run grounding conductors from ground bus to building ground to suit the Electrical Safety Code.
- .6 Check trip unit settings against co-ordination study to ensure proper working and protection of components.
- .7 Co-ordinate with local supply authority and board manufacturer for shipment and installation of metering components at board manufacture's fabrication plant.

END OF SECTION

Part 1 General

1.1 PRODUCT DATA

- .1 Submit product data in accordance with Electrical General Requirements Section.
- .2 Drawings to include electrical detail of panel, branch breaker type, quantity, ampacity and enclosure dimension.

Part 2 Products

2.1 PANELBOARDS

- .1 Panel boards must conform to CSA C22.2 No. 29 (latest edition).
- .2 Panelboards: product of one manufacturer.
- .3 Install circuit breakers in panelboards before shipment.
- .4 In addition to CSA requirements manufacturer's nameplate must show fault current that panel including breakers has been built to withstand. **Series rating is acceptable – submit information with shop drawings. Provide lamicaid label on feeder breaker. Lamicaid label to state "Series Rating Breaker." Lamicaid label to be size 2.**
- .5 Bus and breakers must be rated for [10,000] A (symmetrical) interrupting capacity or as indicated.
- .6 Sequence phase bussing with odd numbered breakers on left and even on right, with each breaker identified by permanent number identification as to circuit number and phase.
- .7 Panelboard mains, number of circuits, and number and size of branch circuit breakers as indicated.
- .8 Two keys for each panelboard and key panelboards alike.
- .9 Aluminum bus with neutral of same ampere rating as mains.
- .10 Mains must be suitable for bolt-on breakers. Provide main (if applicable) and branch breakers as bolt-on style.
- .11 Trim with concealed front bolts and hinges.
- .12 Trim and door finish must be baked grey enamel.
- .13 All panels regardless of voltage and amperage must be provided with a lockable door.
- .14 Branch circuit panelboards (250 AMP or smaller) must be one of the following:
 - .1 Eaton Cat # POW-R-LINE-C PRL-1 or PRL-2
 - .2 Schneider Electric Cat # NQ Series for up to 240V or NF Series for up to 600V
 - .3 Siemens Cat #Sentron P1 Series

- .15 Branch circuit panelboards indicated to be complete with an external surge protective device shall include a suitably sized branch circuit breaker for the surge protective device as noted on panel schedule, and per surge protective device manufacturer recommendations. Surge protective device shall be provided as specified in section 26 43 13, unless noted otherwise.
- .16 Power distribution circuit breaker panelboards (400 AMP or larger) must be one of the following:
 - .1 Eaton CAT# POW-R-Line-C PRL-3A or PRL-4A
 - .2 Schneider Electric CAT# I-Line Series (Bolt-On)
 - .3 Siemens CAT# P2 Series (up to 600A mains and maximum 100A-3P branch breakers)
 - .4 Siemens CAT# S5 Series (up to 1200A mains with branch breakers above 100A-3P)

2.2 BREAKERS

- .1 Breakers: to Moulded Case Circuit Breakers Section.
- .2 Breakers with thermal and magnetic tripping in panelboards except as indicated otherwise.
- .3 Main breaker (as specified) must be separately mounted on top or bottom of panel to suit cable entry. When mounted vertically, down position should open breaker.
- .4 Lock-on devices for fire alarm, stairway, exit and night light circuits.

2.3 EQUIPMENT IDENTIFICATION

- .1 Provide equipment identification in accordance with Electrical General Requirements Section.
- .2 Nameplate for each panelboard size 4 engraved description as indicated. In finished areas install label on inside of panel, and in service areas install label on exterior of panel.
- .3 Nameplate for each circuit in distribution panelboards size 2 engraved "name of load" as indicated.
- .4 Complete circuit directory with typewritten legend showing location of each circuit.
Include a copy of the directories in the maintenance manuals.

Part 3 Execution

3.1 INSTALLATION

- .1 Locate panelboards as indicated and mount securely, plumb, true and square, to adjoining surfaces.
- .2 Install surface mounted panelboards on plywood backboards. Where practical, group panelboards on common backboard. Plywood shall be 21mm (3/4") fire rated or painted with intumescent fire block paint having a minimum of 1h rating, unless noted otherwise.

- .3 Mount panelboards to height specified in Electrical General Requirements Section or as indicated.
- .4 Connect loads to circuits.
- .5 Connect neutral conductors to common neutral bus.
- .6 Mount external surge protective devices as close as possible to panelboard and associated branch breaker to minimize lead lengths and per manufacturers recommendations. Provide modified panel trim for flush mount applications as required to suit.
- .7 Install series rating lamicoids adjacent to all breakers utilized to achieve series ratings.

END OF SECTION

Part 1 General

1.1 PRODUCT DATA

- .1 Submit product data in accordance with Electrical General Requirements Section.

Part 2 Products

2.1 BREAKERS GENERAL

- .1 Moulded case circuit breakers must conform to CSA C22.1 No.5.1-M91 (latest edition.)
- .2 Bolt-on moulded case circuit breaker quick-make, quick-break type, for manual and automatic operation.
- .3 Common-trip breakers: with single handle for multi-pole applications.
- .4 Unless otherwise indicated moulded case circuit breaker to operate automatically by means of thermal and magnetic tripping devices to provide inverse time current tripping and instantaneous tripping for short circuit protection.
- .5 Moulded case circuit breakers 250 Amps and above are to operate by means of a solid-state trip unit with associated current monitors and self-powered shunt trip to provide inverse time current trip under overload condition, and long time, short time, instantaneous tripping for phase and ground fault short circuit protection (if indicated or applicable by the Electrical Safety Code versus the breaker amperage). Unless otherwise specified, complete system selective co-ordination shall be provided by the individually adjustable time/current curve shaping elements as following:
 - .1 Breakers shall have fixed rating plug determining breaker continuous current rating.
 - .2 All breakers shall have adjustable long delay pickup and time, L.
 - .3 All breakers shall have individual adjustments for short delay pickup and time, S; including I2t settings in time adjustment.
 - .4 Breakers shall have adjustable instantaneous pickup, I; that if required by co-ordination study can be turned off, (I).
 - .5 If required by Electrical Safety Code breakers shall have individually adjustable ground fault current pick-up and time, G; including I2t settings in time adjustment.
 - .6 Unless otherwise specified, for the low voltage systems provide an electronic trip unit as specified above for the following moulded case circuit breakers:
 - .1 Mains or ties in main switchboard: LS trip unit with fixed instantaneous over-ride exceeding maximum value of fault at the point of installation.
 - .2 Transformer feeder for the units 225kVA and above: LSI or LS trip unit with fixed instantaneous over-ride, where instantaneous trip setting or instantaneous over-ride allows for transformer inrush of 12xFLA at 0.1s and exceeds maximum value of fault at the transformer secondary.

- .3 Feeders exceeding 250A trip setting: LS trip unit with fixed instantaneous over-ride exceeding maximum value of fault at downstream panelboard.
- .4 Branch circuits or feeders for MCCs with fusible combination starters: LSI trip unit where instantaneous trip setting allows for maximum size downstream fuse total clearing time.

2.2 BREAKERS 1200A AND HIGHER

- .1 Circuit breakers rated 1200A or higher must be equipped with Arc Flash Reduction Maintenance System (ARMS) in conformance with OESC 2024 2-306(3) to provide reduced arc fault clearing time.
- .2 Unless otherwise indicated ARMS mode shall be enabled via integrated breaker mounted switch and indicating light.
- .3 Arc Flash Reduction Maintenance System pickup settings shall be based on the project Arc Flash Hazard Reduction study.

Part 3 Execution

3.1 INSTALLATION

- .1 Install circuit breakers as indicated complete with all necessary mounting hardware and filler panels if necessary.
- .2 Provide lamicoid labels for series rating breakers. Lamicoid label to state "Series Rating Breaker." Lamicoid to be size 2.
- .3 Provide lamicoid labels for ARMS capable breakers. Lamicoid label to state "Arc Flash Reduction Maintenance System Breaker." Lamicoid to be size 2.

END OF SECTION

Part 1 General

1.1 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with Electrical General Requirements Section.

Part 2 Products

2.1 SWITCHES

- .1 Line Voltage Wall Switches
 - .1 AC switches must conform to CSA C22.2 No. 111 (latest edition).
 - .2 AC switches with following features:
 - .1 Terminal holes approved for No. 10 AWG wire.
 - .2 Silver alloy contacts.
 - .3 Urea or melamine molding for parts subject to carbon tracking.
 - .4 Suitable for back and side wiring.
 - .5 Toggle style (Rocker style) (architect to select colour).
 - .3 Toggle operated fully rated for tungsten filament and fluorescent lamps, and up to 80% of rated capacity of motor loads.
 - .4 AC Switches of one manufacturer throughout project.
 - .5 Provide 2 keys per keyed switch.
 - .6 Occupancy sensor switches shall be dual technology style (PIR and Ultrasonic) where noted on the drawings.
 - .7 Acceptable Materials:
 - .1 Single Pole : Hubbell Cat #HBL1201
 - .2 Three Way: Hubbell Cat. #HBL1203
 - .3 Four Way: Hubbell Cat. #HBL1204
 - .4 Illuminated: Hubbell Cat. #HBL1221IL (light on with load off)
 - .5 Keyed: Hubbell Cat. #HBL1221 Series
 - .1 Keys: Hubbell Cat. #HBL1209
 - .6 Motor Rated: Hubbell Cat. #HBL1221PL
 - .7 Single Pole (Decora): Hubbell Cat #HBL2101
 - .8 Three Way (Decora): Hubbell Cat #HBL2103
 - .9 Four Way (Decora): Hubbell Cat. #HBL2124
 - .10 Single Relay Occupancy Sensor includes:
 - .1 Legrand Cat. #DW-100
 - .2 Greengate Cat. #ONW-D-1001
 - .3 Sensorswitch Cat. #WSXA Series

- .11 Dual Relay Occupancy Sensor includes:
 - .1 Legrand Cat. #DW-200
 - .2 Greengate Cat. #ONW/VNW-D-1001-DMV-N
 - .3 Sensorswitch Cat. #WSXA Series
- .8 Acceptable toggle switch alternate manufacturers include:
 - .1 Pass & Seymour
 - .2 Leviton.
- .2 Line Voltage 0-10V Dimming Switches
 - .1 0-10V Dimmers are to be provided complete with the following features:
 - .1 Rating of 15A or 20A, 120V or 347V.
 - .2 0-10V dimming leads
 - .3 Capable of operation with four switch locations.
 - .4 DIP switches or local programming through switch buttons to change mode of operation.
 - .5 Integral on/off switch.
 - .6 Devices must mount in single gang box or multi-ganged where noted.
 - .7 Device and faceplate colour must match other wiring devices.
 - .8 Integral dual technology occupancy sensors (PIR and Ultrasonic).
 - .2 Acceptable Materials:
 - .1 0-10V Occupancy Wall Sensor Switch (Decora): Legrand Cat. #DW-311
 - .2 0-10V Dimming Switch: Leviton Cat. #ZS057 Series
 - .3 Acceptable alternative manufacturer's include:
 - .1 Legrand
 - .2 Leviton
 - .3 Lutron
 - .4 Sensor Switch
 - .5 Greengate
- .3 Digital Interval Timer Switches
 - .1 Where noted supply and install a digital pre-set countdown time switch with the following features:
 - .1 minimum 1/6 HP rated contacts, mounted in recess single gang outlet box.
 - .2 Six (6) pre-set time selection buttons with options up to 1 hour.
 - .3 Unit shall be complete with activation indicator lights.
 - .4 Unit shall have integral On/Off button.
 - .5 White finish unless noted otherwise. (final finish selection by Architect).
 - .2 Acceptable Materials:
 - .1 Legrand Cat. #RT-50

- .3 Acceptable alternative manufacturer's include:
 - .1 Leviton
 - .2 Lutron
 - .3 Hubbell

2.2 RECEPTACLES

- .1 Receptacles, plugs, and other similar wiring devices must conform to CSA 22.2 No 42 (latest edition).
- .2 Duplex receptacles, CSA type 5-15 R, 125 V, 15 A, U ground, with following features (20A where noted):
 - .1 Urea molded housing (Colour by architect).
 - .2 Suitable for No. 10 AWG for back and side wiring.
 - .3 Break-off links for use as split receptacles.
 - .4 Eight back wired entrances, four side wiring screws.
 - .5 Triple wipe contacts and rivetted grounding contacts.
- .3 Other receptacles with ampacity and voltage as indicated.
- .4 Receptacles of one manufacturer throughout project.
- .5 Acceptable materials:
 - .1 Standard Devices
 - .1 Standard duplex receptacle: Hubbell Cat # HBL5252CN
 - .2 T-slot receptacles: Hubbell Cat. #HBL5352
 - .3 Tamper resistant receptacle: Hubbell Cat # BR15TR
 - .4 Tamper resistant T-slot receptacle: Hubbell Cat. #BR20TR
 - .5 Automatically Controlled Receptacles (Green): Hubbell Cat. #BR15C2GN(Green)
 - .2 Above 20A
 - .1 Dryer receptacle: Hubbell Cat # HBL9430A
 - .2 Range receptacle: Hubbell Cat # HBL9450A
 - .3 Decora Style Devices
 - .1 Decora Style: Surge duplex receptacle: Hubbell Cat. #HBL5260SA
 - .2 Ground fault protected T-slot receptacles: Hubbell Cat. # GF20L A
 - .3 USB charger duplex receptacles: Hubbell Cat. # USB15X2 XX
 - .4 USB charger T-slot receptacles: Hubbell Cat. #USB20X2 XX
 - .5 Decora style duplex receptacle: Hubbell Cat. # HBL2152
 - .6 Decora T-slot receptacle: Hubbell Cat. # HBL2162
 - .7 Decora tamper resistant receptacle: Hubbell Cat. #DR15TR
 - .8 Decora tamper resistant T-slot receptacle: Hubbell Cat. #DR20TR

- .4 Tamper resistant
 - .1 Tamper resistant ground fault protected receptacle: Hubbell Cat. #GFTR15
 - .2 Tamper resistant ground fault protected T-slot receptacle: Hubbell Cat. #GFTR20
 - .3 Tamper resistant duplex receptacle complete with dual USB ports: Hubbell Cat. #USB15XXX
 - .4 Automatically Controlled Tamper Resistant Receptacles (Green): Hubbell Cat. #BR15C2GNTR
- .5 Hospital grade decora style duplex receptacle for patient care environments or as otherwise indicated on plans:
Hubbell Cat. #2172RW
- .6 Acceptable alternate manufacturers include:
 - .1 Pass & Seymour
 - .2 Leviton
- .7 Residential grade equivalents for materials noted above for use within residential dwelling units.

2.3 COVER PLATES

- .1 Cover plates from one manufacturer throughout project.
- .2 Sheet steel utility box cover for wiring devices installed in surface-mounted utility boxes.
- .3 Stainless steel, brushed, 1 mm (1/32") thick cover plates for wiring devices mounted in flush-mounted outlet box.
- .4 Sheet metal cover plates for wiring devices mounted in surface-mounted FS or FD type conduit boxes.
- .5 Weatherproof cover plates complete with gaskets and "heavy-duty in use" covers in conformance with the Electrical Safety Authority. Provide product equal to Intermatic Cat. #WP5100C.
- .6 Where noted on plans for exterior weatherproof GFCI receptacles at grade, provide extra-duty single gang horizontal die cast receptacle covers. NEMA 3R rated complete with lockable hasp and reinforced hinge. Suitable for use with 12-gauge cord sets. Intermatic Cat. # WP1010HMXD or equal.
- .7 Where noted on plans for exterior weatherproof cover plates at GFCI receptacles on residential balconies above grade, within 760mm of balcony railing, to avoid climbing hazard provide product equal to Intermatic Cat. #WP7000 (low-profile, in-use, extra-duty).
- .8 Provide p-touch labels on cover plates for all receptacles. Labels shall include source panel and branch circuit, including switch leg indicator as applicable for automatically controlled receptacles.

Part 3 Execution

3.1 INSTALLATION

- .1 Switches:
 - .1 Install single throw switches with handle in "UP" position when switch closed.
 - .2 Install switches in gang type outlet box when more than one switch is required in one location.
 - .3 Mount toggle switches at height specified in Electrical General Requirements Section or as indicated.
- .2 Receptacles:
 - .1 Install receptacles in gang type outlet box when more than one receptacle is required in one location.
 - .2 Mount receptacles at height specified in Electrical General Requirements Section or as indicated.
 - .3 Where split receptacle has one portion switched mount vertically and switch upper portion.
- .3 Occupancy sensors:
 - .1 Occupancy sensors shall be set to 5 minutes "delay to off" unless otherwise noted.
- .4 Occupancy sensors and dimmers:
 - .1 Switches with occupancy sensors and dimmers shall be programmed as follows:
 - .1 5 minutes "delay to off" unless otherwise noted.
 - .2 "Auto on" to 50% dimming level.
- .5 Cover plates:
 - .1 Protect stainless steel cover plate finish with paper or plastic film until painting and other work is finished.
 - .2 Install suitable common cover plates where wiring devices are grouped.
 - .3 Do not use cover plates meant for flush outlet boxes on surface-mounted boxes.
- .6 Dimmer:
 - .1 Dimming Switches
 - .1 Mount devices at height as specified in Electrical General Requirements Section.
 - .2 Install in upright position as per manufacturer's installation instructions.
 - .3 Provide class II 0-10V control wiring from 0-10V dimming switch to each fixture driver in 21mmC.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 Canadian Standards Association (CSA)
 - .1 CSA C22.2 No.248.12/94, Low Voltage Fuses Part 12: Class R (Bi-National Standard with, UL 248-12 (1st Edition).
 - .2 CSA C22.2 No. 106-M92 (latest edition).

1.2 MAINTENANCE MATERIAL

- .1 Three spare fuses of each type and size installed.

1.3 DELIVERY AND STORAGE

- .1 Ship fuses in original containers.
- .2 Store fuses in original containers in moisture free location.

Part 2 Products

2.1 FUSES GENERAL

- .1 Fuses: product of one manufacturer for entire project.
- .2 Fuses specified below must conform to CSA C22.2 No. 106 (latest edition). Fuses conforming to standard C22.2 No. 106-1953 will be rejected.
- .3 Fuses must provide a fully co-ordinated system for both overload and fault conditions.

2.2 FUSE TYPES

- .1 Class L fuses (formerly HRC-L) for ratings 601-6000 A.
 - .1 Time delay, capable of carrying 500% of its rated current for 10 s minimum.
 - .2 Fast acting as noted.
- .2 Class J fuses (formerly HRCI- J).
 - .1 Time delay, capable of carrying 500% of its rated current for 10 s minimum.
 - .2 Fast acting as noted.
- .3 Class R fuses (formerly HRCI- R). For UL Class RK1 fuses, peak let-through current and I^2t values not to exceed limits of UL 198E-1982, table 10.2.

2.3 ACCEPTABLE PRODUCTS

- .1 Service Entrance:
 - 1-600 A: Mersen Type CJ
 - 601-6000 A: Mersen Type CL

- .2 Motor Protection:
 - 1-600 A: Mersen Type AJT
 - 601-2000 A: Mersen Type A4BT
- .3 Other acceptable manufacturers:
 - .1 GEC
 - .2 Little Fuse

Part 3 Execution

3.1 INSTALLATION

- .1 Install fuses in mounting devices immediately before energizing circuit.
- .2 Ensure correct fuses fitted to physically matched mounting devices.
 - .1 Install Class R rejection clips for HRCI-R fuses.
- .3 Ensure correct fuses fitted to assigned electrical circuit.

END OF SECTION

Part 1 General

1.1 PRODUCT DATA

- .1 Submit product data in accordance with Electrical General Requirements Section.

Part 2 Products

2.1 DISCONNECT SWITCHES

- .1 Enclosed manual air break switches must conform to CSA C22.1 No.4 (latest edition).
.2 Fuseholder assemblies must conform to CSA C22.2 No.39 (latest edition).
.3 Fusible, and/or non-fusible, horsepower rated disconnect switches, size as indicated.
.4 Provision for padlocking in off switch position by three locks.
.5 Mechanically interlocked door to prevent opening when handle in ON position.
.6 Fuses: size as indicated, to Fuses - Low Voltage Section.
.7 Fuseholders: relocatable and suitable without adaptors, for type and size of fuse indicated.
.8 Quick-make, quick-break action.
.9 ON-OFF switch position indication on switch enclosure cover.
.10 Disconnects feeding elevator controllers must be equipped with two auxiliary contacts approved by the elevator supplier.
.11 Service entrance rated with fault bracing, fusing and barrier as required.

2.2 EQUIPMENT IDENTIFICATION

- .1 Provide equipment identification in accordance with Electrical General Requirements Section.
.2 Indicate name of load controlled on size 4 nameplate.

2.3 ACCEPTABLE MANUFACTURERS

<u>Manufacturer</u>	<u>General Purpose</u>	<u>Weather Proof</u>
Eaton	IHD Series	3HD Series
Schneider Electric	Type A Series	Type R Series
Siemens	ID Series	NFR/FR Series

Part 3 Execution

3.1 INSTALLATION

- .1 Install disconnect switches complete with fuses if applicable.
- .2 Connect auxiliary contacts to elevator controller using conduit, wire and route approved by the elevator supplier.
- .3 Disconnect switches mounted on mechanical rooftop equipment shall be installed minimum 750 mm (30") above finished roof to be protected against damage and weather (snow build up).

END OF SECTION

Part 1 General

1.1 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings in accordance with Electrical General Requirements Section.
- .2 Indicate:
 - .1 Mounting method and dimensions.
 - .2 Starter/contactor size and type.
 - .3 Layout of identified internal and front panel components.
 - .4 Enclosure types.
 - .5 Wiring diagram for each type of starter.
 - .6 Interconnection diagrams.

1.2 OPERATION AND MAINTENANCE DATA

- .1 Provide operation and maintenance data for incorporation into manual specified in Electrical General Requirements Section.
- .2 Include operation and maintenance data for each type and style of starter/contactor.

1.3 MAINTENANCE MATERIALS

- .1 Provide maintenance materials in accordance with Electrical General Requirements Section.
- .2 Provide listed spare parts for each different size and type of starter:
 - .1 1 operating coil.
 - .2 3 fuses.
 - .3 10% indicating lamp bulbs used.

Part 2 Products

2.1 MATERIALS

- .1 Starters: must conform to CSAC22.2 No. 14 (latest edition) and EEMAC E14-1.
- .2 Control transformers must conform to CSAC22.2 No. 66 (latest edition).
- .3 Auto-transformers must conform to CSAC22.2 No 47 (latest edition).
- .4 Contactors must conform to CSA C22.2 No. 14 (latest edition).
- .5 Half size starters will not be accepted. NEMA and IEC rated starters are acceptable.

2.2 MANUAL MOTOR STARTERS

- .1 Single and Three phase manual motor starters of size, type, rating, and enclosure type as indicated, with components as follows:
 - .1 Switching mechanism, quick make and break.
 - .2 One or Three overload heaters, manual reset, trip indicating handle.
 - .3 Toggle switch: standard duty labeled "on"/"off".
 - .4 Indicating light: standard duty type and red colour.
 - .5 Locking tab to permit padlocking in "ON" or "OFF" position.

2.3 FULL VOLTAGE MAGNETIC STARTERS

- .1 Magnetic and combination magnetic starters of size, type, rating and enclosure type as indicated with components as follows:
 - .1 Contactor solenoid operated, rapid action type.
 - .2 Motor overload protective device in each phase, manually reset from outside enclosure.
 - .3 Wiring and schematic diagram inside starter enclosure in visible location.
 - .4 Identify each wire and terminal for external connections, within starter, with permanent number marking identical to diagram.
- .2 Combination type starters to include fused disconnect switch with operating lever on outside of enclosure to control disconnect, and provision for:
 - .1 Locking in "OFF" position with up to 3 padlocks.
 - .2 Independent locking of enclosure door.
 - .3 Provision for preventing switching to "ON" position while enclosure door open.
- .3 Accessories:
 - .1 Pushbuttons Selector switches standard duty labeled as indicated.
 - .2 Indicating lights: standard duty type and color as indicated.
 - .3 1-N/O and 1-N/C spare auxiliary contacts unless otherwise indicated.
 - .4 1 red pilot light for "stop" or "off" and 1 green light for "start" or "on".

2.4 CONTROL TRANSFORMER

- .1 Single phase, dry type, control transformer with primary voltage as indicated and secondary voltage to suit remote control device, complete with secondary fuse, installed in with starter as indicated.
- .2 Size control transformer for control circuit load plus 20% spare capacity.

2.5 CONTACTORS

- .1 Electrically held and controlled by pilot devices as indicated and rated for type of load controlled.
- .2 Complete with 2 normally open and 2 normally closed auxiliary contacts unless indicated otherwise.

- .3 Mount in CSA Enclosure 1 unless otherwise indicated.
- .4 Include following options in cover:
 - .1 Red indicating lamp.
 - .2 Hand - Off - Auto selector switch.
- .5 Control transformer: mounted in contactor enclosure.
- .6 Contactors must be definite purpose.

2.6 FINISHES

- .1 Apply finishes to enclosure in accordance with Electrical General Requirements Section.

2.7 EQUIPMENT IDENTIFICATION

- .1 Provide equipment identification in accordance with Electrical General Requirements Section.
- .2 Manual starter designation label: black plate, white letters, size 1, engraved as indicated.
- .3 Magnetic starter designation label: black plate, white letters, size 2, engraved as indicated.
- .4 Contactor designation label:
black plate, white letters, size 4, indicating name of load controlled.

2.8 ACCEPTABLE MANUFACTURERS

- .1 The acceptable manufacturers are as follows:
 - .1 Allen Bradley
 - .2 Eaton
 - .3 Siemens
 - .4 Group Schneider
 - .5 Klockner Moeller

Part 3 Execution

3.1 INSTALLATION

- .1 Install starters, connect power and control as indicated.
- .2 Ensure correct fuses and overload devices elements installed.

3.2 FIELD QUALITY CONTROL

- .1 Perform tests in accordance with Electrical General Requirements Section.
- .2 Operate switches, contactors to verify correct functioning.
- .3 Perform starting and stopping sequences of contactors and relays.

- .4 Check that sequence controls, interlocking with other separate related starters, equipment, control devices, operate as indicated.
- .5 Install contactors and connect auxiliary control devices.

END OF SECTION

Part 1 General

1.1 SUMMARY

- .1 The specifications in this section describe the electrical and mechanical requirements for a protection system provided by high-energy transient voltage surge suppressors. The specified system shall provide effective, high-energy surge current diversion and be suitable for application in ANSI/IEEE C62.4.1.1 Category A, B and C environments (as tested by ANSI/IEEE C62).

1.2 STANDARDS

- .1 The specified system shall be designed, manufactured, tested and installed in compliance with the following codes and standards:
 - .1 Institute of Electrical and Electronic Engineers (ANSI/IEEE C62.11, C62.41, C62.45)
 - .2 American National Standards Institute
 - .3 National Electrical Manufacturer Association (NEMA LS-1 1992 Peak Current Testing)
 - .4 Electrical and Electronic Mfg. Association of Canada (EEMAC)
 - .5 National Fire Protection Association (NFPA 75 and 780)
 - .6 MIL Standard 220A Method of Insertion Loss Measurement
 - .7 Ontario Electrical Code
 - .8 Underwriters Laboratories UL 1283 and UL 1449 (latest edition)
 - .9 Canadian Standards (CUL)

1.3 ENVIRONMENTAL REQUIREMENTS

- .1 The operating temperature range shall be -40° to 70°C (-40° to 160°F).
- .2 No appreciable magnetic fields shall be generated.

1.4 SUBMITTALS

- .1 Product Data: Provide catalog sheets showing voltage, physical size, IEEE let through voltage for each waveform listed, UL1449 latest revision, latest edition, suppressed voltage ratings, dimensions showing construction, lifting and support points, enclosure details, per mode and per phase peak surge current, modes of discrete suppression circuitry, warranty period and replacement terms, conductor size, conductor type and lead length.
- .2 Submit product data for all components and accessories per section 26 01 16 'Electrical General Requirements'.
- .3 Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product. Indicate maximum size of circuit breaker or fuse to be connected for each unit.

- .4 List and detail all protection systems such as fuses, disconnecting means and protective features.
- .5 Provide verification that the SPD device complies with the required UL1449 latest edition, latest revision, and CSA approvals.
- .6 Provide actual let through voltage test data in the form of oscillograph results for the ANSI/IEEE C62.41 Category C3 & C1 (combination wave) and A1 (ringwave) tested in accordance with ANSI/IEEE C62.45.
- .7 Provide spectrum analysis of each unit based on MIL-STD-220A test procedures between 10 kHz and 100 kHz verifying the devices noise attenuation equals or exceeds 40 dB at 100 kHz.
- .8 Provide test report from a recognized independent testing laboratory verifying the suppressor components can survive published surge current rating on a per mode basis using the IEEE C 62.41, 8x20 microsecond current wave. Test data must be on a complete SPD with internal fusing in place. Test data on an individual module is not acceptable.

1.5 QUALITY ASSURANCE AND WARRANTY

- .1 The panel mounted SPD and supporting components shall be guaranteed by the manufacturer to be free of defects in material and workmanship for a period of thirty (30) years from the date of substantial completion of service and activation of the system to which the suppressor is attached. Additionally, during the applicable warranty period, any SPD which fails due to any electrical anomaly, including lightning, shall be repaired or replaced by the manufacturer without charge. Special or optional warranties in excess of the unit's standard warranty for purposes of this bid are not acceptable.
- .2 The warranty must specifically provide for unlimited free replacements of the SPD in the event of failure caused by the effects of lightning and all other electrical anomalies. The warranty shall cover the entire device, not just various components, such as modules only. Special warranties for the purpose of this bid are not allowed.
- .3 If the SPD units supplied do not meet the specifications as written, contractor will remove units and re-install approved SPD units to the satisfaction of the consultant. Contractor will be responsible for any and all costs associated with re-installation.

Part 2 Products

2.1 PERFORMANCE

- .1 The SPD shall be listed by ETL, UL, or other nationally recognized test laboratory to UL's 1283 and UL's 1449 standards (latest edition), and not merely the components or modules. All SPDs shall be Type 1 for use in Type 1 and Type 2 locations.

- .2 The SPD shall protect all modes L-G, L-N, L-L, and N-G, have discrete suppression circuitry in L-G, L-N and N-G, and have bidirectional, positive and negative impulse protection. Line-to-neutral-to-ground protection is not acceptable where line-to-ground is specified and accordingly reduced mode units with suppression circuitry built into only 4 modes are not acceptable. In delta systems, line-to-ground-to-line protection is not acceptable where line-to-line is specified.
- .3 Obtain all surge suppression devices through one source from a single manufacturer.
- .4 The maximum continuous operating voltage (MCOV) of all components shall not be less than 125% for a 120V system and 120% for 208 systems, and 115% for 347 and 600V systems.
- .5 All SPDs shall be equipped with a comprehensive monitoring system which shall include a visual LCD panel display providing information on unit status and phase loss/protection loss.
- .6 Each design configuration shall have the maximum single pulse surge current capacity per mode verified through testing at an independent, nationally recognized test laboratory. The manufacturer must submit a test report on a unit which was tested with internal over current fusing in place. The test shall include a UL1449 Second Edition surge defined as a 1.2 X 50 μ sec 6000V open circuit voltage waveform and an 8 X 20 μ sec 500A short circuit current waveform to benchmark the unit's suppression voltage, followed by a single pulse surge of maximum rated surge current magnitude with an approximated 8 X 20 μ sec waveform. To complete the test, another UL1449 surge shall be applied to verify the unit's survival. Compliance is achieved if the suppression voltage found from the two UL1449 surges does not vary by more than +10%. Test data on an individual module is not acceptable.
- .7 SPD manufacturer shall be Total Protection Solutions Canada, as provided by Innosys Power Inc. and represented by Medgar LCI (Contact Scott McGregor, Ph: 519-500-7120).

2.2 SERVICE ENTRANCE PROTECTION

- .1 The SPD for this location shall be as indicated on project drawings. SPD shall be separate from panelboard. Integral SPD shall not be acceptable. SPDs shall be certified to UL1283 and UL 1449 (latest edition). Type 1 for use in Type 1 or Type 2 locations. All SPD units shall be RoHS compliant.

Medium to Low Exposure: Up to 1200 amps Service entrance panels shall be protected by a 240Ka Total Protection Solutions) panel mounted SPD, model TK-ST240-3Y600-L for 347/600 wye (4W+G) volt panels and model TK-ST240-3Y208-L for 120/208 wye (4W+G) volt panels.

- .2 The manufacturer shall provide written specifications showing let-through voltage of the unit with six inches of lead length (at the module or at the lug data is not acceptable as it does not represent true "as installed" performance) pursuant to ANSI/IEEE C62.41 and C62.45, 2002, categories C1 and C3 bi-wave, 90 degree phase angle, positive polarity, measurements in peak voltage from the zero reference, all dynamic tests except N-G, and UL suppressed voltage ratings, all of which shall be no higher than:

ANSI/IEEE C62.41-1991 Measured Limiting Voltage

B3/C1 Impulse (6kV, 3kA)

Voltage (Voltage Code)	L-N	L-G	L-L	N-G
120/208 (3Y208)	502V	627V	864V	568V
347/600 (3Y600)	1090V	1144V	2017V	1155V

C3 Impulse (20kV, 10kA)

Voltage (Voltage Code)	L-N	L-G	L-L	N-G
120/208 (3Y208)	907V	1173V	1267V	1090V
347/600 (3Y600)	1537V	1707V	2470V	1800V

UL Voltage Protection Ratings

Voltage (Voltage Code)	L-N	L-G	L-L	N-G
120/208 (3Y208)	800V	800V	1200V	800V
347/600 (3Y600)	1500V	1500V	2500V	1500V

- .3 The unit shall have a peak surge current of no less than 200kA/mode, 8 X 20 us waveform, single impulse, independently verified.
- .4 Internal Fusing - Over current Protection
- .1 Each Metal Oxide Varistor, or other primary suppression component, shall be individually fused for safety and performance to allow the SPD to withstand the full rated single pulse peak surge capacity per mode without the operation or failure of the fuses. Over current fusing that limits the listed peak surge current of the SPD is not acceptable. Replaceable cartridge type per phase or per mode over current fusing is not acceptable where there is more than one MOV per mode.
- .2 For arc quenching capability, minimization of smoke and contaminants in the event of a failure, and to ensure the safest possible design, all surge components, current carrying paths and fusing shall be packed in fuse grade silica sand.
- .3 Fusing shall be present in every mode, including Neutral-to-Ground.
- .4 The fusing shall be capable of interrupting up to a 200kA symmetrical fault current with 600VAC applied.
- .5 The suppressor shall include Form C dry contacts (N.O. or N.C.) for remote monitoring capability, and shall have at minimum a EEMAC 2 steel enclosure.
- .6 The SPD shall have an internal audible alarm with mute on front cover.
- .7 SPDs for service entrance locations shall have a transient event counter with LCD panel display and reset button on the front cover.

- .8 When SPD lead lengths exceed four (4) feet, low impedance cable (LIC) supplied by the SPD manufacturer shall be utilized. LIC shall have effective lead impedance min. 75% less than standard cable, and shall have nominal impedance, capacitance and inductance values that do not exceed the following:

Nominal Impedance (@10kHz, ohms/ft) Nominal Capacitance

(pf/ft) Nominal Inductance

(μH/ft)

Line	0.009	35.6	0.098
Neutral	0.004	52.6	0.041
Ground	0.004	571	0.021

SPDs shall be installed such that lead length is minimized.

2.3 DISTRIBUTION PANEL AND MOTOR CONTROL CENTER PROTECTION

- .1 SPD(s) for this location shall be as indicated on project drawings. SPD shall be separate from panel board. Integral SPD shall not be acceptable. SPDs shall be certified to UL 1283 and UL1449 (latest edition). Type 1 for use in Type 1 and Type 2 locations.
- .2 Distribution Panels and MCCs shall be protected by a Total Protection Solutions panel mounted SPD, model TK-ST160-600NN-FL for 600 (3W+G) volt panels, model TK-ST160-3Y600-FL for 347/600 (4W+G) volt panels and model TK-ST160-3Y208-FL for 120/208 (4W+G) volt panels.
- .3 The manufacturer shall provide written specifications showing let-through voltage of the unit with six inches of lead length (at the module or at the lug data is not acceptable as it does not represent true "as installed" performance) pursuant to ANSI/IEEE C62.41 and C62.45, 2002, categories B3/C1 and C3 bi-wave, 90 degree phase angle, positive polarity, measurements in peak voltage from the zero reference, all dynamic tests except N-G, and UL suppressed voltage ratings, all of which shall be no higher than:

ANSI/IEEE C62.41-1991 Measured Limiting Voltage

B3/C1 Impulse (6kV, 3kA)

Voltage (Voltage Code)	L-N	L-G	L-L	N-G
120/208 (3Y208)	502V	627V	864V	568V
347/600 (3Y600)	1090V	1144V	2017V	1155V

C3 Impulse (20kV, 10kA)

Voltage (Voltage Code)	L-N	L-G	L-L	N-G
120/208 (3Y208)	907V	1173V	1267V	1090V
347/600 (3Y600)	1537V	1707V	2470V	1800V

UL Voltage Protection Ratings

Voltage (Voltage Code)	L-N	L-G	L-L	N-G
120/208 (3Y208)	800V	800V	1200V	800V
347/600 (3Y600)	1500V	1500V	2500V	1500V

- .4 The unit shall have a peak surge current of no less than 160kA/phase, 80kA/mode, 8 X 20 us waveform, single impulse, verified by third party test reports.
- .5 Internal Fusing - Over current Protection
 - .1 Each Metal Oxide Varistor, or other primary suppression component, shall be individually fused for safety and performance to allow the SPD to withstand the full rated single pulse peak surge capacity per mode without the operation or failure of the fuses. Over current fusing that limits the listed peak surge current of the SPD is not acceptable. Replaceable cartridge type per phase or per mode over current fusing is not acceptable where there is more than one MOV per mode.
 - .2 For arc quenching capability, minimization of smoke and contaminants in the event of a failure, and to ensure the safest possible design, all surge components, current carrying paths and fusing shall be packed in fuse grade silica sand.
 - .3 Fusing shall be present in every mode, including Neutral-to-Ground.
 - .4 The fusing shall be capable of interrupting up to a 200kA symmetrical fault current with 600VAC applied.
- .6 The suppressor shall include Form C dry contacts (N.O. or N.C.) for remote monitoring capability, and shall have at minimum a Nema 4 steel enclosure.
- .7 The SPD shall have an internal audible alarm with mute on front cover.

2.4 SUBPANEL AND LIGHTING PANEL PROTECTION

- .1 SPD(s) for this location shall be as indicated on project drawings. SPD shall be separate from panel board. Integral SPD shall not be acceptable. SPDs shall be certified to UL1283 and UL1449 (latest edition). Type 1 for use in Type 1 and Type 2 locations.
- .2 Subpanels and lighting panels shall be protected by a panel mounted SPD, TK-LP120-3Y208-L-F for 120/208 (4W+G) volt recessed panels and TK-TT2-065-3Y208-FL for surface mounted panels.

- .3 The manufacturer shall provide written specifications showing let-through voltage of the unit with six inches of lead length (at the module or at the lug data is not acceptable as it does not represent true "as installed" performance) pursuant to ANSI/IEEE C62.41 and C62.45, 2002, categories A1 & A3 ring wave, 180 degree phase angle, category B3 Ringwave, and UL suppressed voltage ratings, 90 degree phase angle, positive polarity, measurements in peak voltage from the zero reference, all dynamic tests except N-G, which shall be no higher than:

ANSI/IEEE C62.41-1991 Measured Limiting Voltage

A1 Ring Wave (2kV, 67A) Tested at 180 degree phase angle

Voltage (Voltage Code)	L-N	L-G	L-L	N-G
120/208 (3Y208)	29V	46V	39V	40V

A3 Ring Wave (6kV, 200A) Tested at 180 degree phase angle

Voltage (Voltage Code)	L-N	L-G	L-L	N-G
120/208 (3Y208)	56V	61V	88V	112V

B3 Ring Wave (6kV, 500A) Tested at 90 degree phase angle

Voltage (Voltage Code)	L-N	L-G	L-L	N-G
120/208 (3Y208)	437V	592V	612V	324V

UL Voltage Protection Ratings

Voltage (Voltage Code)	L-N	L-G	L-L	N-G
120/208 (3Y208)	700V	700V	1000V	700V

- .4 The unit shall have a peak surge current of no less than 120kA/phase, 60kA/mode, 8 X 20 us waveform, single impulse, verified by third party test reports.

- .5 Internal Fusing - Over current Protection

- .1 Each Metal Oxide Varistor, or other primary suppression component, shall be individually fused for safety and performance to allow the SPD to withstand the full rated single pulse peak surge capacity per mode without the operation or failure of the fuses. Over current fusing that limits the listed peak surge current of the SPD is not acceptable. Replaceable cartridge type per phase or per mode over current fusing is not acceptable where there is more than one MOV per mode.
- .2 For arc quenching capability, minimization of smoke and contaminants in the event of a failure, and to ensure the safest possible design, all surge components, current carrying paths and fusing shall be packed in fuse grade silica sand.

- .3 Fusing shall be present in every mode, including Neutral-to-Ground.
- .4 The fusing shall be capable of interrupting up to a 200kA symmetrical fault current with 600VAC applied.
- .6 The SPD shall be capable of attenuating internally generated ringing type transients and noise, and shall have an enhanced transient filter supported by a specification sheet which lists the IEEE A1 Ring Wave let-through levels no higher than those set forth above.
- .7 Due to space limitations, the enclosure shall not exceed 4.0" D x 4.0" W x 10.3" H to allow close-to-the load installation on flush mount panels and between adjacent panel board. For recessed panels, a flush mount cover plate shall be provided with each unit along with a flush mount accessory kit Cat. #LP-FMP.
- .8 The suppressor shall include Form C dry contacts (N.O. or N.C.) for remote monitoring capability, and shall have at minimum a Nema 1 steel enclosure.
- .9 The SPD shall have an internal audible alarm with mute on front cover.

2.5 PHONE LINE PROTECTION

- .1 The telephone line surge suppressors shall be Total Protection Solutions model TK-CT2-190TLP4-TB for 4 pair. Coordinate with owner IT representative for phone service characteristics. Provide a minimum of terminal block suppression units to handle a minimum of telephone lines.
- .2 The unit shall be listed under UL 497A, Standard for Secondary Protectors for Communications Circuits.
- .3 The unit shall have a data transmission rate up to 16.0 Mbps.
- .4 Each conductor shall have less than 1 ohm of internal series resistance per wire.
- .5 Each pair of conductors shall have a peak surge current of no less than 2,000 amps, 8 x 20 us waveform.
- .6 The suppressor shall come standard with not less than a ten year warranty which provides for unlimited free replacements of damaged units. Special warranties in excess of the unit's standard warranty for purposes of this bid are not acceptable.
- .7 The maximum let-through voltage on an IEC 10 x 700 us impulse (2kV/80A) shall be 240 volts tip-ring, 240 volts tip to ground, and 240 volts ring to ground.
- .8 The response time of the components of the unit shall be less than one nanosecond.
- .9 Obtain all surge suppression devices through one source from a single manufacturer.
- .10 For quality assurance, manufacturer must provide proof that manufacturer has been regularly engaged in the design, manufacturing and testing of SPDs of the types and ratings required for a period of not less than five years.

Part 3 Execution

3.1 INSTALLATION

- .1 Install the SPDs with the conductors as short and straight as practically possible.
- .2 Follow the SPD manufacturer's recommended installation practice as outlined in the equipment installation manual. The electrical contractor shall ensure that all neutral conductors are bonded to the system ground at the service entrance or the serving isolation transformer prior to installation of the associated SPD.
- .3 Main service entrance units shall be installed on a 60 amp breaker that meets or exceeds the fault current rating of the switchgear.
- .4 Distribution, branch panel, and motor control center units shall be installed on 30 amp dedicated circuit breakers, or, where indicated, shall be wired directly to the main lugs or feed through lugs, or wired directly to the bus bars.
- .5 The installing contractor shall comply with all applicable codes.
- .6 SPD units shall be wired such that connection cable lead lengths are minimized. SPD manufacturer to advise installing contractor on required locations of low impedance cables (LICs).
- .7 **SPD manufacturer shall include in tender for pre-installation visit to the job site to confirm recommended installation methods. Indicate provision for this visit on shop drawing submission.**
- .8 **The entire SPD installation must be inspected by an authorized manufacturer's representative and supply certificate of completion. This cost shall be included in the tender price. Indicate provision for this inspection on shop drawing submission.**

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 American National Standards Institute/Institute of Electrical and Electronics Engineers (ANSI/IEEE)
 - .1 ANSI/IEEE C62.41- 1991, Recommended Practices for Surge Voltages in Low-Voltage AC Power Circuits.
- .2 American Society for Testing and Materials (ASTM)
 - .1 ASTM F1137- 88 (1993), Specification for Phosphate/Oil and Phosphate/Organic Corrosion Protective Coatings for Fasteners.
- .3 United States of America, Federal Communications Commission (FCC)
 - .1 FCC (CFR47) EM and RF Interference Suppression.
- .4 IESNA LM-79-08, IES Electrical Method for the Electrical and Photometric Measurements of Solid State Lighting Products.

1.2 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings in accordance with Electrical General Requirements Section for all light fixtures supplied under this contract.
- .2 Submit complete photometric data prepared by independent testing laboratory for luminaires where specified, for review by Consultant.
- .3 Photometric data to include: VCP Table spacing criterion.

1.3 SCOPE

- .1 This contractor is responsible to supply and install all lighting fixtures as scheduled and/or indicated including lamp and those accessories required for a complete lighting system. This contractor must coordinate lighting installations with all other Divisions of this project.
- .2 All fixtures must be CSA approved or approved at this contractor's expense by the Special Inspection Division of the Electrical Safety Authority.

1.4 GUARANTEE

- .1 Guarantees for materials replacement shall be as follows from date of ready for takeover.
 - .1 LED lamps: 3 months
 - .2 LED fixtures, and driver: 5 years.
- .2 The labour required to replace these ballasts, lamps or drivers must be included in the above guarantee, however only for the extent of the contract guarantee and warranty period as noted in Electrical General Requirements.

Part 2 Products

2.1 FIXTURE CONSTRUCTION

- .1 Fixtures must be constructed of 20 gauge (minimum) cold rolled steel. All metal edges require smooth finish.
- .2 Light leaks must be prevented by providing gasketting, stops, and barriers.
- .3 Fixtures must be finished in high reflective baked white enamel. This surface must have a reflectance of not less than 85%.
- .4 **All fixtures operating on 347 Volts must be provided with an integral disconnecting means.**

2.2 FIXTURE LENS

- .1 Unless otherwise noted fixture lenses shall be as follows:
 - .1 Lens thickness: 3.2 mm (1/8")
 - .2 Material: injection moulded clear prismatic virgin acrylic
 - .3 Frame: hinged, latched, steel.

2.3 LED FIXTURES

- .1 Fixture LEDs must be tested in conformance with IESNA LM80 standard.
- .2 LEDs must be selected using a binning algorithm to ensure colour and lumen output of a given fixture are consistent, as well as meet or surpass ANSI C78.377 specification for the rated lifetime of the fixture. Colour accuracy between products must be within a 2-step MacAdam ellipse.
- .3 Luminaires must be tested to IESNA LM79 by an independent approved laboratory.
- .4 Luminaires must be tested prior to shipping.
- .5 Luminaires must be ULC certified and approved for use in Canada.
- .6 Fixtures must maintain a minimum of 90% of their initial light output for 60,000 hours. Submit test results upon request.
- .7 Lumen values indicated for fixtures in the project documents are to be considered as "absolute" or "delivered" values.
- .8 Other than for specialty fixtures, and unless otherwise indicated, the maximum driver current is to be 750 mA.

2.4 STANDARD EXIT LIGHTING UNITS

- .1 Exit lighting units must conform to CSA C860, CSA 22.2 No. 141 (latest edition).
- .2 Housing: extruded aluminum housing, white finish.
- .3 Face and back plates: extruded aluminum.
- .4 Lamps: 2W LED.
- .5 Operation: 25 year.

- .6 Units are to be provided with three (3) pictogram legends indicating "left from here", "straight from here", and "right from here".
- .7 Face plate to remain captive for relamping.

2.5 SELF-POWERED COMBINATION EXIT/EMERGENCY LIGHTING UNITS

- .1 Exit lighting units must conform to CSA C860, CSA 22.2 No. 141 (latest edition).
- .2 Housing: Extruded aluminum housing. White Finish.
- .3 Face and back plates: Extruded aluminum.
- .4 Lamps 2W LED (EXIT).
- .5 Operation: 25 year life.
- .6 Units are to be provided with three (3) pictogram legends indicating "left from here", "straight from here", and "right from here".
- .7 Face plate to remain captive for relamping.
- .8 Supply voltage: As noted on drawings.
- .9 Output voltage: 12 V DC.
- .10 Battery: Sealed maintenance free 10 year life.

Note: Battery must be capable of supplying the wattage indicated for a minimum of 30 minutes.
- .11 Charger: Solid state, voltage/current regulated, inverse temperature compensated, short circuit protected, with regulated output of plus or minus 0.01 V for plus or minus 10% V input variation.
- .12 Solid state transfer circuit.
- .13 Signal lights: "AC Power On" condition and "charging" condition.
- .14 Lamp heads: Integral on unit, 345° horizontal and 180° vertical adjustment. Lamp type: minimum 4 watt LED.
- .15 Mounting: Suitable for universal mounting directly on junction box and complete with knockouts for conduit. Removable or hinged front panel for easy access to batteries.
- .16 Cabinet: finish: White.
- .17 Auxiliary equipment:
 - .1 Test switch.

2.6 EMERGENCY LIGHTING UNITS

- .1 Emergency lighting units must conform to CSA C22.2 No 141 (latest edition).
- .2 Supply voltage: As noted on drawings.
- .3 Output voltage: 12 V DC.

- .4 Battery: Sealed, maintenance free, 10 year life.
Note: Battery units must be capable of supplying the wattage indicated for a minimum of 30 minutes.
- .5 Charger: Solid state, multi rate, voltage/current regulated, inverse temperature compensated, short circuit protected with regulated output of plus or minus 0.01 V for plus or minus 10% input variations.
- .6 Solid state transfer circuit.
- .7 Low voltage disconnect: Solid state, modular, operates at 80% battery output voltage.
- .8 Signal lights: "AC Power ON" condition and "charging" condition.
- .9 Lamp heads: Integral on unit, 345° horizontal and 180° vertical adjustment. Lamp type: minimum 4 watt LED.
- .10 Cabinet suitable for direct or shelf mounting to wall and complete with knockouts for conduit. Removable or hinged front panel for easy access to batteries.
- .11 Auxiliary equipment:
 - .1 Test switch.
 - .2 Ac input and DC output terminal blocks inside cabinet.
 - .3 Shelf.
 - .4 Cord and plug connection for AC. **(Not applicable on 347 V units).**

2.7 REMOTE EMERGENCY LIGHTING FIXTURES

- .1 Remote emergency lighting fixtures must conform to CSA C22.2 No141 (latest edition).
- .2 Fixtures shall be small "micro" size or recessed style as indicated in the Light Fixture Schedule.
- .3 Fixtures must be adjustable type heads with canopy.
- .4 Fixtures are to be provided with protective lexan cube when specified in the Light Fixture Schedule.
- .5 Unless otherwise indicated surface mounted fixtures in washrooms, locker rooms, changerooms, and gymnasiums must be provided with wire guard.

2.8 ACCEPTABLE LIGHTING MANUFACTURERS

- .1 Refer to the light fixture schedule as indicated on drawings.

2.9 ACCEPTABLE FIXTURE ENERGY LISTINGS

- .1 Fixtures as noted on lighting fixture schedules are to be DLC or Energy Star listed as noted. Equal manufacturers shall supply proof of DLC/Energy Star listing as part of fixture approval and shop drawing process.

Part 3 Execution

3.1 INSTALLATION

- .1 Locate and install luminaires as indicated. Luminaires are not to be supported from the roof deck. Provide additional Unistrut support channel and/or support from structure. Co-ordinate with consultant on site.
- .2 Ball align hangers must be provided for rod suspended fixtures.
- .3 Fixtures surface mounted to suspended ceilings must be secured through ceiling assembly to cross member supports. These supports are to be steel channels or angles independently secured **to structure** using # 12 "jack" chain. Each chain must be secured so no fixture weight is added to the ceiling assembly.
- .4 Plaster frames/flange kits must be provided by this Division for fixtures recessed in plaster and/or drywall ceilings.
- .5 Where specified, fixtures to be chain hung shall be hung using "jack" chain with a capacity to suit the fixture weight. Branch circuit wiring feeding these fixtures shall be AC90 cable "ty-wrapped" at 900 mm (36") intervals along length of drop. Final appearance must be neat and professional.
- .6 Install exit lighting units with illuminated faces and chevrons/arrows indicating path(s) of exit as indicated. Unless otherwise noted install exit fixtures at 2400 mm (8'-0") above finished floor.
- .7 Install emergency lighting units and associated remote mounted fixtures as indicated.
- .8 Direct "heads" on units and remote mounted fixtures to illuminate path(s) of exit.
- .9 Install emergency lighting units and remote fixtures at 300 mm (12") below finished ceiling, unless indicated otherwise.
- .10 Provide a 15 A 120 V duplex receptacle (connected to circuit indicated) adjacent to unit. **Not applicable on 347 V units. This receptacle connection is to be no lower than 8'-0" (2400 mm) AFF.**
- .11 **Special installation: Secure fixtures to structure to conform to the Electrical Safety Code using "jack chain" NOT ceiling suspension wire. Where coreslab is used, suspension point must be independent of the one used for suspension of the ceiling assembly. As an alternate to jack chain the contractor may use a pre-manufactured aircraft cable suspension and fastening system as manufactured by Gripple (Gripple Cat. #HF02-10F2). Provide minimum 2 per fixture.**
- .12 All battery units are to be provided with a visible lamicoid label indicating the unit number as per drawings.

3.2 WIRING

- .1 Connect luminaires to lighting circuits as indicated.
- .2 Connect exit fixtures to exit lighting circuits and unit equipment (if applicable).
- .3 Connect unit equipment to circuits as indicated.

- .4 All wiring of remote emergency fixtures shall be minimum #10 T90 for each circuit and run in conduit. Wiring must be sized in conformance with manufacturer's recommendations for distances required.

3.3 LUMINAIRE ALIGNMENT

- .1 Align luminaires mounted in continuous rows to form straight uninterrupted line.
- .2 Align luminaires mounted individually parallel or perpendicular to building grid lines.

3.4 DELIVERIES

- .1 Fixtures are to be completely assembled at the manufacturer's plant and delivered to the project site in original unitized containers. Ensure that a dry, protected and secure space is available for proper storage before scheduling delivery of fixtures.

3.5 TESTING/CERTIFICATION

- .1 At the completion of the project and in the presence of the consultant, test all exit and emergency fixtures. On company letterhead, the contractor is to prepare a chart indicating:
 - .1 Project
 - .2 Date
 - .3 Equipment type
 - .4 Certification of correct connection
 - .5 Certification of correct operation
 - .6 Duration of test in minutes (minimum 30)
 - .7 Actual period of testing (time of day)

3.6 INTEGRATED LIFE SAFETY SYSTEM TESTING

- .1 This electrical contractor shall participate in integrated testing of this life safety system in conformance with Electrical General Requirements. Include all associated costs in tender.

3.7 ADDITIONAL INSTALLED EXIT SIGNS

- .1 The electrical contractor is to include in their bid the cost to add three (3) additional standard exit lighting units to be installed and tested in locations as directed by the consultant. Note: This installation and test will be occurring after the initial testing/certification testing is complete.

END OF SECTION

Part 1 General

1.1 SUMMARY

- .1 The lighting controls system will be supplied as a cash allowance. This section includes information on the system for pricing of installation. This is a wired lighting control system utilizing low voltage network cabling, comprised of the following components:
 - .1 System Software Interfaces
 - .1 Management Interface
 - .2 Visualization Interface
 - .2 Wired Control System Devices
 - .1 Wall Stations
 - .2 Digital Key Switches
 - .3 Auxiliary Input/Output Devices
 - .4 Occupancy and Photocell Sensors
 - .5 Wall Switch Sensors
 - .6 Relay Packs and Secondary Relays
- .2 The contractor shall provide, install and verify proper operation of all equipment necessary for proper operation of the system as specified herein and as shown on applicable drawings.
- .3 All equipment must be CSA approved or approved at this contractor's expense by the Special Inspection Division of the Electrical Safety Authority.
- .4 Reference section 26 51 13 for Lighting information.
- .5 Reference section 26 27 26 Wiring Devices for wall mounted sensor switches.
- .6 Reference section 26 05 75 for Line Voltage Power Packs and associated analog sensors.

1.2 SUBMITTALS

- .1 Submit shop drawings in accordance with Section 26 01 16.
- .2 Submit composite wiring diagrams and control schedule for each room control circuit type as proposed to be installed. Include load type, sequence of operation, sensor parameters, time delays, sensitivities and daylighting set points.
- .3 Catalog cut sheets with performance specifications demonstrating compliance with specified requirements.

1.3 QUALITY ASSURANCE

- .1 Product Qualifications
 - .1 System electrical components shall be listed or recognized by a nationally recognized testing laboratory (e.g., UL, ETL, or CSA) and shall be labeled with required markings as applicable.
 - .2 System luminaires and controls shall be certified by the manufacturer to have been designed, manufactured, and tested for interoperability.
- .2 Installation and Startup Qualifications
 - .1 System startup shall be performed by qualified personnel approved or certified by the manufacturer.
- .3 Service and Support Requirements
 - .1 Phone Support: Toll-free technical support shall be available. The manufacturer shall provide an online tool to schedule a technical support appointment. Manufacturer shall provide 24/7 emergency support.
 - .2 Onsite Support: The manufacturer shall offer onsite support that is billable.

1.4 WARRANTY

- .1 The manufacturer shall provide a minimum five-year warranty on all hardware devices supplied and installed. Warranty coverage shall begin on the date of shipment.
- .2 The hardware warranty shall cover repair or replacement of any defective products within the warranty period.

Part 2 Equipment

2.1 SYSTEM PERFORMANCE REQUIREMENTS

- .1 System Architecture
 - .1 System shall have an architecture that is based upon these main concepts: (1) plug and play (local network) intelligent lighting control devices, and (2) standalone lighting control zones using distributed intelligence.
 - .2 Intelligent lighting control devices shall have individually addressable local network communication capability and consist of one or more basic lighting control components: occupancy sensor, photocell sensor, relay, dimming output, contact closure input, analog 0-10V input, and manual wall station capable of indicating switching, dimming, and/or scene control. Combining one or more of these components into a single device enclosure shall be permissible so as to minimize overall device count of system.
 - .3 System must be capable of interfacing directly with integrated controls luminaires such that low voltage network cabling is used to interconnect luminaires with control components such as sensors, switches and system backbone.

- .4 Intelligent lighting control devices shall support individual (unique) configuration of device settings and properties, with such configuration residing within the controlled luminaires and intelligent control devices.
- .5 Lighting control zones consisting of one or more intelligent lighting control devices and shall be capable of providing automatic control from sensors (occupancy and/or photocell) and manual control from local wall stations without requiring connection to a higher-level system backbone; this capability is referred to as “distributed intelligence.”
 - .1 Lighting control zones (wired) of at least 128 devices per zone shall be supported.
- .6 Intelligent lighting control devices shall have distributed intelligence programming stored in non-volatile memory, such that following any loss of power the lighting control zones shall operate according to their defined default settings and sequence of operations.
- .7 All system devices shall support firmware update, either remotely or from within the applications space, for purposes of upgrading functionality at a later date.
- .2 Wired Networked Control Zone Characteristics
 - .1 Connections to devices within a wired lighting control zone and to backbone components shall be with a single type of low voltage network cable, which shall be compliant with CAT5e specifications or higher. To prevent wiring errors and provide cost savings, the use of mixed types of low voltage network cables shall not be permitted.
 - .2 Devices in an area shall be connected via a “daisy-chain” topology. “Hub-and-spoke” topology, requiring all individual networked devices to be connected back to a central component, shall not be permitted, so as to reduce the total amount of network cable required for each control zone.
 - .3 System shall provide the option of having pre-terminated plenum rated low voltage network cabling supplied with hardware to reduce the opportunity for improper wiring and communication errors during system installation.
 - .4 Following proper installation and provision of power, all devices connected with low voltage network cable shall automatically form a functional lighting control zone without requiring any type of programming, regardless of the programming mechanism (e.g. software application, handheld remote, pushbutton).
 - .1 The “out of box” default sequence of operation is intended to provide typical sequence of operation to minimize the system startup and programming requirements and to also have functional lighting control operation prior to system startup and programming.
 - .5 Once software is installed, system shall be able to automatically discover all connected devices without requiring any provisioning of system or zone addresses.
 - .6 All devices shall have the ability to detect improper communication wiring and blink its LED in a specific cadence as to alert installation/startup personnel.

- .7 Control devices intended for control of egress and/or emergency light sources shall not require the use of additional, externally mounted UL924 shunting and/or 0-10V disconnect devices, so as to provide a compliant sequence of operation while reducing the overall installation and wiring costs of the system. The following types of wired networked control devices shall be provided for egress and/or emergency light fixtures:
 - .1 Low-Voltage power sensing: These devices shall automatically provide 100% light level upon detection of loss of power sensed via the low voltage network cable connection.
 - .2 UL924 Listed Line-Voltage power sensing: These devices shall be listed as emergency relays under the UL924 standard, and shall automatically close the load control relay and provide 100% light output upon detection of loss of power sensed via line voltage connection to normal power.
- .8 Wired networked Wall stations shall provide the follow Scene Control Capabilities:
 - .1 Preset Scenes that can activate a specific combination of light levels across multiple local and global channels, as required.
 - .2 Profile Scenes that can modify the sequence of operation for the devices in the area (group) in response to a button press. This capability is defined as supporting "Local Profiles" and is used to dynamically optimize the occupant experience and lighting energy usage.
 - .1 Wall stations shall be able to manually start and stop Local Profiles, or the local profile shall be capable of ending after a specific duration of time between 5 minutes and 12 hours.
 - .2 Parameters that shall be configurable and assigned to a Local Profile shall include, but not be limited to, fixture light level, occupancy time delay, response to occupancy sensors (including enabling/disabling response), response to daylight sensors (including enabling/disabling response), and enabling/disabling of wall stations.
 - .3 3-way / multi-way control: multiple wall stations shall be capable of controlling the same local and global control zones, so as to support "multi-way" preset scene and profile scene control.
- .3 Supported Sequence of Operations
 - .1 Control Zones
 - .1 Intelligent lighting control devices installed in an area (also referred to as a group of devices) shall be capable of transmitting and tracking occupancy sensor, photocell sensor, and manual switch information within at least 48 unique control zones to support different and reconfigurable sequences of operation within the area. These shall also be referred to as local control zones.

- .2 Wall station Capabilities
 - .1 Wall stations shall be provided to support the following capabilities:
 - .1 On/Off of a local control zone.
 - .2 Continuous dimming control of light level of a local control zone.
 - .2 3-way / multi-way control: multiple wall stations shall be capable of controlling the same local control zones, so as to support “multi-way” switching and/or dimming control.
- .3 Occupancy Sensing Capabilities
 - .1 Occupancy sensors shall be configurable to control a local zone.
 - .2 Multiple occupancy sensors shall be capable of controlling the same local zones. This capability combines occupancy sensing coverage from multiple sensors without consuming multiple control zones.
 - .3 System shall support the following types of occupancy sensing sequence of operations:
 - .1 On/Off Occupancy Sensing
 - .2 Partial-On Occupancy Sensing
 - .3 Partial-Off Occupancy Sensing
 - .4 On/Off, Partial-On, and Partial-Off Occupancy Sensing modes shall function according to the following sequence of operation:
 - .1 Occupancy sensors shall automatically turn lights on to a designated level when occupancy is detected. To support fine tuning of Partial-On sequences the designated occupied light level shall support at least 100 dimming levels.
 - .2 Occupancy sensors shall automatically turn lights off or to a dimmed state (Partial-Off) when vacancy occurs or if sufficient daylight is detected. To support fine tuning of Partial-Off sequences the designated unoccupied dim level shall support at least 100 dimming levels.
 - .3 To provide additional energy savings the system shall also be capable of combining Partial-Off and Full-Off operation by dimming the lights to a designated level when vacant and then turning the lights off completely after an additional amount of time.
 - .4 Photocell readings, if enabled in the Occupancy Sensing control zone, shall be capable of automatically adjusting the light level during occupied or unoccupied conditions as necessary to further reduce energy usage. Additional requirements and details for photocell sensing capabilities are indicated under *Photocell Sensing Capabilities*.
 - .5 The use of a wall station shall change the dimming level or turn lights off as selected by the occupant. The lights shall optionally remain in this manually-specified light level until the zone becomes vacant; upon vacancy the normal sequence of operation, as defined above, shall proceed.

- .5 To accommodate diverse types of environments, occupancy time delays before dimming or shutting off lights shall be specifiable for control zones between 15 seconds to 2 hours.
- .4 Photocell Sensing Capabilities (Automatic Daylight Sensing)
 - .1 Photocell sensing devices shall be configurable to control a local zone.
 - .2 The system shall support the following type of photocell-based control:
 - .1 Continuous Dimming: The control zone automatically adjusts its dimming output in response to photocell readings, such that a minimum light level consisting of both electric light and daylight sources is maintained at the task. The photocell response shall be configurable to adjust the photocell setpoint and dimming rates.

2.2 SYSTEM CABLING REQUIREMENTS

- .1 Provide conduit and cabling for all Lighting Control Systems.
- .2 Controls devices are to be installed, cabled, and connected by this electrical contractor.
- .3 Electrical design drawing lighting control schematics are generic and meant to show intent of controls approach. Contact lighting control system manufacturer rep for lighting control system schematics, wiring diagrams, controls risers, sensor layouts, etc. and installation instructions prior to bid.
- .4 All devices have RJ-45 female ports. Making network control cables on site is required.
- .5 Cabling for system shall be Category 5e as per manufacturer's recommendations.
 - .1 Cable shall be 4 pair, 24 AWG solid bare annealed copper conductors, ANSI/TIA/EIA-568-B.2 and ISO/IEC 11801 category 5e compliant.
 - .2 The jacket shall be printed with TRU-Mark™ 1000' to 0' marking system, CMP (FT-6) rated with outer sheath colour for each level in the system to be according to advisement by school board representative
 - .3 Shall be suitable for use indoor, riser or plenum, and horizontal applications.

2.3 SYSTEM PROGRAMMING REQUIREMENTS

- .1 Programming capabilities shall include the following:
 - .1 Switch/occupancy/photosensor zone configuration.
 - .2 Manual/automatic on modes.
 - .3 Turn-on dim level.
 - .4 Occupancy sensor time delays.
 - .5 Dual technology occupancy sensors sensitivity.
 - .6 Photosensor calibration adjustment and auto-setpoint.
 - .7 Multiple photosensor zone offset.
 - .8 Trim level settings.
 - .9 Preset scene creation and copy for scene capable devices.
 - .10 Application of custom device labels to individual connected lighting control devices.

2.4 WIRED DEVICES

- .1 Wired Wall Switches, Dimmers, Scene Controllers
 - .1 Devices shall recess into single-gang switch box and fit a standard Decorator opening.
 - .2 Communication and low voltage power shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors.
 - .3 All switches shall have the ability to detect when it is not receiving valid communication and blink its LED in a pattern to visually indicate a potential wiring issue.
 - .4 Devices with mechanical push-buttons shall provide tactile and LED user feedback.
 - .5 Devices with mechanical push-buttons shall be made available with custom button labeling.
 - .6 Wall switches & dimmers shall support the following device options:
 - .1 Number of control zones: 1, 2 or 4
 - .2 Control Types Supported:
 - .1 On/Off
 - .2 On/Off/Dimming
 - .3 On/Off/Dimming/Correlated Color Temperature Control for specific luminaire types
 - .3 Colors: Ivory, White, Light Almond, Gray, Black, Red
 - .7 Scene controllers shall support the following device options:
 - .1 Number of scenes: 1, 2 or 4
 - .2 Control Types Supported:
 - .1 On/Off
 - .2 On/Off/Dimming
 - .3 Preset Level Scene Type
 - .4 On/Off/Dimming/Preset Level for Correlated Color Temperature
 - .5 Reprogramming of other devices within daisy-chained zone so as to implement user selected lighting scene. This shall support manual start/stop from the scene controller, or optionally programmed to automatically end after a user selectable duration between 5 minutes and 12 hours.
 - .6 Selecting a lighting profile to be run by the system's upstream controller so as to implement a selected lighting profile across multiple zones. This shall support manual start/stop from the scene controller, or optionally programmed to automatically end after a user selectable duration between 5 minutes and 12 hours.
 - .3 Colors: Ivory, White, Light Almond, Gray, Black, Red

.2 Wired Graphic Wall Stations

- .1 Device shall surface mount to single-gang switch box.
- .2 Device shall have a 3.5", capacitive full color touch screen.
- .3 Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply.
- .4 Device shall enable mobile application control of control zones and scenes through Bluetooth.
- .5 Communication shall be over standard low voltage network cabling with RJ-45 connectors.
- .6 Device shall enable user supplied screen saver image to be uploaded within one of the following formats: jpg, png, gif, bmp, tif.
- .7 Device shall enable configuration of all switches, dimmers, control zones, and lighting preset scenes via password protected setup screens.
- .8 Graphic wall stations shall support the following device options:
 - .1 Number of control zones: Up to 16
 - .2 Number of scenes: Up to 16
 - .3 Profile type scene duration: User configurable from 5 minutes to 12 hours
 - .4 Colors: White, Black

.3 Wired Digital Key Switches

- .1 Devices shall recess into single-gang switch box and fit a standard GFI opening.
- .2 Communication and low voltage power shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors.
- .3 All switches shall have the ability to detect when it is not receiving valid communication and blink its LED in a pattern to visually indicate a potential wiring issue.
- .4 Devices shall have LED user feedback to provide indication of on/off status of the programmed lights or scene, as well as indication of device power.
- .5 Digital key switches shall support the following device options:
 - .1 Control Types Supported:
 - .1 On/Off
 - .2 On/Off/Dimming
 - .3 Preset Level Scene Type
 - .4 Reprogramming of other devices within daisy-chained zone so as to implement user selected lighting scene. This shall support manual start/stop from the scene controller, or optionally programmed to automatically end after a user selectable duration between 5 minutes and 12 hours.

- .5 Selecting a lighting profile to be run by the system's upstream controller so as to implement a selected lighting profile across multiple zones. This shall support manual start/stop from the scene controller, or optionally programmed to automatically end after a user selectable duration between 5 minutes and 12 hours.
 - .2 Colors: Ivory, White, Light Almond, Stainless Steel
 - .4 Wired Auxiliary Input / Output (I/O) Devices
 - .1 Devices shall be plenum rated and be inline wired, screw mountable, or have an extended chase nipple for mounting to a ½" knockout.
 - .2 Communication and low voltage power shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors.
 - .3 Auxiliary Input/Output Devices shall be specified as an input or output device with the following options:
 - .1 Contact closure or Pull High input
 - .1 Input shall be programmable to support maintained or momentary inputs that can activate local or global scenes and profiles, activate lights at a preconfigured level, ramp light level up or down, or toggle lights on/off.
 - .2 0-10V analog input
 - .1 Input shall be programmable to function as a daylight sensor.
 - .3 RS-232/RS-485 digital input
 - .1 Input supports activation of up to 4 local or global scenes and profiles, and on/off/dimming control of up to 16 local control zones.
 - .4 0-10V dimming control output, capable of sinking up to 20mA of current
 - .1 Output shall be programmable to support all standard sequence of operations supported by system.
 - .5 Digital control output via EdoLED LEDcode communication
 - .1 Output shall be programmable to support light intensity control, as well as optional correlated color temperature (CCT) control, of the connected luminaire.
 - .5 Wired Occupancy and Photosensors
 - .1 Occupancy sensors shall sense the presence of human activity within the desired space and fully control the on/off function of the lights.
 - .2 Sensors shall utilize passive infrared (PIR) technology, which detects occupant motion, to initially turn lights on from an off state, thus preventing false on conditions. Ultrasonic or Microwave based sensing technologies shall not be accepted.
 - .3 For applications where a second method of sensing is necessary to adequately detect maintained occupancy (such as in rooms with obstructions), a sensor with an additional "dual" technology shall be used.

- .4 Dual technology sensors shall have one of its two technologies not require motion to detect occupancy. Acceptable dual technology includes PIR/Microphonics (also known as Passive Dual Technology or PDT) which both looks for occupant motion and listens for sounds indicating occupants. Sensors where both technologies detect motion (PIR/Ultrasonic) shall not be acceptable.
- .5 All sensing technologies shall be acoustically passive, meaning they do not transmit sound waves of any frequency (for example in the Ultrasonic range), as these technologies have the potential for interference with other electronic devices within the space (such as electronic white board readers and hearing devices). Acceptable detection technologies include Passive Infrared (PIR), and/or Microphonic technology. Ultrasonic or Microwave based sensing technologies shall not be accepted.
- .6 System shall have ceiling, fixture, recessed & corner mounted sensors available, with multiple lens options available customized for specific applications.
- .7 Communication and low voltage power shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors.
- .8 All sensors shall have the ability to detect when it is not receiving valid communication and blink its LED in a pattern to visually indicate a potential wiring issue.
- .9 Sensor programming parameter shall be available and configurable remotely from the software and locally via the device push-button.
- .10 Ceiling mount occupancy sensors shall be available with zero or one integrated dry contact switching relays, capable of switching 1 amp at 24 VAC/VDC (resistive only).
- .11 Sensors shall be available with one or two occupancy "poles", each of which provides a programmable time delay.
- .12 Sensors shall have optional features for photosensor/daylight override, automatic dimming control, and low temperature/high humidity operation.
- .13 Photosensor shall provide for an on/off set-point, and a dead band to prevent the artificial light from cycling. Delay shall be incorporated into the photocell to prevent rapid response to passing clouds.
- .14 Photosensor and dimming sensor's set-point and dead band shall be automatically calibrated through the sensor's microprocessor by initiating an "Automatic Set-point Programming" procedure. Min and max dim settings as well as set-point may be manually entered and/or modified.
- .15 Dead band setting shall be verified and modified by the sensor automatically every time the lights cycle to accommodate physical changes in the space (i.e., furniture layouts, lamp depreciation, or lamp outages).
- .16 A dual zone option shall be available for On/Off Photocell, Automatic Dimming Control Photocell, or Combination units. The secondary daylight zone shall be capable of being controlled as an "offset" from the primary zone.

- .6 Wired Wall Switch Sensors
 - .1 Devices shall recess into single-gang switch box and fit a standard GFI opening.
 - .2 Communication and low voltage power shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors.
 - .3 All wall switch sensors shall have the ability to detect when it is not receiving valid communication and blink its LED in a pattern to visually indicate a potential wiring issue.
 - .4 Devices with mechanical push-buttons shall provide tactile user feedback.
 - .5 Wall switch sensors shall support the following device options:
 - .1 User Input Control Types Supported: On/Off or On/Off/Dimming
 - .2 Occupancy Sensing Technology: PIR only or Dual Tech acoustic
 - .3 Daylight Sensing Option: Inhibit Photosensor
 - .4 Colors: Ivory, White, Light Almond, Gray, Black, Red
- .7 Wired Digital Relay Packs and Secondary Relays
 - .1 Relay Packs shall incorporate one optional Class 1 relay, optional 0-10 VDC dimming output, and contribute low voltage Class 2 power to the rest of the system.
 - .2 Relay Packs shall accept 120 or 277 VAC (or optionally 347 VAC) and carry a plenum rating.
 - .3 Secondary Relays shall incorporate the relay and 0-10 VDC or line voltage dimming output, but shall not be required to contribute system power.
 - .4 Power Supplies shall provide system power only, but are not required to switch line voltage circuit.
 - .5 Auxiliary Relay Packs shall switch low voltage circuits only, capable of switching 1 amp at 40 VAC/VDC (resistive only).
 - .6 Communication shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors. Secondary packs shall receive low voltage power via standard low voltage network cable.
 - .7 Relay Pack programming parameters shall be available and configurable remotely from the software and locally via the device push-button.
 - .8 Relays Pack shall securely mount through a threaded ½ inch chase nipple or be capable of being secured within a luminaire ballast/driver channel. Plastic clips into junction box shall not be accepted. All Class 1 wiring shall pass through chase nipple into adjacent junction box without any exposure of wire leads. Note: UL Listing under Energy Management or Industrial Control Equipment automatically meets this requirement, whereas Appliance Control Listing does not meet this safety requirement.
 - .9 When required by local code, Relay Pack must install inside standard electrical enclosure and provide UL recognized support to junction box. All Class 1 wiring is to pass through chase nipple into adjacent junction box without any exposure of wire leads.

- .10 Relay/Secondary Relay Packs shall be available with the following options:
 - .1 Relay Pack capable of full 16-Amp switching of all normal power lighting load types, with optional 0-10V dimming output capable of up to 100mA of sink current.
 - .2 Secondary Relay with UL924 listing for switching of full 16-Amp Emergency Power circuits, with optional 0-10V dimming output capable of up to 100mA of sink current.
 - .3 Relay and Secondary Relay Packs capable of full 20-Amp switching of general purpose receptacle (plug-load) control.
 - .4 Secondary Relay Pack capable of full 16-Amp switching of all normal power lighting load types.
 - .5 Secondary Relay Pack capable of 5-Amps switching and dimming 120 VAC incandescent lighting loads or 120/277 VAC line voltage dimmable fluorescent ballasts (2-wire and 3-wire versions).
 - .6 Secondary Relay Pack capable of 5-Amps switching and dimming of 120/277 VAC magnetic low voltage transformers.
 - .7 Secondary Pack capable of 4-Amps switching and dimming of 120 VAC electronic low voltage transformers.
 - .8 Secondary Relay Pack capable of louver/damper motor control for skylights.
 - .9 Secondary Relay Pack capable of providing a pulse on/pulse off signal for purposes of controlling shade systems via relay inputs.
 - .10 Secondary Relay Pack capable of switching 1 amp at 40 VAC/VDC (resistive only) with the intent to provide relay signal to auxiliary system (e.g. BAS).
 - .11 Power Supply capable of providing auxiliary bus power (no switched or dimmed load).
- .8 Control Modules for Low-Voltage Fixtures:
 - .1 Shall be powered by 120 or 277 VAC and be UL2043 listed.
 - .2 Shall be remotely configurable using networked lighting control software.
 - .3 Shall be able to provide UL924-compliant control without the need of an additional, externally-mounted device.

Part 3 Execution

3.1 INSTALLATION REQUIREMENTS

- .1 Installation Procedures and Verification
 - .1 The successful bidder shall review all required installation and pre-startup procedures with the manufacturer's representative through pre-construction meetings.
 - .2 The successful bidder shall install and connect the networked lighting control system components according to the manufacturer's installation instructions, wiring diagrams, the project submittals and plans specifications.

- .3 The successful bidder shall be responsible for testing of all low voltage network cable included in the bid. Bidder is responsible for verification of the following minimum parameters:
 - .1 Wire Map (continuity, pin termination, shorts and open connections, etc.)
 - .2 Length
 - .3 Insertion Loss

3.2 SYSTEM CABLING REQUIREMENTS

- .1 Install the work of this Section in accordance with manufacturer's printed instructions unless otherwise indicated.
- .2 Calibrate all sensor time delays and sensitivity to guarantee proper detection of occupants and energy savings.
 - .1 Adjust time delay so that controlled area remains lighted for 15 minutes after occupant leaves area or as indicated on sequence of operation.
- .3 Install power packs in accessible areas for future maintenance as indicated on design drawings.
- .4 Do not install digital relay and power packs above drywall ceilings.
- .5 Install sensors in gym where noted on plan at mid-height of wall.
- .6 It shall be the contractor's responsibility to locate and aim sensors in the correct location required for complete and proper coverage within the range of coverage as per the manufacturer's recommendations. The locations and quantities of sensors shown on the drawings are diagrammatic and indicate only the rooms which are to be provided with sensors. The contractor shall provide additional sensors if required to properly and completely cover the respective rooms.
- .7 Provide written or computer-generated documentation on the commissioning of the system including room by room description including:
 - .1 Sensor parameters, time delays, sensitivities, and daylighting setpoints.
 - .2 Sequence of operation, (e.g. manual ON, Auto OFF. etc.)
 - .3 Load Parameters (e.g. blink warning, etc.)
- .8 Re-commissioning – After 30 days from occupancy re-calibrate all sensor time delays and sensitivities to meet the Owner's Project Requirements. Provide a detailed report to the Architect / Owner of re-commissioning activity.
- .9 Include the following support service visits to site:
 - .1 Pre-wiring visit.
 - .2 ASHRAE functional testing coordination visit.
 - .3 Final system commissioning visit.
- .9 Site Commissioning
 - 1. Participate in project site commissioning with lighting control system manufacturer representative present. Coordinate project commissioning requirements with commissioning agents per that specification section.

.10 Factory Commissioning

- .1 Upon completion of the installation, the system shall be commissioned by the manufacturer's factory authorized representative who will verify a complete fully functional system.
 - .1 The electrical contractor shall provide both the manufacturer and the electrical engineer with ten working days written notice of the system startup and adjustment date.
 - .2 Upon completion of the system commissioning the factory-authorized technician shall provide the proper training to the owner's personnel on the adjustment and maintenance of the system.
 - .3 Factory commissioning shall include functional testing and documentation of the control system conforming to the "Functional Testing" requirements included in the current ASHRAE standard. This cost shall be included in the Tender Price.

.11 Cabling Installation

- .1 Cabling Contractor is to adhere to all Standards, regulations and documents listed following.
- .2 All products installed must meet or exceed all local, provincial and federal building, fire, health, safety and electrical codes.
- .3 The responsibility of this sub-contractor is to include but not be limited to:
- .4 Supply and installation of data cabling to every digital lighting control device as per manufacturer's recommendations.
- .5 Termination of data cabling as per manufacturer's recommendations.
- .6 General installation practices shall be as follows:
 - .1 Supply and install cabling to locations as detailed on floor plan(s). The Cabling Contractor shall use the cabling support system (supplied by others) to distribute the cables throughout the facility. Where the cables leave the cable support system and extend to the termination point they shall use the conduit provided or cable management system. Any horizontal exposed cable must be installed in surface raceways equal to Wiremold Series 500/700.
 - .2 All Cables and components to be installed and terminated in accordance with CSA, ANSI/EIA/TIA-568 and its' Amendments as well as UL Guidelines. Particular attention must be given to maintaining the integrity of the pair twists, bend radius and ensuring proper distance is kept from fluorescent light fixtures, electrical cables or any other source of EMI.
 - .3 The maximum horizontal run length is not to exceed 457 m (1,500').
 - .4 Avoid scraping, denting, or otherwise damaging cables, before, during or after installation. The Cabling Contractor without any additional compensation shall replace damaged cables.
 - .5 Ensure that all cable lengths are sufficient to allow for slack, vertical runs, wastage, connectorization, and future moves.

- .6 Bush, ream and remove any sharp projections on all conduits prior to installation of communications cables.
- .7 When terminating copper cables remove only enough cable jacket to perform termination, untwist pairs a maximum of 13 mm (1/2") for, Enhanced Category 5e.

3.3 SYSTEM SEQUENCE OF OPERATION PROGRAMMING

- .1 System shall be programmed according to the Sequence of Operation as listed on design drawings.
- .2 Include intended Sequence of Operation programming with system shop drawings for review and approval.

3.4 SYSTEM STARTUP

- .1 Upon completion of installation by the installer, including completion of all required verification and documentation required by the manufacturer, the system shall be started up and programmed.
 - .1 For CAT5e wired devices, low voltage network cable testing shall be performed prior to system startup.
- .2 System start-up and programming shall include:
 - .1 Verifying operational communication to all system devices.
 - .2 Programming the network devices into functional control zones to meet the required sequence of operation.
 - .3 Programming and verifying all sequence of operations.
- .3 Manufacturer shall be capable of on-site or remote startup and programming.
- .4 Manufacturer shall be capable of participating in on-site project commissioning.
- .5 Lighting controls Manufacturer to include for the following visits to site:
 - .1 Pre-wiring visit.
 - .2 System setup and BAS integration visit.
 - .3 ASHRAE functional testing coordination visit.
 - .4 System commissioning visit.

3.5 PROJECT TURNOVER

- .1 System Documentation
 - .1 Submit software database file with desired device labels and notes completed. Changes to this file will not be made by the factory.
 - .2 Installing contractor to grant access to the owner for the programming database, if requested.
- .2 Owner Training
 - .1 Provisions for onsite training for owner and designated attendees to be included in submittal package.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 CAN/ULC-S524 (latest edition), Installation of Fire Alarm Systems.
- .2 ULC-S525 (latest edition), Audible Signal Appliances for Fire Alarm Systems.
- .3 CAN/ULC-S526 (latest edition), Visual Signal Appliances, Fire Alarm.
- .4 CAN/ULC-S527 (latest edition), Control Units, Fire Alarm.
- .5 CAN/ULC-S528 (latest edition), Manual Pull Stations.
- .6 CAN/ULC-S529 (latest edition), Smoke Detectors.
- .7 CAN/ULC-S530 (latest edition), Heat Actuated Fire Detectors, Fire Alarm.
- .8 CAN/ULC-S531 (latest edition), Smoke Alarms.
- .9 CAN/ULC-S536 (latest edition), Inspection and Testing of Fire Alarm Systems.
- .10 CAN/ULC-S537 (latest edition), Verification of Fire Alarm Systems.
- .11 CAN/ULC-S552 (latest edition), Inspection, Testing and Maintenance of Smoke Alarms.
- .12 CAN/ULC-S553 (latest edition), Installation of Smoke Alarms.
- .13 OBC-2024, Ontario Building Code Compendium.

1.2 DESCRIPTION OF EXISTING SYSTEM

- .1 The existing addressable system includes:
 - .1 An addressable control panel as manufactured by **Autocall** to carry out fire alarm and protection functions including receiving alarm signals, initiating general alarm, supervising system continuously, actuating zone annunciators, and initiating trouble signals.
 - .2 Trouble signal devices.
 - .3 Power supply facilities.
 - .4 Addressable manual alarm stations.
 - .5 Addressable automatic alarm initiating devices.
 - .6 Audible and visual signal devices.
 - .7 End-of-line devices.
 - .8 Annunciator(s).
 - .9 Ancillary devices.
 - .10 Interface and zone modules.
 - .11 Remote trouble indicator.

1.3 REQUIREMENTS OF REGULATORY AGENCIES

- .1 This system is subject to review by local building department officials, local fire department officials. **Therefore, submission of verification certificate and field technician device verification sheets is required prior to inspection by these officials. Schedule accordingly.**

1.4 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with Electrical General Requirements Section.
- .2 Include:
 - .1 New components.
 - .2 Complete wiring diagram for control panel replacements.

1.5 OPERATION AND MAINTENANCE DATA

- .1 Provide operation and maintenance data for Fire Alarm System for incorporation into manual specified in Electrical General Requirements Section.
- .2 Include:
 - .1 Operation and maintenance instructions for complete fire alarm system to permit effective operation and maintenance.
 - .2 Technical data - illustrated parts lists with parts catalogue numbers.
 - .3 Copy of approved shop drawings.
 - .4 List of recommended spare parts for system.

1.6 TRAINING

- .1 Arrange and pay for on-site demonstrations by fire alarm equipment manufacturer to train operational personnel in use and maintenance of fire alarm system. **Obtain written receipt of training session and include in maintenance manual.**

1.7 SYSTEM OPERATION

- .1 The existing Fire Alarm Sequence of Operation shall remain as currently programmed and to include new devices and zones per design drawings.
- .2 Refer to Fire Alarm Sequence of Operation for specific fire alarm sequence functions which generally include the following:
 - .1 Activation of audible and visual signal devices.
 - .2 Cause alarm and supervisory zone of alarm device to be indicated on control panel and remote annunciator(s).
 - .3 Cause system trouble indications.
 - .4 Activate auxiliary functions.
 - .5 Transmit signal to fire department via monitoring station.
 - .6 Log the alarm in the historical alarm log file.
 - .7 System silence parameters.
 - .8 System reset parameters.

1.8 PERFORMANCE CRITERIA

- .1 These specifications describe the minimum functional requirements for an electronically supervised, microprocessor based, fully integrated system. The initial installation shall include all the necessary electronic hardware, software and memory for a completely operable system in accordance with these specifications.

1.9 QUALITY ASSURANCE

- .1 Each and all items of the fire alarm system shall be listed as the products of a single manufacturer under the appropriate category by the Underwriter's Laboratories of Canada and shall bear the "U.L.C." label.
- .2 Each and all items of the fire alarm system shall be covered by a one year parts and labour warranty covering defects resulting from faulty workmanship and materials. The warranty shall be deemed to begin on the date the system is accepted by the Project Manager on issuance of the substantial performance certificate for the project.
- .3 All control equipment must have Transient Protection Devices to comply with U.L.C. requirements.

Part 2 Products

2.1 GENERAL

- .1 It is the intention of this renovation to maintain the existing addressable fire alarm system control panel and remote annunciator, as well as existing signal and detection devices, while expanding the system to include additional control panel components, additional signal devices, and additional detection devices as shown on design drawings to suit the project scope.

2.2 ADDRESSABLE MANUAL ALARM STATIONS

- .1 Manual alarm stations shall be addressable, single action, non-coded, semi-flush mounted type. Pull stations shall be break-glass style. Contacts are to activate when the handle is pulled down.
- .2 Addressable pull station electronics shall be mounted to the back plate of the station. The station's address will be set at the time of installation. Device addressing shall be accomplished by either an electrical or mechanical means.
- .3 Where noted on drawings, stations are to be equipped with tamperproof guard equal to Stopper II Cat. # STI-1100.
- .4 Where noted on drawings, stations are to be relocated to code required mounting height via the use of surface raceway and surface device box or pre-manufactured ADA station relocater raceway equal to Edwards EST Cat. # RR-32RL.

2.3 CONVENTIONAL MANUAL ALARM STATIONS

- .1 Manual alarm stations: pull lever, style, wall mounted semi-flush type, non-coded single pole normally open contact for single stage, English signage.

- .2 Where noted on drawings, stations are to be relocated to code required mounting height via the use of surface raceway and surface device box.

2.4 INTELLIGENT DETECTORS-GENERAL OPERATION

- .1 Addressable devices shall use simple to install and maintain decade, numbered 0 to 9, address switches. Detectors that have expanded addressing will have decade switch numbered from 0 to 15 for the most significant digit to allow detector addressing from 1 to 250.
- .2 Device addressing shall be accomplished by either an electrical or mechanical means.
- .3 Detectors shall be intelligent (analog) and addressable and shall connect with two wires to the fire alarm control panel signalling line circuits.
- .4 Addressable smoke detectors shall provide dual alarm and power/polling LEDs. Both LEDs shall flash under normal conditions, indicating that the detector is operational and in regular communication with the control panel, and both LEDs shall be placed into steady illumination by the control panel, indicating that an alarm condition has been detected. If required, the LED flash shall have the ability to be removed from the system program. An output connection shall also be provided in the base to connect an external remote alarm LED.
- .5 The fire alarm control panel shall permit detector sensitivity adjustment through field programming of the system. Sensitivity shall be automatically adjusted by the panel on a time-of-day basis.
- .6 Using software in the FACP, detectors shall automatically compensate for dust accumulation and other slow environmental changes that may affect their performance.
- .7 The detectors shall be ceiling-mount and shall include a separate twist-lock base with tamper proof feature.
- .8 The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself (by activating a magnetic switch) or initiated remotely on command from the control panel.
- .9 Detectors shall also store an internal identifying type code that the control panel shall use to identify the type of device (PHOTO, THERMAL).
- .10 Detectors will operate in an analog fashion, where the detector simply measures its designed environment variable and transmits an analog value to the FACP based on real-time measured values. The FACP software, not the detector, shall make the alarm/normal decision, thereby allowing the sensitivity of each detector to be set in the FACP program and allowing the system operator to view the current analog value of each detector.
- .11 Detectors shall provide address-setting means using decimal switches and shall also store an internal identifying code that the control panel shall use to identify the type of device. LEDs shall be provided that shall flash under normal conditions, indicating that the device is operational and is in regular communication with the control panel.

- .12 Addressable devices shall provide address-setting means using decimal switches and shall also store an internal identifying code that the control panel shall use to identify the type of device. LED(s) shall be provided that shall flash under normal conditions, indicating that the device is operational and is in regular communication with the control panel.
- .13 The sensors shall be of a low profile design and ULC listed for both ceiling and wall mount applications.
- .14 Automatic smoke sensors shall be equipped with a dust cover, which shall be removed at the time of verification to prevent dust and dirt entering the smoke chamber during construction.
- .15 A magnetic test switch shall be provided to test detectors and modules. Detectors shall report an indication of an analog value reaching 100% of the alarm threshold.

2.5 INTELLIGENT MULTI-DETECTOR

- .1 The intelligent multi-detector shall be an addressable device, which is designed to monitor photoelectric, ionization, and thermal technologies in a single sensing device. This detector shall utilize advanced electronics which react to smaller products of combustion found in fast flaming fires (ionization), slow smouldering fires (photoelectric), and heat (thermal) all within a single sensing device.
- .2 The multi-detector shall include two bicolor LEDs, which flash green in normal operation and turn on steady red in alarm.
- .3 Detectors are to be provided with relay base where noted on the drawings.
- .4 Separately mounted photoelectric ionization and heat detectors in the same location are not acceptable alternatives.

2.6 FIXED TEMPERATURE HEAT DETECTOR

- .1 These heat detectors shall have a low mass thermistor heat sensor and operate at a fixed temperature. It shall continually monitor the temperature of the air in its surroundings to minimize thermal lag to the/ time required to process an alarm. The integral microprocessor shall determine if an alarm condition exists and initiate an alarm based on the analysis of the data. The heat detector shall have a nominal alarm point rating of 57°C (135°F). The heat detector shall be rated for ceiling installation at a minimum of 21.3m (70') centres and be suitable for wall mount applications.

2.7 FIXED TEMPERATURE / RATE OF RISE HEAT DETECTOR

- .1 These heat detectors shall have a low mass thermistor heat sensor and operate at a fixed temperature and at a temperature rate-of-rise. It shall continually monitor the temperature of the air in its surroundings to minimize thermal lag to the time required to process an alarm, The integral microprocessor shall determine if an alarm condition exists and initiate an alarm based on the analysis of the data. Systems using central intelligence for alarm decisions shall not be acceptable. The intelligent heat detector shall have a nominal fixed temperature alarm point rating of 57°C (135°F) and a rate-of-rise alarm point of 9°C (15°F) per minute. The heat detector shall be rated for ceiling installation at a minimum of 21.3m (70') centres and be suitable for wall mount applications.

2.8 PHOTOELECTRIC SMOKE DETECTOR

- .1 The intelligent photoelectric detector shall utilize a light scattering type photoelectric smoke sensor to sense changes in air samples from its surroundings. The integral microprocessor shall dynamically examine values from the sensor and initiate an alarm based on the analysis of data. The detector shall continually monitor any changes in sensitivity due to the environmental affects of dirt, smoke, temperature, aging, and humidity. The photo detector shall be rated for ceiling installation at a minimum of Soft (Olin) centres and be suitable for wall mount applications.
- .2 The percent smoke obscuration per foot alarm set point shall be field selectable to any of five sensitivity settings ranging from 1.0% to 3.5%. The photo detector shall be suitable for operation in the following environment:
 - .1 Temperature: 0°C to 49°C (32°F to 120°F)
 - .2 Humidity: 0-93% RH, non-condensing
 - .3 Elevation: no limit
- .3 Detectors are to be provided with relay base where noted on the drawings.

2.9 STANDARD DETECTOR MOUNTING BASES

- .1 Provide standard detector mounting bases suitable for mounting on North American 1-gang, 85mm (3 ½ ") or 100 mm (4") octagon box and 100 mm (4") square box. The base shall, contain no electronics, support all detector types and have the following minimum requirements:
 - .1 Removal of the respective detector shall not affect communications with other detectors.
 - .2 Terminal connections shall be made on the room side of the base. Bases which must be removed to gain access to the terminals shall not be acceptable.

2.10 INTELLIGENT DUCT SMOKE DETECTOR

- .1 The smoke detector housing shall accommodate an intelligent photoelectric detector (as noted above) that provides continuous analog monitoring and alarm verification from the panel.
- .2 When sufficient smoke is sensed, an alarm signal is initiated at the FACP, and appropriate action taken to change over air handling systems to help prevent the rapid distribution of toxic smoke and fire gases throughout the areas served by the duct system.
- .3 Duct smoke detector sensor assemblies shall be complete with duct housing, photoelectric smoke detector, and sampling tubes as required. The duct-housing base shall come complete with an auxiliary set of form C dry contacts rated at 120 VAC, 3 Amps.
- .4 The system shall automatically indicate when an individual duct sensor needs cleaning.

2.11 CONVENTIONAL AUTOMATIC ALARM INITIATING DEVICES

- .1 Thermal fire detectors: fixed temperature, non-restorable, rated 57°C (135°F) or 88°C (194°F) as indicated.

- .2 Thermal fire detectors, combination fixed temperature and rate of rise, non-restorable fixed temperature element, self-restoring rate of rise, fixed temperature 57°C (135°F) or 88°C (194°F), rate of rise 8.3°C (15°F) per minute.
- .3 Smoke detector: ceiling mounted, photo electric type, visual alarm indicator, complete with relay base where noted.
- .4 Smoke detector: photo electric type air duct type with sampling tubes with protective housing.
 - .1 Plug-in type with fixed base.
 - .2 Wire-in base assembly with integral red alarm LED, and terminals for remote alarm LED.

2.12 AUDIBLE/VISUAL SIGNAL DEVICES

- .1 Horn: flush mounted temporal horn, 24Vdc operation, 94 dBA rating at 3 m (10'), red finish, FM and ULC listed.
- .2 Mini Horns: flush mounted temporal mini horn, 24Vdc operation, selectable HIGH/LOW setting 94.5 dBA (high)/89.8 dBA (low) at 3 m (10'), white or red coverplate, FM and ULC listed. Suitable for mounting on a single gang box.
- .3 Strobe: semi-recessed, 24Vdc operation, complete with selectable 15/30/75/110 candela output (unless otherwise noted set at 75 cd), synchronized strobe, red finish, FM and ULC listed. Suitable for mounting on a single gang box.
- .4 Mini Horn/Strobe: flush mounted temporal combination mini horn/strobe, 24 Vdc operation, selectable HIGH/LOW setting 94.5 dBA (high)/89.8 dBA (low) at 3 m (10') selectable 15/30/75/110 candela output (unless otherwise noted set at 75 cd), synchronized strobe white or red coverplate, FM and ULC listed. Suitable for mounting on a single gang box.

NOTES:

- .1 **Signal devices with integral strobe lights in high abuse areas (i.e. gymnasium, change rooms, etc.) must be provided with protective wireguards.**
- .2 **Any surface mounted signal devices must be provided with suitable backboxes supplied by the manufacturer.**
- .3 **Provide synchronization modules to suit signal devices (if required by manufacturer).**
- .4 **Set signal devices in classrooms to LOW setting.**

2.13 END OF LINE RESISTORS

- .1 End-of-line resistors for signalling circuits shall be sized to ensure the correct supervisory current flows in each circuit.
- .2 End-of-line resistors shall be mounted on a stainless steel plate for mounting on a standard single gang box and bear the ULC label.

2.14 REMOTE ANNUNCIATOR PANELS

- .1 It is the intention of this renovation to maintain the existing remote annunciator panel and update the zone indicators to reflect additional zones as indicated on drawings as part of the project scope.

2.15 GRAPHIC DISPLAY (PASSIVE)

- .1 It is the intention of this renovation to replace the existing passive graphic with new which includes updated zone layout to suit project scope as indicated on drawings.
- .2 Colour graphic layout of facility showing all zones as specified/indicated. Zones shall each have descriptions and zone number indications per fire alarm zone schedule.
- .3 Display is to be found behind Plexiglas, approximate size: 500 mm x 500 mm (20" x 20"). Adjust frame size of graphic accordingly to clearly display building zones and zone labels clearly. Max frame size shall be coordinated with available wall space at indicated mounting location. Electrical trade to confirm final graphic location on site.
- .4 Finish frame to architects' direction.

2.16 INTELLIGENT MODULES – GENERAL OPERATION

- .1 The modules shall have a minimum of 2 diagnostic LED's mounted behind a finished coverplate. A green LED shall flash to confirm communication with the loop controller. A red LED shall flash to display alarm status. The module shall be capable of storing up to 24 diagnostic codes, which can be retrieved for troubleshooting assistance. Input and output circuit wiring shall be supervised for open and ground faults. The module shall be suitable for operation in the following environment:
 - .1 Temperature: 0°C to 49°C (32°F to 120°F).
 - .2 Humidity: 0-93% RH, non-condensing.

2.17 MONITOR MODULE

- .1 The monitor modules shall have the following operating characteristics:

A flashing LED indicates that the module is in communication with the control panel. The LED latches steady on alarm (subject to current limitations on the loop).
- .2 The monitor modules shall have the following features:

Nominal operating voltage:	15 to 32 VDC.
Maximum current draw:	5.1 mA (LED on)
Average operating current:	400 uA (LED flashing)
EOL resistance:	47K ohms.
Temperature range:	0°C to 49°C (32°F to 120°F)
Humidity range:	10% to 93% noncondensing
Dimensions:	114.3mm (4.5") high x 101.6 mm (4") wide x 31.75 mm (1.25") deep. Mounts to a 101.6 mm (4") square x 53.975 mm (2.1/8") deep box.

2.18 ISOLATOR MODULE

- .1 Fault isolator modules shall be provide to automatically isolate wire-to-wire short circuits on an SLC loop. The fault isolator module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC loop. If a wire-to wire short occurs, the fault isolator module shall automatically open-circuit (disconnect) the SLC loop. When the short circuit condition is corrected, the fault isolator module shall automatically reconnect the isolated section of the SLC loop. The fault isolator module shall not require any address-setting, and its' operations shall be totally automatic. It shall not be necessary to replace or reset a fault isolator module after its normal operation. The fault isolator module shall mount in a standard 10.16 cm (4") deep electrical box, in a surface-mounted backbox, or in the fire alarm control panel. It shall provide a single LED which shall flash to indicate that the isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.

2.19 CONTROL MODULE

- .1 Addressable control modules shall be provided to supervise and control the operation of one conventional NACs of compatible, 24 VDC powered, polarized audio/visual notification appliances. For fan shutdown and other auxiliary control functions, the control module may be set to operate as a dry contract relay.
- .2 The control module NACs may be wired for Style Z or Style Y (Class A/B) with up to 1 Amp of inductive A/V signal, or 2 Amps of resistive A/V signal operation, or as a dry contact (Form-C) relay. The relay coil shall be magnetically latched to reduce wiring connection requirements, and to ensure that 100% or all auxiliary relay or NACs may be energized at the same time on the same pair of wires.
- .3 The control module shall be suitable for pilot duty applications and rated for a minimum of 0.6 Amps at 30 VDC.

2.20 DOOR HOLD OPEN DEVICES

- .1 Units to be complete with the following features:
 - .1 Wall mounted style.
 - .2 Long life electromagnet.
 - .3 Low current operation.
 - .4 Completely silent operation.
 - .5 25 lbf (111N) minimum holding force.
 - .6 Adjustable swivel contact plate.
 - .7 Brushed zinc finish.
 - .8 Maintenance free operation.
 - .9 Water resistant design.
 - .10 ULC, CSA, and FM approved.

2.21 SPRINKLER AND SUPERVISED VALVE CONNECTIONS

- .1 Sprinkler and standpipe system contacts shall be provided by the mechanical/sprinkler contractor but connected into the fire alarm system by this Division.

2.22 REMOTE TROUBLE INDICATOR

- .1 A system remote trouble indicator where noted on the drawings shall be provided complete with the following features:
 - .1 Flush mounted in a double gang box.
 - .2 Trouble LED.
 - .3 Trouble buzzer.

2.23 SMOKE ALARMS 120V HARDWIRED

- .1 Photoelectric sensor 3-in-1 smoke alarm unit c/w LED strobe and CO alarm.
- .2 Integral 177 candela strobe with ability to synchronize to other interconnected strobe alarms during an alarm event.
- .3 120V hardwired with 10-year sealed battery backup (sealed 3V lithium battery on smoke and CO alarm portion only).
- .4 Low profile construction.
- .5 Auxiliary relay for use with smart building systems as specified.

2.24 SYSTEM WIRING

- .1 Maintain existing device wiring where noted on drawings for replacement devices.
- .2 The system wiring must be FSA rated in conformance with the Electrical Safety Code to suit the type of installation.
- .3 Wiring shall be minimum #18 AWG twisted shielded pair in conduit. "Securex 2" armoured cable will be permitted to be used for "drops" to devices on accessible ceilings.
- .4 As indicated on system riser diagram initiating device wiring shall be run in a loop with a home run from the last device to the control panel (Class 'A' configuration). Wiring from the "loop" module to conventional devices must be supervised, run in conduit, and conform to the standards of the Electrical Safety Code.
- .5 Signal wiring is to be cross connected in a class 'B' configuration.
- .6 Install isolator modules and end of line resistors in service rooms no higher than 2.4 M AFF. Provide location of these devices at the time of shop drawing submission.
- .7 **These are the basic wiring requirements for system operation. Prior to tender close manufacturer and contractor are to confirm all necessary wiring specifications and requirements.**

2.25 APPROVED EQUIPMENT

<u>DEVICE</u>	<u>AutoCall</u>
<u>Existing Control Panel</u>	
	4100-ES
<u>Intelligent Devices</u>	
Manual Alarm Stations 1-Stage	4099-5214
Addressable Base	4098
Heat Sensor	4098 Series
Smoke Detectors	4098 Series
Monitor Module	4090 Series
Control Module	4090 Series
Isolator Module	4090 Series
<u>Conventional and Auxiliary Devices</u>	
Smoke Alarms 3-in-1 (120V hardwired) complete with Strobe, 10 Year Sealed Battery and CO Alarm	KIDDE Cat. # P4010ACLEDSCOCA
Carbon Monoxide Alarm 120V with Battery Backup	Kidde 900-0128-001 (Pro Series CO)
Horn	True Alert Series
Mini Horn	4901 Series
Door Holder	2088 Series
Mini Horn complete with strobe	4906 Series
Strobe	4906 Series

Part 3 Execution

3.1 INSTALLATION

- .1 Install new and replacement components in accordance with CAN/ULC-S524 (latest edition) and approved manufacturers manuals and wiring diagrams. The contractor shall furnish all conduit, wiring, outlet boxes, junction boxes, cabinets and similar devices necessary for the complete installation, All wiring shall be of the type recommended by the Electrical Safety Code, approved by local authorities having jurisdiction for the purpose, and shall be installed in dedicated conduit throughout.
- .2 Disruption of fire alarm coverage for the building shall be kept to a minimum. Coordinate with owner and consultants required system shutdowns, periods of bypass, etc. to suit the required scope of renovation and replacement work.
- .3 Locate and install manual alarm stations and connect to alarm circuit wiring.
- .4 Locate and install detectors and connect to alarm circuit wiring. **Do not mount detectors within 1 m (39") of air outlets.** Maintain at least 600 mm (24") radius clear space on ceiling, below and around detectors. Locate duct type detectors in straight portions of ducts.
- .5 Connect alarm circuits to main control panel.
- .6 Locate and install signal devices and connect to signalling circuits.
- .7 Connect signalling circuits to main control panel.
- .8 Install end-of-line devices at end of applicable alarm and signalling circuits.
- .9 Locate and install door releasing devices.
Note: Door holders must release by way of local smoke detector and signal from main control panel. Provide additional relays to suit.
- .10 Locate and install remote relay units to control fan shut down.
- .11 Sprinkler system: wire alarm and supervisory switches and connect to control panel.
- .12 Connect fire suppression systems to control panel.
- .13 Where more than one smoke alarm is installed within a space, interconnect smoke alarms to each other such that audible signal sounds throughout the space upon activation of any smoke alarm. Smoke alarms are to be interconnected with 3#12 conductors in conduit and connected per manufacturers recommendations.
- .14 Provide 120V power and fire alarm connections to all fire smoke dampers c/w integral smoke detector. Connect all fire / smoke damper integral detector outputs to monitor modules for alarm condition and for monitoring of AC power to smoke damper as trouble condition at fire alarm panel based on module address. Coordinate exact location and connection requirements with mechanical contractor prior to rough-in. All fire smoke dampers c/w integral smoke detectors shall be provided and installed by mechanical contractor.

3.2 PROTECTION

- .1 Contractor is to ensure all fire protection system detectors are protected from dust, dirt, humidity, and water at all times during construction. This applies to detectors installed, stored on site or stored in storage containers. Any detectors that are damaged or dirty shall be replaced at the contractor's expense.

3.3 FIELD QUALITY CONTROL

- .1 The system shall be installed and fully tested under the supervision of trained manufacturer's representative. The system shall be demonstrated to perform all the functions as specified.

3.4 ACCEPTABLE INSTALLER

- .1 The fire alarm / life safety system specified herein shall be installed by an Authorized Electrical Contractor who is CFAA certified.

3.5 EXAMINATION

- .1 Prior to the commencement of any of the work detailed herein, an examination and analysis of the area(s) where the Fire Alarm / Life Safety System and all associated components are to be installed shall be made.
- .2 Any of these area(s) which are found to be outside the manufacturers' recommended environments for the particular specified products shall be noted on a Site Examination Report which shall be given to the Building Owners Representative, and the Consultant.
- .3 Any shorts, opens, or grounds found on existing wiring shall be corrected prior to the connection of these wires to any panel component or field device.

3.6 DEMONSTRATION

- .1 Each of the intended operations of the installed Fire Alarm / Life Safety System shall be demonstrated to the Building Owners' Representative and the Consultant.

3.7 SYSTEM TEST

- .1 Perform tests in accordance with General Electrical Requirements Section and CAN/ULC-S537-(latest edition) Standard for the Verification of Fire Alarm Systems.
- .2 Fire alarm system:
 - .1 Test each device and alarm circuit to ensure noted devices transmit alarm to control panel and actuate general alarm and ancillary devices.
 - .2 Check annunciator panels to ensure zones are shown correctly.
 - .3 Simulate grounds and breaks on alarm and signalling circuits to ensure proper operation of system.
 - .4 Class A circuits.
 - .1 Test each conductor on all circuits for capability of providing alarm signal on each side of single open-circuit fault condition imposed near middlemost point of circuit. Reset control unit after each alarm function and correct imposed fault after completion of each test.

- .2 Test each conductor on all circuits for capability of providing alarm signals during ground-fault condition imposed near middlemost point of circuit. Reset control unit after each alarm function and correct imposed fault after completion of each test.
 - .5 Class B circuits
 - .1 Test each conductor on all circuits for capability of providing alarm signal on line side of single open-circuit fault condition imposed at electrically most remote device on circuit. Reset control unit after each alarm function and correct imposed fault after completion of each test.
 - .3 The control panel shall continuously perform as automatic self-test routine on each sensor, which will functionally check the sensor electronics and ensure the accuracy of the valves being transmitted to the control panel.
 - .4 Automatic testing will occur at a rate of one sensor every four minutes.
 - .5 The sensor's average analogue value is the average of the last 2000 recorded analogue entries of its chamber.
 - .6 Any sensor that fails this test shall indicate a '**SELF-TEST ABNORMAL**' trouble condition with the sensor's address at the control panel.
 - .7 The system shall automatically indicate when an individual sensor needs cleaning. When the sensor's average value reaches a predetermined value, a '**DIRTY SENSOR**' trouble condition shall be audibly and visually indicated at the local control panel for that sensor. IF a '**DIRTY SENSOR**' indication is left unattended and its average value increases to a second predetermined value, an '**EXCESSIVELY DIRTY SENSOR**' trouble condition shall be indicated at the local control panel for that sensor. To prevent false alarms, these '**DIRTY**' conditions shall in no way decrease the amount of smoke obscuration necessary to generate an alarm condition.
 - .8 An operator having a proper access level, shall have the capability to manually access the following information from the control panel:
 - .1 Primary Status
 - .2 Device Type
 - .3 Present Average Value
 - .4 Present Sensitivity Selected*
 - .5 Highest Peak Detection Values (HVP)*
 - .6 Sensor Range (Normal, Dirty, Excessively Dirty)
- * Values shall be in 'percent of smoke obscuration' format so that no interpretation is required by the operator.

3.8 AUDIBILITY TESTING

- .1 It is the intention of this renovation to have the audibility tested in portions of the building within the scope of the project as indicated on drawings.

- .2 Audibility Testing:
 - .1 The contractor is to coordinate an audibility test prior to occupancy of the facility. The test is to be performed by the representatives of the fire alarm manufacturer in the presence of the consultant. The test report is to be in chart form indicating:
 - .1 Project
 - .2 Date of test
 - .3 Room name and number
 - .4 Ambient dB level
 - .5 Alarm dB level
 - .6 Name of testing technician
 - .2 The test results are to be submitted to the consultant for review prior to issuing to owner's representatives and/or authorities having jurisdiction.

3.9 SMOKE ALARM TESTING

- .1 Perform tests on smoke alarms in accordance with CAN/ULC-S552-(latest edition) Standard for Inspection, Testing and Maintenance of Smoke Alarms, and in accordance with manufacturer's instructions.
- .2 Smoke testing shall be completed for each smoke alarm device installed (not button testing).
- .3 Each smoke alarm shall be individually tested. Smoke alarm interconnections shall also be tested such that all connected smoke alarms will sound when any one of the smoke alarms is tested.
- .4 At the completion of the project and in the presence of the consultant, test all smoke alarms. On company letterhead, the contractor is to prepare a chart indicating:
 - .1 Project
 - .2 Date
 - .3 Equipment type
 - .4 Certification of test completion of each individual device
 - .5 Certification of testing conducted with smoke producing device
 - .6 Certification of correct operation
 - .7 Confirmation for all smoke alarms functioning together (integration between multiple smoke alarms in common space).
 - .8 Actual period of testing (time of day)

3.10 ADDITIONAL INSTALLED FIRE ALARM SYSTEM COMPONENTS

- .1 The electrical contractor is to include in their bid the cost to add two (2) additional signaling devices to be installed and verified in locations as directed by the consultant. Note: This installation and verification and subsequent audibility test will be occurring after the initial audibility testing is complete.

- .2 The electrical contractor is to include in their bid the cost to add two (2) additional fire detection devices (heat or smoke detectors) to be installed and verified in locations as directed by the consultant.
- .3 The electrical contractor is to include in their bid the cost to add five (5) additional fire smoke damper connections and 120V loss of power trouble signal with associated module and including five (5) additional isolation modules to be installed and verified as directed by the consultant.

END OF SECTION