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END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Read and conform to:
 - .1 The Contract CCDC 2-2020, Stipulated Price Contract as amended,
 - .2 Division 01 requirements and documents referred to therein.
- .2 This Section applies to and governs the work of Division 21.
- .3 The technical Sections of this Division are generally divided into units of work for the purpose of ready reference.
- .4 The division of the work among subcontractors is not the Consultant's responsibility and the Consultant assumes no responsibility to act as an arbiter and/or to establish subcontract limits between any Sections of the work.
- .5 The specifications are integral with the drawings which accompany them. Neither is to be used alone. Any item or subject omitted from one but implied in the other is fully and properly required.
- .6 Wherever differences occur in the tender documents, the most onerous condition governs. Base the bid on the costliest arrangement.

1.2 DEFINITIONS

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

materials and arrangement.

1.3 WORK INCLUDED

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

1.4 SUBMITTALS

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

review shall not mean that the Consultant approves the detailed design inherent in the shop drawings, responsibility for which shall remain with the Contractor submitting same, and such review shall not relieve the Contractor of his responsibility for errors or omissions in the shop drawings or of his responsibility for meeting all requirements of the Contract Documents. The Contractor is responsible for dimensions to be confirmed and correlated at the job site, for information that pertains solely to fabrication processes or to techniques of construction and installation and for coordination of the work of all sub trades."

- .3 As-Built Records: Prepare and submit complete as-built records prior to Substantial Performance of the Contract. Refer to paragraph 3.3 and to Division 1 for requirements. Submit two sets of as-builts drawings in AutoCAD format showing changes & concealed services dimensioned. AutoCAD files can be provided to the contractor by the Consultant at a fee of \$300.00 plus \$25.00 per sheet upon request.
- .4 Requests for Shut-Down: Obtain permission for systems shut-down and/or service interruption from the Owner prior to disruption of any system or service in use by the Owner. Employ the Owner's standard form of request where available. Refer to Division 1 for additional requirements.
- .5 Requests for Start-up: Obtain permission from the Owner to start-up or to return to service any item of equipment, system or service installed new or previously shutdown. Refer to Division 1 for additional requirements.
- .6 Contractor's Material and Test Certificates: Prepare and submit certificates for each system installed. Where certificates are prescribed by regulations, codes or standards ensure they conform to the requirements of those documents (e.g. NFPA-standards). Include a copy of each certificate in the Operation and Maintenance manual. Include the following:
 - .1 description of the system (description and type),
 - .2 description of the tests conducted, and results observed, including re-testing, where necessary,
 - .3 description of corrective measures undertaken,
 - .4 description of materials used (pipe and fittings),
 - .5 list of witnesses for each test conducted,
 - .6 date system left ready for service,
 - .7 signature of installing Contractor.
- .7 Maintenance Data and Operating Instructions
 - .1 Submit three (3) copies of Operation and Maintenance Manual individually bound in hard backed three-ring binders.
 - .2 Ensure the binder spines have typewritten lettering as follows:
OPERATION & MAINTENANCE MANUAL

for

"Insert project name"

"Insert date of submission"

Division 21 00 00

- .3 Provide a list of names, addresses and telephone numbers of equipment suppliers, installing contractors, general contractors, architect and Consultant. Include special telephone numbers for service departments on normal and emergency call basis.
- .4 Provide descriptive literature (shop drawings) of each manufactured item. Include a bill of material with purchase order numbers and vendor's identification of equipment orders for each item.
- .5 Include copies of start-up reports and checklists and all certificates issued with respect to this contract.
- .6 Ensure operating instructions include the following:
 - .1 General description of each fire suppression system altered as part of this project.
 - .2 Step by step procedure to follow in putting each piece of equipment into service.
- .7 Ensure maintenance instructions include the following:
 - .1 Manufacturer's maintenance instructions for each item of mechanical equipment installed under this Division. Instructions shall include installation instructions, parts numbers and lists, name of supplier and maintenance instructions.
 - .2 Summary list of each item of mechanical equipment.
 - .3 Equipment directory indicating name, model, serial number and nameplate data of each item of equipment supplied, and system with which it is associated.
 - .4 Copy of valve directory.
- .8 As-Built Records: Prepare and submit complete as-built records prior to Substantial Performance of the Contract. Refer to Division 01 for requirements.

1.5 QUALITY ASSURANCE

- .1 Conform to minimum requirements or better of provincial and local codes, where existing, and to requirements of local inspection authorities for execution of work under this Division.
- .2 Ensure materials supplied under this Division conform to minimum requirements and recommendations or better of applicable standards of the following:
 - .1 NFPA National Fire Protection Association
 - .2 OBC Ontario Building Code

- .3 OFC Ontario Fire Code
- .4 OFM Ontario Fire Marshall
- .3 Use latest editions and amendments in effect on date of bid call subject to requirements of OBC.
- .4 Arrange and pay for permits and inspections by authorities having jurisdiction, required in the undertaking of this Division. Make modifications required by authorities.
- .5 All tradesmen employed on the project shall hold valid trade certificates/licenses and shall make a copy available for review by the Consultant and/or Owner when requested.

1.6 JOB CONDITIONS

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

1.7 WARRANTY

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

1.8 EXTRAS AND CREDITS

- .1 Accompany price submissions requested by Consultant for extra work, or work to be deleted, with a complete cost breakdown as follows:
 - .1 Materials, quantities, and unit costs including any applicable contractors trade discount clearly identified. Provide supplier quotations.
 - .2 Labour hours and unit costs.
 - .3 Total materials and labour costs.
 - .4 Overhead and profit mark-ups in accordance with the General Conditions of the Contract.
- .2 Quotations from software such as Allpriser will not be accepted. Provide actual material costs.

2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

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

2.2 ACCEPTABLE PRODUCTS

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

2.3 EQUIVALENTS AND ALTERNATIVES

- .1 Suppliers wishing approval for additional equipment items or alternatives as equivalent to those specified **must submit complete description, technical and performance data to the Consultant at least twelve (12) working days prior to Bid closing date.** Such equivalent equipment, if accepted, must conform to specifications regarding details, accessories, modifications, features and performance. Deviations from specifications must be stated in writing at time of submission for approval.
- .2 Bid Prices shall include only products specified or approved equivalents. Contractors may propose unsolicited alternatives to the products specified. Alternative proposals shall be submitted in sealed envelope at time of general contract Bid submission and shall include full description and technical data, and a statement of the related increase or decrease in Bid Price should alternatives be accepted. All additional costs associated with unsolicited alternative proposals such as larger motor starters, larger power feeders, space revisions to associated equipment, controls, etc. shall be included in alternative price. Prior approval by Consultant is not required for unsolicited alternative proposals.
- .3 Where the Contractor uses equipment other than that first named, on which the design is based, he shall be responsible for the details of installation including

equipment size, arrangement, fit, and maintenance of required clearances. Contractor shall prepare and submit revised layouts to indicate arrangement of affected piping, ductwork, conduit, lighting, equipment, etc. Failure by Contractor to provide such drawings will be considered indication that original arrangements and space allocations are adequate.

- .4 Include in the Bid Price for additional costs associated with equivalent equipment such as larger motor starters, larger power feeders, space revisions to associated equipment, controls, changes to ductwork, piping, etc. No extras for changes arising from alternatives, equivalents (approved or otherwise) or substitutions will be considered.

2.4 SUBSTITUTIONS DURING PROGRESS OF WORK

- .1 Refer to Division 01.

2.5 CONSULTANT'S REVIEW

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

3 EXECUTION

3.1 RELATIONSHIP WITH OTHER TRADES

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

3.2 INSTALLATION REQUIREMENTS

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

3.3 CONTRACT DRAWINGS

- .1 The drawings of this Division are performance drawings and indicate general arrangement of the work. They are diagrammatic except where specific details are given.
- .2 Obtain accurate dimensions from the architectural and structural drawings, or by

measurement. Location and elevation of services are approximate. Verify them before construction is undertaken.

- .3 Make changes where required to accommodate structural conditions (beams, columns, etc.). Obtain Consultant's approval before proceeding.
- .4 Adjust the location of materials and/or equipment as directed without adjustment to contract price, provided that the changes are requested before installation and do not affect material quantity. **Note that Products may be relocated up to 10 feet (3 m) in any direction without a change to the contract price.**
- .5 Note that the layout and orientation of the ceiling outlets on the architectural reflected ceiling drawings may differ from that shown on the mechanical drawings. Make the installation in accordance with the latest architectural ceiling drawings. Provide the equipment as specified and/or shown on the documents of this Division.
- .6 The drawings of this Division are intended for tender pricing. The quantities and quality to be included in the bid price shall be based on the layout and specifications as shown on the mechanical documents. If there is a difference in quantity between the architectural and drawings of this Division, base the contract price on the greater quantity.
- .7 Prepare installation (construction) drawing to reflect the latest architectural ceiling layout.

3.4 INSTRUCTION

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

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

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Division 01.

1.2 WORK INCLUDED

- .1 Identification of existing services.
- .2 Installation, protection and maintenance of temporary services as required to support continuing operation of the facility.
- .3 Disconnection and making safe of sprinkler and fire suppression systems and equipment in areas to be demolished and/or renovated.
- .4 Disposal of waste materials in accordance with waste management requirements.

1.3 REGULATORY REQUIREMENTS

- .1 Notify authorities of intent to demolish and schedule for the work. Obtain required permits from authorities.
- .2 Conform to codes for demolition work, dust control, products requiring disconnection and re-connection.
- .3 Do not close or obstruct egress width to any building or site exit.
- .4 Do not disable or disrupt building fire or life safety systems without 3 days prior written notice to Owner.
- .5 Conform to procedures applicable when hazardous or contaminated materials are discovered.
- .6 Arrange for re-certification and inspection of changes made to any equipment, machine or apparatus by authorities having jurisdiction. This includes requirements for marking of equipment under rules 2-100 and 2-102 of the Ontario Electrical Safety Code.

1.4 JOB CONDITIONS

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

1.5 INTERRUPTIONS

- .1 Arrange execution of work to maintain present building operations, and to minimize the effect of work under this Division on existing operations.
- .2 Prior to interrupting any existing service notify the Owner and Consultant, in writing, at least Seven (7) days in advance, and obtain written authorization. Do not interrupt existing service without Consultant's specific authorization. Refer to Division 01 for requirements.
- .3 Include in Bid Price for overtime or premium time hours necessary to minimize duration of service interruption.
- .4 Test and verify the proper operation of existing equipment and systems that are shut down due to work of this project, prior to returning to service.
- .5 Assume responsibility for consequential costs on failure to obtain permission to shut down and/or start-up any item of equipment, system or service.

1.6 PHASING AND SCHEDULING

- .1 Refer to Division 01 phasing and scheduling of the work.
- .2 Coordinate with the work of all Sections of Division 21, 23, 25 and with other trades and assist in the development of the Phasing Strategy.

1.7 DISCONNECTION OF SPRINKLER PIPES FROM EXISTING SPRINKLER ZONE

- .1 This portion of the work affects the disconnecting of the existing sprinkler piping in the areas to be renovated as shown.
- .2 Review site conditions and be familiar with existing conditions such as the location and sizes of the existing main branch pipes serving the areas to be renovated.
- .3 Provide a detailed procedure or method describing the overall work for shutting down the existing sprinkler zones, draining zones, and its associated disconnection work, based on reviewed site conditions, and forward this procedure to the consultant and owner for review and approval.
- .4 Engage other parties involved that directly affect this work i.e. fire alarm contractor.

1.8 NEW SPRINKLER TIE-IN INTO AN EXISTING SPRINKLER ZONE

- .1 This portion of the work affects the reconnection of the new sprinkler main branches in the areas to be renovated.
- .2 Provide a detailed procedure or method and forward this procedure to the consultant and owner for review and approval. This submission shall describe the overall work for shutting down the existing sprinkler zone, draining zones, re-connecting the new sprinkler branch pipes to the existing zone main, and re-filling.
- .3 Engage other parties involved that directly affect this work i.e. fire alarm contractor.

1.9 FIRE WATCH

- .1 Prior to commencing work, prepare a fire watch plan and submit to the owner, and prime consultant for approval.
- .2 Do not commence Work without written approval by Owner and prime consultant of the fire watch plan.
- .3 Execute the fire watch plan during the shutdown period of the sprinkler system.
- .4 Keep a copy of the fire watch plan at the project site.

2 PRODUCTS (N/A)

3 EXECUTION

3.1 PREPARATION

- .1 Prior to start of work under this Section, ensure that the General Trades:
 - .1 Provide, erect, and maintain temporary barriers at locations indicated.
 - .2 Erect and maintain weatherproof closures for exterior openings.
 - .3 Erect and maintain temporary partitions to prevent spread of dust, odours, and noise to permit continued Owner occupancy.
 - .4 Prevent movement of structure; provide bracing and shoring.
- .2 Install, protect and maintain temporary services as required to support continuing operation of the facility.
- .3 Protect services and equipment which are not to be demolished.
- .4 Coordinate service shutdowns with Owner's project coordinator. Provide notice as required by Owner and submit schedule for the work.
- .5 Notify affected utility companies before starting work and comply with their requirements.
- .6 Mark location and termination of utilities.
- .7 Provide appropriate temporary signage including signage for exit or building egress.

3.2 RELATIONSHIP WITH OTHER TRADES

- .1 Cooperate with other trades whose work affects or is affected by work of this Division to ensure satisfactory installation and to avoid delays.
- .2 Remove and dispose of built-in items such as sleeves, anchors, and inserts.
- .3 Remove and dispose of supports and anchors for piping, mounted on or in walls, supported and suspended from the structure.

3.3 PROTECTION

- .1 Protect existing and new work to remain free from damage due to execution of work under this Division with tarpaulins and other protective coverings as necessary.
- .2 Repair damage to the building and components resulting from failure to provide sufficient protection, to the satisfaction of the Consultant.

3.4 DEMOLITION

- .1 Notify authorities of intent to demolish and schedule for the work.
- .2 Conform to codes, regulations, standards and bylaws applicable to the work.
- .3 Isolate and drain systems as required. Disconnect, cap and make safe mechanical services to the building including, but not limited to: water supply to sprinkler systems, and fire suppression systems.
- .4 Protect existing equipment and services to remain from debris and unwanted materials. Clean as necessary to maintain service during demolition period and on completion of the work.
- .5 Coordinate service shutdowns with Owner's project coordinator. Provide notice as required by Owner and submit schedule for the work.
- .6 Remove and dispose of all redundant mechanical services and equipment within the limits of the demolition site and where demolished systems extend beyond these limits.
- .7 Conform to Occupational Health & Safety and Environmental regulations. Ensure that all parties are familiar with requirements and experienced in the work to be undertaken.
- .8 Conform to the requirements of Division 1, municipal By-Laws and Ministry of the Environment regulations and standards for waste disposal.
- .9 Demolish in an orderly and careful manner. Protect existing supporting structural members.
- .10 Remove demolished materials from site except where specifically noted otherwise. Do not burn or bury materials on site.
- .11 Remove materials as Work progresses. Upon completion of Work, leave areas in clean condition.
- .12 Remove temporary Work.

3.5 RENOVATIONS

- .1 Isolate and drain systems as required to effect renovations, modifications and/or repairs. On completion of renovations, modifications and/or repairs, test entire system as if new. Report repairs or replacements required of existing equipment, piping, fittings or devices that are not included in contract to Consultant and Owner for instruction. Flush, clean and refill renovated systems as specified for new.
- .2 Relocate or remove existing items so designated unless specifically indicated to

be relocated or removed under other Sections.

- .3 Clear and repair existing items to be relocated or altered as required to suit new location. Replace damaged or ineffective parts and make the item "as new".
- .4 Existing items to be removed remain the property of the owner and shall be delivered to a location on site designated by the owner. If the owner declares no interest in the removed items, assume ownership and remove the items from the site.
- .5 Make good surfaces and finishes in areas from which items have been removed and in which items are relocated. Cap existing services required to be severed to effect alterations and do all other work necessary to make good such areas to satisfaction of consultant.
- .6 Temporarily seal openings in existing floor assemblies and vertical fire separations necessitated by installation of equipment and systems or construction with fire barrier materials such as mineral wool or other noncombustible insulation.
- .7 If during alteration work existing asbestos material, other than known asbestos, is discovered (e.g. fireproofing, acoustic or thermal insulation, tank covering), stop work in the affected area and immediately notify consultant.

END OF SECTION

1. GENERAL

1.1 GENERAL REQUIREMENTS

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

1.2 REFERENCE STANDARDS

- .1 American Society of Testing and Materials (ASTM)
 - .1 ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - .2 ASTM B61, Standard Specification for Steam or Valve Bronze Castings.
 - .3 ASTM B62, Standard Specification for composition Bronze or Ounce Metal Castings.
 - .4 ASTM A126, Standard Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
 - .5 ASTM B283 C37700, Standard Specification for Copper and Copper-Alloy Die Forgings (Hot Pressed).
- .2 American Society of Mechanical Engineers (ASME)
 - .1 ASME B16.1, Gray Iron Pipe Flanges & Flanged Fittings Class 25, 125 & 250.
 - .2 ASME B16.3, Malleable Iron Threaded Fittings, Classes 150 and 300.
 - .3 ASME B16.4, Gray Iron Threaded Fittings, Classes 125 and 250.
 - .4 ASME B16.9, Factory-Made Wrought Buttwelding Fittings.
 - .5 ASME B16.10, Face-to-Face and End-to-End Dimensions of Valves.
 - .6 ASME B16.15, Cast Copper Alloy Threaded Fittings: Classes 125 and 250.
 - .7 ASME B16.18, Cast Copper Alloy Solder Joint Pressure Fittings.
 - .8 ASME B16.22, Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
 - .9 ASME B16.39, Malleable Iron Threaded Pipe Unions: Classes 150, 250 and 300.
- .3 American Water Works Association (AWWA)
 - .1 AWWA C104, Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
 - .2 AWWA C105, Polyethylene Encasement for Ductile-Iron Pipe Systems.
 - .3 AWWA C111, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - .4 AWWA C115, Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
 - .5 AWWA C150, Thickness Design of Ductile-Iron Pipe.
 - .6 AWWA C151, Ductile-Iron Pipe, Centrifugally Cast.

- .7 AWWA C600, Standard for the Installation of Ductile Iron Water Mains and Their Appurtenances.
- .4 Factory Mutual (FM)
 - .1 Factory Mutual Approval Guide.
- .5 Manufacturers Standardization Society of Valve and Fittings Industry (MSS)
 - .1 MSS-SP-25, Standard Marking Systems for Valves, Fittings, Flanges, and Unions.
 - .2 MSS-SP-67, Butterfly Valves.
 - .3 MSS-SP-70, Gray Iron Gate Valves, Flanged and Threaded Ends.
 - .4 MSS-SP-71, Gray Iron Swing Check Valves, Flanged and Threaded Ends.
 - .5 MSS-SP-80, Bronze Gate, Globe, Angle and Check Valves.
 - .6 MSS-SP-85, Gray Iron Globe & Angle Valves, Flanged and Threaded Ends.
- .6 National Fire Protection Association (NFPA)
 - .1 NFPA 10, Standard for Portable Fire Extinguishers.
 - .2 NFPA 13, Standard for the Installation of Sprinkler Systems.
 - .3 NFPA 14, Standard for the Installation of Standpipe and Hose Systems.
 - .4 NFPA 20, Standard for the Installation of Stationary Pumps for Fire Protection.
 - .5 NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.
 - .6 NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.
- .7 Ontario Fire Code
- .8 Underwriter's Laboratories of Canada (ULC)
 - .1 CAN4 S543-M984, Standard for Internal Lug Quick Connect Couplings for Fire Hose.
 - .2 ULC/ORD C263.1, Sprinkler Protected Window Systems.
 - .3 ULC Fire Resistance Directory.
- .9 Underwriters Laboratory (UL)
 - .1 UL 199, Automatic Sprinklers for Fire-Protection Service.

1.3 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submit in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:

- .1 Submit manufacturer's instructions, printed product literature and data sheets for fire suppression products and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:
 - .1 Submit drawings stamped and signed by professional engineer registered or licensed in Ontario, Canada.
 - .2 Indicate on drawings:
 - .1 Mounting arrangements.
 - .2 Operating and maintenance clearances.
 - .3 Shop drawings and product data 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 current model production.
 - .5 Certification of compliance to applicable codes.
 - .4 In addition to transmittal letter referred to in Section 01 33 00 - Submittal Procedures: use MCAC "Shop Drawing Submittal Title Sheet". Identify section and paragraph number.

1.4 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Division 01 - Closeout Submittals.
- .2 Operation and Maintenance Data: submit operation and maintenance data for fire suppression products for incorporation into manual.
 - .1 Ensure operation and maintenance manual is approved by, and final copies deposited with Consultant before final inspection.
 - .2 Operation data:
 - .1 Control schematics for systems including environmental controls.
 - .2 Description of systems and their controls.
 - .3 Description of operation of systems at various loads together with reset schedules and seasonal variances.
 - .4 Operation instruction for systems and component.
 - .5 Description of actions to be taken in event of equipment failure.
 - .6 Valves schedule and flow diagram.
 - .7 Colour coding chart.

- .3 Maintenance data:
 - .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.
- .4 Performance data:
 - .1 Equipment manufacturer's performance datasheets with point of operation as left after commissioning is complete.
 - .2 Equipment performance verification test results.
 - .3 Special performance data as specified.
 - .4 Testing, adjusting and balancing reports as specified in Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.
- .5 Approvals:
 - .1 Submit draft copy Operation and Maintenance Manual to Consultant for approval. Submission of individual data will not be accepted unless directed by Consultant.
 - .2 Make changes as required and re-submit as directed by Consultant.
- .6 Additional data:
 - .1 Prepare and insert into operation and maintenance manual additional data when need for it becomes apparent during specified demonstrations and instructions.
- .7 Site records:
 - .1 Provide sets of prints as required for each phase of work. Mark changes as work progresses and as changes occur. Include changes to existing mechanical systems, control systems and low voltage control wiring.
 - .2 Transfer information on a weekly basis to reproducibles, revising reproducibles to show work as actually installed.
 - .3 Use different colour waterproof ink for each service.
 - .4 Make available for reference purposes and inspection.
- .8 As-Built drawings:
 - .1 Prior to start of Testing, Adjusting and Balancing for HVAC, finalize production of as-built drawings.

- .2 Identify each drawing in lower right hand corner in letters at least 12 mm high as follows: "AS BUILT DRAWINGS: THIS DRAWING HAS BEEN REVISED TO SHOW MECHANICAL SYSTEMS AS INSTALLED" (Signature of Contractor) (Date).
- .3 Submit to Consultant for approval and make corrections as directed.
- .4 Perform testing, adjusting and balancing for HVAC using as-built drawings.
- .5 Submit completed reproducible as-built drawings with Operating and Maintenance Manuals.
- .9 Submit copies of as-built drawings for inclusion in final TAB report.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- .1 Submit in accordance with Division 01 - Closeout Submittals.
- .2 Furnish spare parts as follows:
 - .1 One set of packing for each pump.
 - .2 One casing joint gasket for each size pump.
 - .3 One glass for each gauge glass.
- .3 Provide one set of special tools required to service equipment as recommended by manufacturers and in accordance with Division 01 - Closeout Submittals.
- .4 Furnish one commercial quality grease gun, grease and adapters to suit different types of grease and grease fittings.

1.6 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials off ground, indoors, in a dry location, and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect fire protection products from nicks, scratches, blemishes, theft, vandalism and vermin.
 - .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal

2. PRODUCTS

2.1 MATERIALS

- .1 HVAC&R Equipment:
 - .1 Refrigerant:
 - .1 HCFC based refrigerant.
 - .2 HFC based refrigerant.

3. EXECUTION

3.1 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for Product installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Consultant.
 - .2 Inform Consultant of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Consultant.

3.2 CONNECTION TO WATER SUPPLY

- .1 Provide mating flange and other fittings as required to connect fire suppression system to water supply piping from site services.

3.3 PAINTING REPAIRS AND RESTORATION

- .1 Do painting in accordance with Division 09 - Interior Painting.
- .2 Prime and touch up marred finished paintwork to match original.
- .3 Restore to new condition, finishes which have been damaged.

3.4 SYSTEM CLEANING

- .1 Clean interior and exterior of all systems including strainers. Vacuum interior of ductwork and air handling units.

3.5 FIELD QUALITY CONTROL

- .1 Site Tests: conduct following tests in accordance with Division 01 - Quality Control and submit report as described in PART 1 - ACTION AND INFORMATIONAL SUBMITTALS.
- .2 Manufacturer's Field Services:

- .1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in PART 1 - ACTION AND INFORMATIONAL SUBMITTALS.
- .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.

3.6 DEMONSTRATION

- .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 Use operation and maintenance manual, as-built drawings, and audio visual aids as part of instruction materials.
- .3 Instruction duration time requirements as specified in appropriate sections.

3.7 CLEANING

- .1 Progress Cleaning: clean in accordance with Division 01 - Cleaning.
 - .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Division 01 - Cleaning.
 - .1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

3.8 PROTECTION

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

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

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

1.2 SECTION INCLUDES

- .1 Pipe and equipment hangers and supports.

1.3 REFERENCES

- .1 American Society of Mechanical Engineers (ASME)
 - .1 ASME B31.9, Building Services Piping.
- .2 American Society for Testing and Materials (ASTM)
 - .1 ASTM F708, Design and Installation of Rigid Pipe Hangers.
- .3 American National Standards Institute (ANSI)
 - .1 MSS SP58, Pipe Hangers and Supports - Materials, Design and Manufacturer.
 - .2 MSS SP69, Pipe Hangers and Supports - Selection and Application.
 - .3 MSS SP89, Pipe Hangers and Supports - Fabrication and Installation Practices.
- .4 Canadian Standards Association (CSA)
 - .1 CSA S832, Seismic Risk Reduction of Operational and Functional Components (OFCs) of Buildings.
 - .2 CSA B51, Boiler, Pressure Vessel and Pressure Piping Code.
- .5 National Fire Protection Association (NFPA)
 - .1 NFPA 13, Standard for the Installation of Sprinkler Systems.
 - .2 NFPA 14, Standard for the Installation of Standpipe and Hose Systems.
- .6 Ontario Fire Code
- .7 Underwriters Laboratories (UL)
 - .1 UL 203, Pipe Hanger Equipment for Fire protection Service.

1.4 SUBMITTALS

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

assembly of components.

1.5 REGULATORY REQUIREMENTS

- .1 Conform to CSA B51 for support of piping.
- .2 Conform to CSA S832 for seismic restraint of piping and equipment.
- .3 Conform to NFPA requirements for support of piping and equipment.
- .4 Conform to ASME B31.9 requirements for support of piping.

2 PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

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

2.2 ACCESSORIES

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

3 EXECUTION

3.1 INSTALLATION

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

3.2 INSERTS

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

through-bolt with recessed square steel plate and nut above slab.

3.3 PIPE HANGERS AND SUPPORTS

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

3.4 SCHEDULES

- .1 Imperial Measure (IP)

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

- .2 Metric Measure (SI)

		Support Spacing (m)

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

END OF SECTION

1. GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Refer to Section 21 01 01.

1.2 REFERENCE STANDARDS

- .1 National Fire Prevention Association (NFPA)
 - .1 NFPA 13, Standard for the Installation of Sprinkler Systems.
 - .2 NFPA 20, Standard for the Installation of Stationary Pumps for Fire Protection.
 - .3 NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.
 - .4 NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.
- .2 Underwriter's Laboratories of Canada (ULC)
 - .1 CAN4 S543-M984, Standard for Internal Lug Quick Connect Couplings for Fire Hose.
 - .2 ULC/ORD C263.1, Sprinkler Protected Window Systems.
 - .3 ULC Fire Resistance Directory.
- .3 Underwriters Laboratory (UL)
 - .1 UL 199, Automatic Sprinklers for Fire-Protection Service.
- .4 Factory Mutual (FM)
 - .1 Factory Mutual Approval Guide.
- .5 American Society of Testing and Materials (ASTM)
 - .1 ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - .2 ASTM B61, Standard Specification for Steam or Valve Bronze Castings.
 - .3 ASTM B62, Standard Specification for composition Bronze or Ounce Metal Castings.
 - .4 ASTM A126, Standard Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
 - .5 ASTM B283 C37700, Standard Specification for Copper and Copper-Alloy Die Forgings (Hot Pressed).
- .6 American Society of Mechanical Engineers (ASME)
 - .1 ASME B16.1, Gray Iron Pipe Flanges & Flanged Fittings Class 25, 125 & 250.
 - .2 ASME B16.3, Malleable Iron Threaded Fittings, Classes 150 and 300.
 - .3 ASME B16.4, Gray Iron Threaded Fittings, Classes 125 and 250.

- .4 ASME B16.9, Factory-Made Wrought Buttwelding Fittings.
- .5 ASME B16.10, Face-to-Face and End-to-End Dimensions of Valves.
- .6 ASME B16.15, Cast Copper Alloy Threaded Fittings: Classes 125 and 250.
- .7 ASME B16.18, Cast Copper Alloy Solder Joint Pressure Fittings.
- .8 ASME B16.22, Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
- .9 ASME B16.39, Malleable Iron Threaded Pipe Unions: Classes 150, 250 and 300.
- .7 American Water Works Association (AWWA)
 - .1 AWWA C104, Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
 - .2 AWWA C105, Polyethylene Encasement for Ductile-Iron Pipe Systems.
 - .3 AWWA C111, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - .4 AWWA C115, Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
 - .5 AWWA C150, Thickness Design of Ductile-Iron Pipe.
 - .6 AWWA C151, Ductile-Iron Pipe, Centrifugally Cast.
 - .7 AWWA C600, Standard for the Installation of Ductile Iron Water Mains and Their Appurtenances.
- .8 Manufacturers Standardization Society of Valve and Fittings Industry (MSS)
 - .1 MSS-SP-25, Standard Marking Systems for Valves, Fittings, Flanges, and Unions.
 - .2 MSS-SP-67, Butterfly Valves.
 - .3 MSS-SP-70, Gray Iron Gate Valves, Flanged and Threaded Ends.
 - .4 MSS-SP-71, Gray Iron Swing Check Valves, Flanged and Threaded Ends.
 - .5 MSS-SP-80, Bronze Gate, Globe, Angle and Check Valves.
 - .6 MSS-SP-85, Gray Iron Globe & Angle Valves, Flanged and Threaded Ends.

1.3 SHOP DRAWING SUBMITTALS

- .1 Provide submittals in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Provide manufacturer's printed product literature and data sheets, and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:

- .1 Submit drawings stamped and signed by professional engineer registered or licensed in Ontario.
- .2 Indicate:
 - .1 Materials.
 - .2 Finishes.
 - .3 Method of anchorage
 - .4 Number of anchors.
 - .5 Supports.
 - .6 Reinforcement.
 - .7 Assembly details.
 - .8 Accessories.
- .4 Layout Drawings:
 - .1 Show finished ceiling areas indicating sprinkler locations coordinated with ceiling installation.
 - .2 Indicate the following:
 - .3 Name and department or agency
 - .4 Location, including street address.
 - .5 Point of compass
 - .6 Ceiling construction.
 - .7 Full height cross section.
 - .8 Location of fire walls.
 - .9 Occupancy of each area or room.
 - .10 Location and size of blind spaces and closets.
 - .11 Any questionable small enclosures in which no sprinklers are to be installed.
 - .12 Make, type and orifice size of sprinklers.
 - .13 Temperature rating and location of high temperature sprinklers.
 - .14 Number of sprinklers on each zone, and total area protected by each zone.
 - .15 Make, type, model and size of alarm valves.
 - .16 Cutting lengths of pipe or centre to centre dimensions.
 - .17 Type of hangers, inserts and sleeves.
 - .18 Control valves, checks, drain pipes and test pipes.
 - .19 Provisions for flushing.
 - .20 Name and address of contractor

- .21 A summary sheet, clearly indicating:
 - .1 Date.
 - .2 Location.
 - .3 Name of department of agency.
 - .4 Building number or other identification.
 - .5 Description of hazard.
 - .6 Name and address of contractor or designer.
 - .7 Name of approving agency.
 - .8 System design requirements, including design area of water application, minimum rate of application and area per sprinkler.
- .5 Samples:
 - .1 Submit samples of following:
 - .1 Each type of sprinkler head.
 - .2 Signs.
- .6 Test reports:
 - .1 Submit certified test reports for wet pipe fire protection sprinkler systems from approved independent testing laboratories, indicating compliance with specifications for specified performance characteristics and physical properties.
- .7 Certificates:
 - .1 Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .8 Manufacturers' Instructions:
 - .1 Provide manufacturer's installation instructions.
- .9 Field Quality Control Submittals:
 - .1 Manufacturer's Field Reports: manufacturer's field reports specified.

1.4 CLOSEOUT SUBMITTALS

- .1 Provide operation, maintenance and engineering data for incorporation into manual specified in Division 01 - Closeout Submittals in accordance with ANSI/NFPA 20.
- .2 Manufacturer's catalogue Data, including specific model, type, and size for:
 - .1 Pipe and fittings.
 - .2 Alarm valves.

- .3 Valves, including gate, check, and globe.
- .4 Water motor alarms.
- .5 Sprinkler heads.
- .6 Pipe hangers and supports.
- .7 Pressure or flow switch.
- .8 Fire department connections.
- .9 Excess pressure pump.
- .10 Mechanical couplings.
- .3 Drawings:
 - .1 Sprinkler heads and piping system layout.
 - .1 Prepare 760 mm by 1050 mm detail working drawings of system layout in accordance with NFPA 13, "Working Drawings (Plans)".
 - .2 Show data essential for proper installation of each system.
 - .3 Show details, plan view, elevations, and sections of systems supply and piping.
 - .4 Show piping schematic of systems supply, devices, valves, pipe, and fittings. Show point to point electrical wiring diagrams.
 - .2 Electrical wiring diagrams.
- .4 Design Data:
 - .1 Calculations of sprinkler system design.
 - .2 Indicate type and design of each system and certify that each system has performed satisfactorily in the manner intended for not less than 18 months.
- .5 Field Test Reports:
 - .1 Preliminary tests on piping system.
- .6 Records:
 - .1 As-built drawings of each system.
 - .1 After completion, but before final acceptance, submit complete set of as-built drawings of each system for record purposes.
 - .2 Submit 760 mm by 1050 mm drawings on reproducible media.
- .7 Operation and Maintenance Manuals:
 - .1 Provide detailed hydraulic calculations including summary sheet, and Contractors Material and Test Certificate for aboveground and underground piping and other documentation for incorporation into manual in accordance with NFPA 13.

1.5 QUALITY ASSURANCE

- .1 Qualifications:
 - .1 Installer: company or person specializing in wet sprinkler systems with documented experience approved by manufacturer.
- .2 Supply grooved joint couplings, fittings, valves, grooving tools and specialties from a single manufacturer. Use date stamped castings for coupling housings, fittings, valve bodies, for quality assurance and traceability.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- .1 Extra Materials:
 - .1 Provide maintenance materials in accordance with Division 01 - Closeout Submittals.
 - .2 Provide spare sprinklers and tools in accordance with NFPA 13.

1.7 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements:
 - .1 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .3 Storage and Protection:
 - .1 Store materials indoors, in dry location.
 - .2 Store and protect materials from exposure to harmful weather conditions and at temperature and humidity conditions recommended by manufacturer.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of packaging materials in accordance with Division 01 - Waste Management and Disposal.

2. PRODUCTS

2.1 DESIGN REQUIREMENTS

- .1 Design automatic wet pipe fire suppression sprinkler systems in accordance with required and advisory provisions of NFPA 13, by hydraulic calculations for uniform distribution of water over design area.
- .2 Include with each system materials, accessories, and equipment inside and outside building to provide each system complete and ready for use.
- .3 Design and provide systems to account for blind spaces, piping, electrical equipment, ducts, and other construction and equipment in accordance with detailed shop drawings.

- .4 Locate sprinkler heads in consistent pattern with ceiling grid, lights, and air supply diffusers.
- .5 Devices and equipment for fire protection service: ULC approved for use in wet pipe sprinkler systems.
- .6 Design systems for earthquake protection as required by seismic zone and building classification.
- .7 Location of Sprinkler Heads:
 - .1 Locate heads in relation to reflected ceiling plan. Ensure spacing of sprinkler heads does not exceed that permitted by NFPA 13.
 - .2 Uniformly space sprinklers on branch.
- .8 Water Distribution:
 - .1 Make distribution uniform throughout the area in which sprinkler heads will open.
 - .2 Discharge from individual heads in hydraulically most remote area to be 100 % of specified density.
- .9 Density of Application of Water:
 - .1 Size pipe to provide specified density when system is discharging specified total maximum required flow.
- .10 Sprinkler Discharge Area:
 - .1 Area: hydraulically most remote area as defined in NFPA 13.
- .11 Outside Hose Allowances:
 - .1 Include allowance in hydraulic calculations of for outside hose streams as required.
- .12 Friction Losses:
 - .1 Calculate losses in piping in accordance with Hazen-Williams formula with 'C' value of 120 for steel piping, 150 for copper tubing, and 140 for cement-lined ductile-iron piping.
- .13 Water Supply:
 - .1 Base hydraulic calculations on static pressure and residual water pressure available at design flow as per hydrant test reports provided.

2.2 ABOVE GROUND PIPING SYSTEMS

- .1 Provide fittings for changes in direction of piping and for connections.
 - .1 Make changes in piping sizes through tapered reducing pipe fittings, bushings will not be permitted.
- .2 Conceal piping in areas with suspended ceilings.

2.3 PIPE AND FITTINGS

- .1 Steel Pipe: ASTM A53B.

- .1 Joined by welding or by roll grooved pipe and fittings:
 - .1 schedule 10 for sizes 5" (125mm) and smaller,
 - .2 0.134" (3.40mm) for 6" (150mm) diameter,
 - .3 0.188" (4.78mm) for 8" and 10" (200mm and 250mm) diameter.
- .2 Joined with threaded fittings or cut groove pipe and fittings:
 - .1 schedule 40 for sizes 6" (150mm) diameter and smaller,
 - .2 schedule 30 for sizes 8" (200mm) diameter and larger.
- .2 Copper tube: to NFPA 13.
- .3 Fittings and joints to NFPA 13:
 - .1 Ferrous: screwed, welded, flanged or roll grooved.
 - .1 Grooved joints designed with two ductile iron housing segments, pressure responsive gasket, and zinc-electroplated steel bolts and nuts. Cast with offsetting angle-pattern bolt pads for rigidity and visual pad-to-pad offset contact.
 - .2 Steel Fittings: ASME B16.9, wrought steel, buttwelded.
 - .3 Cast Iron Fittings: ASME B16.1, flanges and flanged fittings.
 - .4 Malleable Iron Fittings: ASME B16.39, threaded fittings.
 - .5 Mechanical Grooved Couplings: Malleable iron housing clamps to engage and lock, "C" shaped elastomeric sealing gasket, steel bolts, nuts, and washers; galvanized for galvanized pipe.
 - .6 Mechanical Formed Fittings: Carbon steel housing with integral pipe stop and O-ring pocket and O-ring uniformly compressed into permanent mechanical engagement onto pipe.
 - .2 Copper tube: screwed, soldered, brazed, grooved.
 - .3 Plain-end fittings with mechanical couplings and fittings which use steel gripping devices to bite into pipe when pressure is applied will not be permitted.
 - .4 Rubber gasketed grooved-end pipe and fittings with mechanical couplings are permitted in pipe sizes 32 mm and larger.
 - .5 Fittings: ULC approved for use in wet pipe sprinkler systems.
 - .6 Ensure fittings, mechanical couplings, and rubber gaskets are supplied by same manufacturer.
 - .7 Side outlet tees using rubber gasketed fittings are not permitted.
 - .8 Sprinkler pipe and fittings: metal.

2.4 VALVES

- .1 Provide cUL or ULC and FM approved, listed and labelled.
- .2 Provide listed indicating valves for controlling connections to water supplies.

- .3 Conform to requirements of ANSI, ASTM, ASME, and applicable MSS standards.
- .4 Provide valves of the same manufacturer where possible.
- .5 Ensure manufacturer's name and pressure rating clearly marked on body to MSS-SP-25.
- .6 Provide valves and fittings with valid Canadian Registration Number for the Province of Ontario. Indicate CRN on submittals.
- .7 Isolation Valves:
 - .1 ULC listed for fire protection service. Electrically Supervised: ULC listed, FM approved, NO/NC SPDT dry contact switch suitable for electrical supervision on trouble circuit of facility fire alarm system. Valve monitoring switches shall be Potter Electric Signal and Manufacturing Limited or equivalent.
- .8 Gate valves: open by counterclockwise rotation.
 - .1 Up to 2": ULC listed, FM approved, Class 300, non-shock WOG, ASTM B62 bronze body, solid wedge disc, rising stem, bronze trim, threaded ends.
 - .2 2-1/2" and larger: ULC listed, FM approved, Class 175, CWP, outside screw and yoke, cast iron body, stem with ACME double threads, tapered solid wedge disc, flanged ends, renewable bronze seat rings.
- .9 Provide valves beneath each alarm valve in each riser when more than one alarm valve is supplied from same water supply pipe.
- .10 Check valves: flanged clear opening swing or spring actuated check type with flanged inspection and access cover plate for sizes 4" and larger.
- .11 Provide gate valve in piping protecting elevator hoist ways, machine rooms, and machinery spaces.
- .12 Drain Valves:
 - .1 ULC listed and FM approved, brass ball valve with cap and chain, 3/4" (20 mm) hose thread.

2.5 PIPE HANGERS AND SUPPORTS

- .1 ULC listed for fire protection services in accordance with NFPA 13.
- .2 Hangers for Pipe Sizes 1/2" to 1-1/2" (15 to 40 mm): Carbon steel, adjustable swivel, split ring.
- .3 Hangers for Pipe Sizes 2" (50 mm) and Over: Carbon steel, adjustable, clevis.
- .4 Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
- .5 Wall Support for Pipe Sizes to 3-1/4" (80 mm): Cast iron hook.
- .6 Wall Support for Pipe Sizes 4" (100 mm) and Over: Welded steel bracket and wrought steel clamp.
- .7 Vertical Support: Steel riser clamp.

- .8 Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

2.6 SPRINKLER HEADS

- .1 General: to NFPA 13 and ULC listed for fire services.
- .2 Sprinkler Head Type:
 - .1 Standard Upright:
 - .1 Type: Standard upright type with guard.
 - .2 Finish: Brass.
 - .3 Fusible Link: Glass bulb type temperature rated for specific area hazard.
 - .2 Concealed Pendant:
 - .1 Type: Adjustable concealed standard spray pendant.
 - .2 Sprinkler Frame Finish: Plain Brass.
 - .3 Deflector: Bronze per UNS C22000.
 - .4 Cover plate: Brass per UNS C26000. Factory painted (confirm colour with architect prior to ordering)
 - .5 Cover plate attachment with 1/2" (13mm) assembly adjustment.
 - .6 Smooth aesthetic ceiling profile.
 - .7 Factory installed protective cap.
 - .3 Guards: Finish to match sprinkler finish.
- .3 Provide nominal 1.2 cm orifice sprinkler heads.
 - .1 Provide higher temperature release elements as required for specific applications/
 - .2 Provide polished stainless steel ceiling plates or chromium-plated finish on copper alloy ceiling plates, and chromium-plated pendent] sprinklers below suspended ceilings.
 - .3 Provide corrosion-resistant sprinkler heads and sprinkler head guards in accordance with NFPA 13.
 - .4 Deflector: not more than 75 mm below suspended ceilings.
 - .5 Ceiling plates: not more than 25 mm deep.
 - .6 Ceiling cups: not permitted.

2.7 ALARM CHECK VALVE

- .1 Alarm check valve to NFPA 13 and ULC listed for fire service.
- .2 Provide variable pressure type alarm valve complete with retarding chamber, alarm test valve, alarm shutoff valve, drain valve, pressure gauges, accessories, and appurtenances for proper operation of system.

- .3 Provide valve complete with internal components that are replaceable without removing the valve from the installed position.

2.8 WATER MOTOR ALARMS

- .1 Provide alarms approved weatherproof and guarded type, to sound locally on flow of water in each corresponding sprinkler system.
- .2 Mount alarms on outside of outer walls of each building at location as directed.
- .3 Provide separate drain piping directly to exterior of building.

2.9 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 Pressure or flow switch type:
 - .1 With normally open and normally closed contacts and supervisory capability.
 - .2 Provide switch with circuit opener or closer for automatic transmittal of alarm over facility fire alarm system.
 - .3 Connect into building fire alarm system.
 - .4 Connection of switch: Division 28 - Fire Detection and Alarm.
 - .5 Alarm actuating device: mechanical diaphragm controlled retard device adjustable from 10 to 60 seconds and instantly recycle.
- .4 Pressure alarm switch:
 - .1 With normally open and normally closed contacts and supervisory capability.

2.10 WATER GONG

- .1 To NFPA 13 and ULC listed for fire service. Location as indicated.

2.11 EXCESS PRESSURE PUMP

- .1 Provide pumps on each sprinkler piping riser.
- .2 Pumps:
 - .1 Pumps: positive displacement, gear type, integrally mounted with motor.
 - .2 Double acting displacement type, open cylinder design, direct drive, ULC listed, complete with relief valve.
- .3 Pump and motor unit:

- .1 Approved for automatic wet pipe fire extinguishing sprinkler systems; complete with pilot light panel, differential motor control switch, high pressure switch, and low pressure switch.
- .2 EEMAC Class B squirrel cage induction 1725 rpm, continuous duty, drip proof, ball bearing, maximum temperature rise 50 degrees C, 120/1/60.
- .4 Provide electrical power supply connections for pump and pilot light panel at supply side of building service panel.
- .5 Provide separate fused safety-type switch with locked lever for each connection.
- .6 Provide pressure pump sensing piping in supply piping upstream of fire pump.
- .7 Pump operation switch: to operate excess pressure pump with pressure differential of 103 kPa.
- .8 Shut-off valve and strainer on pump inlet. Relief valve, check valve and shut-off valve on discharge connections.

2.12 PRESSURE GAUGES

- .1 ULC listed and to Section 23 05 19.13 - Thermometers and Pressure Gauges - Piping Systems.
- .2 Maximum limit of not less than twice normal working pressure at point where installed.

2.13 PIPE SLEEVES

- .1 Provide pipe sleeves where piping passes through walls, floors, and roofs.
- .2 Secure sleeves in position and location during construction.
- .3 Provide sleeves of sufficient length to pass through entire thickness of walls, floors, and roofs.
- .4 Provide 2.5 cm minimum clearance between exterior of piping and interior of sleeve or core-drilled hole.
 - .1 Firmly pack space with mineral wool insulation.
 - .2 Seal space at both ends of sleeve or core-drilled hole with mechanically adjustable segmented elastomeric seal.
 - .3 In fire walls and fire floors, seal both ends of pipe sleeves or core-drilled holes with ULC listed fill, void, or cavity material.
- .5 Sleeves in Masonry and Concrete Walls, Floors, and Roofs:
 - .1 Provide hot-dip galvanized steel.
 - .2 Core drilling of masonry and concrete may be provided in lieu of pipe sleeves when cavities in core-drilled hole are completely grouted smooth.
- .6 Sleeves in Other Than Masonry and Concrete Walls, Floors, and Roofs:
 - .1 Provide 0.61 mm thick galvanized steel sheet.

2.14 ESCUTCHEON PLATES

- .1 Provide one piece type metal plates for piping passing through walls, floors, and ceilings in exposed spaces.
- .2 Provide polished stainless steel plates or chromium-plated finish on copper alloy plates in finished spaces.
- .3 Provide paint finish on metal plates in unfinished spaces.

2.15 INSPECTOR'S TEST CONNECTION

- .1 Locate inspector's test connection at hydraulically most remote part of each system, provide test connections approximately 3 m above floor for each sprinkler system or portion of each sprinkler system equipped with alarm device.
- .2 Provide test connection piping to location where discharge will be readily visible and where water may be discharged without property damage.
- .3 Provide discharge orifice of same size as corresponding sprinkler orifice.

2.16 SIGNS

- .1 Attach properly lettered and approved metal signs to each valve and alarm device to NFPA 13.
- .2 Permanently fix hydraulic design data nameplates to riser of each system.

2.17 ANTIFREEZE

- .1 Antifreeze loops to NFPA 13, locations as indicated.

2.18 SPARE PARTS CABINET

- .1 Provide metal cabinet with extra sprinkler heads and sprinkler head wrench adjacent to each alarm valve. Number and types of extra sprinkler heads as specified in NFPA 13.

3. EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

- .1 Install, inspect and test to acceptance in accordance with NFPA 13 and NFPA 25.
- .2 Provide mating flange or fittings as required for connection to water supply provided by others.

3.3 PIPE INSTALLATION

- .1 Install piping straight and true to bear evenly on hangers and supports. Do not hang piping from plaster ceilings.
- .2 Keep interior and ends of new piping and existing piping thoroughly cleaned of water and foreign matter.
- .3 Keep piping systems clean during installation by means of plugs or other approved methods. When work is not in progress, securely close open ends of piping to prevent entry of water and foreign matter.
- .4 Inspect piping before placing into position.
- .5 Ream pipe and tube ends. Remove burrs.
- .6 Remove scale and foreign material, from inside and outside, before assembly.
- .7 Prepare piping connections to equipment with flanges or unions.
- .8 Install piping to conserve building space, to not interfere with use of space and other work.
- .9 Sleeve pipes passing through partitions, walls, and floors.
- .10 Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

3.4 PIPE HANGERS AND SUPPORTS

- .1 Install hangers to provide minimum 1/2" (15 mm) space between finished covering and adjacent work.
- .2 Place hangers within 12" (300 mm) of each horizontal elbow.
- .3 Use hangers with 1-1/2" (40 mm) minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
- .4 Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
- .5 Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- .6 Provide copper plated hangers and supports for copper piping.

3.5 VALVES AND FITTINGS

- .1 Install valves with stems upright or horizontal, not inverted. Remove protective coatings prior to installation.
- .2 Provide ball valves for shut-off or isolating service.
- .3 Provide drain valves at main shut-off valves, low points of piping and apparatus.
- .4 Provide control, drain and test connection valves with permanently engraved and marked weatherproof metal or rigid plastic identification signs, secured with weather resistant chain or other approved method.
- .5 Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.

- .6 When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

3.6 ELECTRICAL CONNECTIONS

- .1 Provide electrical work associated with this section under Division 26 - Common Work Results for Electrical.
- .2 Provide fire alarm system under Division 28 - Fire Detection and Alarm.
- .3 Provide control and fire alarm wiring, including connections to fire alarm systems, in accordance with National Electrical Code.
- .4 Provide wiring in rigid metal conduit or intermediate metal conduit.

3.7 DISINFECTION

- .1 Disinfect new piping and existing piping.
- .2 Fill piping systems with solution containing minimum of 50 parts per million of chlorine and allow solution to stand for minimum of 24 hours.
- .3 Flush solution from systems with clean water until maximum residual chlorine content is not greater than 0.2 part per million or residual chlorine content of domestic water supply.
- .4 Obtain at least two consecutive satisfactory bacteriological samples from piping, analyzed by certified laboratory, and submit results prior to piping being placed into service.

3.8 CONNECTIONS TO EXISTING WATER SUPPLY SYSTEMS

- .1 Notify Contracting Officer in writing at least 15 days prior to connection date.
- .2 Use tapping or drilling machine valve and mechanical joint type sleeves for connections to be made under pressure.
- .3 Bolt sleeves around main piping.
- .4 Bolt valve to branch connection. Open valve, attach drilling machine, make tap, close valve, and remove drilling machine, without interruption of service.
- .5 Furnish materials required to make connections into existing water supply systems, and perform excavating, backfilling, and other incidental labour as required.

3.9 BURIED PIPING SYSTEM

- .1 Bury tape with printed side up at depth of 30 cm below the top surface of earth or top surface of subgrade under pavements.

3.10 FIELD PAINTING

- .1 Clean, pretreat, prime, and paint new systems including valves, piping, conduit, hangers, supports, miscellaneous metalwork, and accessories.
- .2 Apply coatings to clean, dry surfaces, using clean brushes.
- .3 Clean surfaces to remove dust, dirt, rust, and loose mill scale.
- .4 Immediately after cleaning, provide metal surfaces with 1 coat of pretreatment primer applied to minimum dry film thickness of 0.3 ml, and one coat of zinc chromate primer applied to minimum dry film thickness of 1.0 ml.
- .5 Shield sprinkler heads with protective covering while painting is in progress.
- .6 Upon completion of painting, remove protective covering from sprinkler heads.
- .7 Remove sprinkler heads which have been painted and replace with new sprinkler heads.
- .8 Provide primed surfaces with following:
 - .1 Piping in Finished Areas:
 - .1 Provide primed surfaces with 2 coats of paint to match adjacent surfaces.
 - .2 Provide valves and operating accessories with 1 coat of red alkyd gloss enamel applied to minimum dry film thickness of 1.0 mil.
 - .3 Provide piping with 50 mm wide red enamel bands spaced at maximum of 6 m intervals throughout piping systems.

3.11 FIELD QUALITY CONTROL

- .1 Site Test, Inspection:
 - .1 Perform test to determine compliance with specified requirements in presence of Consultant.
 - .2 Test, inspect, and approve piping before covering or concealing.
 - .3 Preliminary Tests:
 - .1 Hydrostatically test each system at 200 psig for a 2 hour period with no leakage or reduction in pressure.
 - .2 Flush piping with potable water in accordance with NFPA 13.
 - .3 Piping above suspended ceilings: tested, inspected, and approved before installation of ceilings.
 - .4 Test alarms and other devices.
 - .5 Test water flow alarms by flowing water through inspector's test connection. When tests have been completed and corrections made, submit signed and dated certificate in accordance with NFPA 13.
 - .4 Formal Tests and Inspections:
 - .1 Do not submit request for formal test and inspection until preliminary test and corrections are completed and approved.

- .2 Submit written request for formal inspection at least 15 days prior to inspection date.
 - .3 Repeat required tests as directed.
 - .4 Correct defects and make additional tests until systems comply with contract requirements.
 - .5 Furnish appliances, equipment, instruments, connecting devices, and personnel for tests.
 - .6 Authority of Jurisdiction, will witness formal tests and approve systems before they are accepted.
- .2 Manufacturer's Field Services:
- .1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in PART 1 - ACTION AND INFORMATIONAL SUBMITTALS.
 - .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
 - .3 Schedule site visits, to review Work, as directed in PART 1 - QUALITY ASSURANCE.
- .3 Site Tests:
- .1 Field test fire pump, driver and controllers in accordance with NFPA 20:
 - .1 Verification of proper installation system initiation adjustment and fine tuning.
 - .2 Verification of the sequence of operations and alarm systems.
 - .2 Testing to be witnessed by authority having jurisdiction.
 - .3 Develop, with Consultant assistance, detailed instructions for O & M of this installation.

3.12 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Read and conform to:
 - .1 The Contract CCDC 2-2020, Stipulated Price Contract as amended,
 - .2 Division 1 requirements and documents referred to therein.
- .2 This Section applies to and governs the work of all Sections of Division 22.
- .3 The technical Sections of this Division are generally divided into units of work for the purpose of ready reference.
- .4 The division of the work among subcontractors is not the Consultant's responsibility and the Consultant assumes no responsibility to act as an arbiter and/or to establish subcontract limits between any Sections of the work.
- .5 The specifications are integral with the drawings which accompany them. Neither is to be used alone. Any item or subject omitted from one but implied in the other is fully and properly required.
- .6 Wherever differences occur in the tender documents, the most onerous condition governs. Base the bid on the costliest arrangement.

1.2 DEFINITIONS

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

1.3 WORK INCLUDED

- .1 Products and methods mentioned or shown in the Contract Documents complete with incidentals necessary for a complete operating installation. Provide all tools, equipment and services required to do the work.
- .2 Cutting and patching of new or existing work.
- .3 Identification of piping, and valves.
- .4 Take such measures and include in Bid Price for the proper protection of the existing building and its finishes during alterations and construction of the new addition. Coordinate this protective work with all trades.
- .5 Verify the correct operation of each plumbing fixture provided and/or altered and each system in total and obtain the Owner's approval prior to starting and/or returning to operation.

1.4 SUBMITTALS

- .1 Shop Drawings: Prepare and submit two (2) copies of shop drawings of major equipment items (including those items specifically indicated under Part 1: General of each Section), to the Consultant for review. The Consultant will return one copy, marked with comments and his review stamp as he deems appropriate. Prepare the necessary number of copies of the returned set and distribute to the Owner, the Prime Consultant, the General Contractor, the site, and to subcontractors and suppliers.
 - .1 Clearly indicate manufacturer's and supplier's names, catalogue model numbers, details of construction, accurate dimensions, capacities and performance. Prior to submission check and certify as correct, shop drawings and data sheets. Do not order equipment until a copy of the shop drawings, reviewed by Consultant, has been returned to Contractor.
 - .2 Clearly indicate the weight, location, method of support and anchor point forces and locations for each piece of equipment on shop drawings.
 - .3 The Consultant will not review shop drawings that fail to bear the Contractor's stamp of approval or certification.
 - .4 Read the following in conjunction with the wording on the shop drawing review stamp applied to each and every drawing submitted:

"This review by the Consultant is for the sole purpose of ascertaining conformance with general design concept. This review shall not mean that the Consultant approves the detail design inherent in the shop drawings, responsibility for which shall remain with the Contractor submitting same, and such review shall not relieve the Contractor of his responsibility for errors or omissions in the shop drawings or of his responsibility for meeting all requirements of the Contract Documents. The Contractor is responsible for dimensions to be confirmed and correlated at the job site, for information that pertains solely to fabrication processes or to techniques of construction and installation and for coordination of the work of all sub trades."
- .2 Maintenance Data and Operating Instructions

- .1 Submit three (3) copies of Operation and Maintenance Manual individually bound in hard backed three-ring binders.
- .2 Ensure the binder spines have typewritten lettering as follows:

OPERATION & MAINTENANCE MANUAL

for

[Insert project name]
[Insert date of submission]

Division 22 00 00
- .3 Provide a list of names, addresses and telephone numbers of equipment suppliers, installing contractors, general contractors, architect and Consultant. Include special telephone numbers for service departments on normal and emergency call basis.
- .4 Provide descriptive literature (shop drawings) of each manufactured item. Include a bill of material with purchase order numbers and vendor's identification of equipment orders for each item.
- .5 Include copies of start-up reports and checklists and all certificates issued with respect to this contract.
- .6 Ensure operating instructions include the following:
 - .1 General description of each mechanical system.
 - .2 Step by step procedure to follow in putting each piece of equipment into service.
 - .3 Schematic control diagrams for each separate mechanical system.
 - .4 Diagram of the electrical control system indicating the wiring of all related electrical components.
 - .5 Drawings of each control panel including temperature control and electrical panels, completely identifying all components on the panels and their function.
- .7 Ensure maintenance instructions include the following:
 - .1 Manufacturer's maintenance instructions for each item of mechanical equipment installed under this Division. Instructions shall include installation instructions, parts numbers and lists, name of supplier and maintenance and lubrication instructions.
 - .2 Summary list of each item of mechanical equipment requiring lubrication, indicating the name of the equipment item, location of all points of lubrication, type of lubricant recommended, and frequency of lubrication.
 - .3 Equipment directory indicating name, model, serial number and nameplate data of each item of equipment supplied, and system with which it is associated.

- .4 Balancing and testing reports.
- .5 Copy of valve directory.
- .3 As-Built Records: Prepare and submit complete as-built records prior to Substantial Performance of the Contract. Refer to paragraph 3.3 and to Division 1 for requirements. Submit two sets of as-builts drawings in AutoCAD format showing changes & concealed services dimensioned. AutoCAD files can be provided to the contractor by the Consultant at a fee of \$300.00 plus \$25.00 per sheet upon request.
- .4 Requests for Shut-Down: Obtain permission for systems shut-down and/or service interruption from the Owner prior to disruption of any system or service in use by the Owner. Employ the Owner's standard form of request where available. Refer to Division 1 for additional requirements.
- .5 Requests for Start-up: Obtain permission from the Owner to start-up or to return to service any item of equipment, system or service installed new or previously shutdown. Refer to Division 1 for additional requirements.

1.5 QUALITY ASSURANCE

- .1 Conform to minimum requirements or better of provincial and local codes, where existing, and to requirements of local inspection authorities for execution of work under this Division.
- .2 Ensure materials supplied under this Division conform to minimum requirements and recommendations or better of applicable standards of the following:
 - .1 ASTM American Society of Testing and Materials
 - .2 AWWA American Water Works Association
 - .3 CAN2 National Standard of Canada (Published by CGSB)
 - .4 CAN3 National Standard of Canada (Published by CSA)
 - .5 CGSB Canadian General Standards Board
 - .6 CSA Canadian Standards Association
 - .7 NBC National Building Code of Canada
 - .8 OBC Ontario Building Code
 - .9 TIAC Thermal Insulation Association of Canada
 - .10 ULC Underwriter's Laboratories of Canada Ltd
 - .11 UL Underwriter's Laboratories (including cUL)
- .3 Use latest editions and amendments in effect on date of Bid call subject to requirements of OBC.
- .4 Arrange and pay for inspections by authorities having jurisdiction, required in the undertaking of this Division. Make modifications required by authorities.
- .5 Ensure tradesmen employed on the project hold valid trade certificates/licenses and shall make a copy available for review by the Consultant and/or Owner when requested.

1.6 PRODUCT DELIVERY, HANDLING AND STORAGE

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

1.7 JOB CONDITIONS

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

1.8 INTERRUPTIONS

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

1.9 WARRANTY

- .1 Refer to Division 01.

1.10 EXTRAS AND CREDITS

- .1 Accompany price submissions requested by Consultant for extra work, or work to be deleted, with a complete cost breakdown as follows:
 - .1 Materials, quantities, and unit costs including any applicable contractors trade discount clearly identified. Provide supplier quotations.

- .2 Labour hours and unit costs.
 - .3 Total materials and labour costs.
 - .4 Overhead and profit mark-ups in accordance with the General Conditions of the Contract.
- .2 Quotations from software such as Allpriser will not be accepted. Provide actual material costs.

2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

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

2.2 ACCEPTABLE PRODUCTS

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

2.3 EQUIVALENTS AND ALTERNATIVES

- .1 Suppliers wishing approval for additional equipment items or alternatives as equivalent to those specified **must submit complete description, technical and performance data to Consultant at least twelve (12) working days prior**

to Bid closing date. Equivalent equipment, if accepted, must conform to specifications regarding details, accessories, modifications, features and performance. Deviations from specifications must be stated in writing at time of submission for approval.

- .2 Bid Prices shall include only products specified or approved equivalents. Contractors may propose unsolicited alternatives to the products specified. Alternative proposals shall be submitted in sealed envelope at time of general contract Bid submission and shall include full description and technical data, and a statement of the related increase or decrease in Bid Price should alternatives be accepted. All additional costs associated with unsolicited alternative proposals such as larger motor starters, larger power feeders, space revisions to associated equipment, controls, etc. shall be included in alternative price. Prior approval by Consultant is not required for unsolicited alternative proposals.
- .3 Where the Contractor uses equipment other than that first named, on which the design is based, he shall be responsible for the details of installation including equipment size, arrangement, fit, and maintenance of required clearances. Contractor shall prepare and submit revised layouts to indicate arrangement of affected piping, ductwork, conduit, lighting, equipment, etc. Failure by Contractor to provide such drawings will be considered indication that original arrangements and space allocations are adequate.
- .4 Include in the Bid Price for additional costs associated with equivalent equipment such as larger motor starters, larger power feeders, space revisions to associated equipment, controls, changes to ductwork, piping, etc. No extras for changes arising from alternatives, equivalents (approved or otherwise) or substitutions will be considered.

2.4 SUBSTITUTIONS DURING PROGRESS OF WORK

- .1 Refer to Section 01 25 00.

2.5 CONSULTANT'S REVIEW

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

3 EXECUTION

3.1 RELATIONSHIP WITH OTHER TRADES

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

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

3.2 INSTALLATION REQUIREMENTS

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

3.3 CONTRACT DRAWINGS

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

3.4 RECORD DRAWINGS

- .1 Maintain project "as-built" record drawings. Obtain white prints from the

Consultant for this purpose and pay printing costs. Identify each set as "Project Record Copy".

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

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

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

1.2 WORK INCLUDED

- .1 Identification of existing services and utility connections.
- .2 Installation, protection and maintenance of temporary services as required to support continuing operation of the facility.
- .3 Disconnection and removal of various mechanical equipment in areas to be turned over to the Owner.
- .4 Disconnection and making safe of various mechanical systems and equipment in areas to be demolished and/or renovated.
- .5 Disposal of waste materials in accordance with waste management requirements.

1.3 REGULATORY REQUIREMENTS

- .1 Notify authorities of intent to demolish and schedule for the work. Obtain required permits from authorities.
- .2 Conform to codes for demolition work, dust control, products requiring disconnection and re-connection.
- .3 Do not close or obstruct egress width to any building or site exit.
- .4 Do not disable or disrupt building fire or life safety systems without 3 days prior written notice to Owner.
- .5 Conform to procedures applicable when hazardous or contaminated materials are discovered. Refer to designated hazard substance report for such procedures.

1.4 JOB CONDITIONS

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

1.5 INTERRUPTIONS

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

- .2 Prior to interrupting any existing service notify the Owner and Consultant, in writing, at least 7 days in advance, and obtain written authorization. Do not interrupt any existing service without Consultant's specific authorization. Refer to Division 01 for requirements.
- .3 Arrange time and duration of interruption through the Owner's Physical Plant Department. Include in Bid Price for all overtime or premium time hours necessary to minimize duration of service interruption.
- .4 Test and verify the proper operation of existing equipment and systems that are shut down due to work of this project, prior to returning to service.
- .5 Assume responsibility for consequential costs on failure to obtain permission to shut down and/or start-up any item of equipment, system or service.

1.6 PHASING AND SCHEDULING

- .1 Refer to Division 01 phasing and scheduling of the work.
- .2 Coordinate with the work of Division 22 with other trades and assist in the development of the Phasing Strategy.

2 PRODUCTS

2.1 N/A

- .1 N/A

3 EXECUTION

3.1 PREPARATION

- .1 Prior to start of work under this Section, ensure that the General Trades:
 - .1 Provide, erect, and maintain temporary barriers at locations indicated.
 - .2 Erect and maintain weatherproof closures for exterior openings.
 - .3 Erect and maintain temporary partitions to prevent spread of dust, odours, and noise to permit continued Owner occupancy.
 - .4 Prevent movement of structure; provide bracing and shoring.
- .2 Install, protect and maintain temporary services as required to support continuing operation of the facility.
- .3 Protect services and equipment which are not to be demolished.
- .4 Coordinate all service shutdowns with Owner's project coordinator. Provide notice as required by Owner and submit schedule for the work.
- .5 Notify affected utility companies before starting work and comply with their requirements.
- .6 Mark location and termination of utilities.
- .7 Provide appropriate temporary signage including signage for exit or building egress.

3.2 RELATIONSHIP WITH OTHER TRADES

- .1 Cooperate with other trades whose work affects or is affected by work of this Division to ensure satisfactory installation and to avoid delays.
- .2 Remove and dispose of built-in items such as sleeves, anchors, and inserts.
- .3 Remove and dispose of bases, supports and anchors for piping mounted on or in walls, supported and suspended from the structure.

3.3 PROTECTION

- .1 Protect existing and new work to remain free from damage due to execution of work under this Division with tarpaulins and other protective coverings as necessary.
- .2 Repair damage to the building and components resulting from failure to provide sufficient protection, to the satisfaction of the Consultant.
- .3 If dust and debris from construction work does penetrate the building and/or its air distribution systems, be responsible for cleaning the affected areas and/or systems.

3.4 DEMOLITION

- .1 Notify authorities of intent to demolish and schedule for the work.
- .2 Conform to codes, regulations, standards and by-laws applicable to the work.
- .3 Isolate and drain systems as required to effect demolition. Disconnect, cap and make safe all mechanical services to the building including, but not limited to; sanitary sewer(s), storm sewer(s), water service, and natural gas service.
- .4 Protect existing equipment and services to remain from debris and unwanted materials. Clean as necessary to maintain service during demolition period and on completion of the work.
- .5 Coordinate service shutdowns with Owner's project coordinator. Provide notice as required by Owner and submit schedule for the work.
- .6 Remove and dispose of all redundant mechanical services and equipment within the limits of the demolition site and where demolished systems extend beyond these limits.
- .7 Turn over items identified for recovery by the Owner.
- .8 Conform to Occupational Health & Safety and Environmental regulations. Ensure that all parties are familiar with requirements and experienced in the work to be undertaken.
- .9 Conform to the requirements of Division 01, municipal By-Laws and Ministry of the Environment regulations and standard for waste disposal.
- .10 In the event that dust and debris from demolition work does penetrate the building and/or its air distribution systems, be responsible for cleaning the affected areas and/or systems.
- .11 Disconnect remove, cap and identify utilities within demolition areas.

- .12 Demolish in an orderly and careful manner. Protect existing supporting structural members.
- .13 Remove demolished materials from site except where specifically noted otherwise. Do not burn or bury materials on site.
- .14 Remove materials as Work progresses. Upon completion of Work, leave areas in clean condition.
- .15 Remove temporary Work.

3.5 RENOVATIONS

- .1 Isolate and drain systems as required to effect renovations, modifications and/or repairs. On completion of renovations, modifications and/or repairs, test entire system as if new. Report repairs or replacements required of existing equipment, piping, fittings or devices that are not included in contract to Consultant and Owner for instruction. Flush, clean and refill renovated systems as specified for new.
- .2 Relocate or remove existing items so designated unless specifically indicated to be relocated or removed under other Sections.
- .3 Cleaned and Repair or alter existing items to be relocated to suit new location. Replace damaged or ineffective parts and make the item "as new".
- .4 Delivery existing items to be removed remain the property of the owner to a location on site designated by the owner. If the owner declares no interest in the removed items, assume ownership and remove the items from the site.
- .5 Make good surfaces and finishes in areas from which items have been removed and in which items are relocated. Cap existing services required to be severed to effect alterations and do all other work necessary to make good such areas to satisfaction of consultant.
- .6 Temporarily seal openings in existing floor assemblies and vertical fire separations necessitated by installation of equipment and systems or construction in general with fire barrier materials such as mineral wool or other noncombustible insulation.
- .7 If during alteration work existing asbestos material, other than known asbestos, is discovered (e.g. fireproofing, acoustic or thermal insulation, tank covering), stop work in the affected area and immediately notify consultant.

END OF SECTION

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1 GENERAL

1.1 GENERAL REQUIREMENTS

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

1.2 REFERENCE STANDARDS

- .1 Provide work in accordance with requirements of Regulatory Agencies and conform to:
 - .1 Local and district by-laws, regulations and published engineering standards.
 - .2 the Ontario Building Code as amended,
 - .3 Regulations for Construction Projects under The Occupational Health and Safety Act.
- .2 ASTM International (ASTM)
 - .1 ASTM A105 - Standard Specification for Carbon Steel Forgings for Piping Applications.
 - .2 ASTM A182 - Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
- .3 American Society of Mechanical Engineers (ASME)
 - .1 ASME B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
- .4 CSA Group (CSA):
 - .1 CSA B53, Identification of Piping Systems.
 - .2 CSA B242 Groove and Shoulder Type: Mechanical Pipe Couplings.
 - .3 CAN1-B149.1 Natural Gas and Propane Code.
- .5 Standards Council of Canada (SCC)
 - .1 CAN/CGSB-24.3, Standard for Pipe Identification.
 - .2 CAN/ULC – S115, Standard Method Of Fire Tests Of Firestop Systems
- .6 Conform to following National Research Council Canada publications:
 - .2 National Building Code of Canada and Supplements to National Building Code of Canada
 - .3 Canadian Plumbing Code.

1.3 QUALIFICATIONS

- .1 Firestop Sealant Manufacturer: Company specializing in manufacture of sealants with minimum three years documented product development, testing, and

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manufacturing experience.

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

1.4 SUBMITTALS

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

1.5 DELIVERY, STORAGE, AND HANDLING

- .2 Deliver, store and handle in accordance with Division 01 - Common Product Requirements.
- .3 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of packaging materials in accordance with Division 01 - Waste Management and Disposal.

1.6 WASTE MANAGEMENT & DISPOSAL

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

2 PRODUCTS

2.1 PIPING SPECIALTIES

- .1 Provide cast brass, pressure, copper to copper unions for seamless copper tubing smaller than 3" (75 mm).
- .2 Provide cast brass flanges with seamless copper tubing, type L for tubing 3" (75 mm) and larger.
- .5 Provide dart type, 125 lb. (860 kPa) black malleable iron unions for steel pipe for piping 2-1/2" (65 mm) and smaller.
- .6 Provide RFSO CL150 steel flanges for steel pipe for piping larger than 2-1/2" (65 mm).
- .7 Provide Cranite ring type gaskets.
- .8 Provide line sized piping specialties unless indicated otherwise on drawings.

2.2 STRAINERS

- .1 Manufacturers:

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- .1 S. A. Armstrong
- .2 Conbraco
- .2 In copper tubing: Class 250, wye type, bronze, screwed connection, with blind caps, and 1/32" (0.8 mm) perforated stainless steel screen.

2.3 ADHESIVES, SEALANTS, PAINTS AND COATINGS

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

2.4 FIRESTOPPING COMPOUNDS

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

2.5 TAGS

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

2.6 ACCESS DOORS

- .1 Standard:
 - .1 Material: Up to 16" x 16" (400x400) 16 Gauge mounting frame, over 16" x 16" (400x400) 14 gauge door, 16 gauge mounting frame.
 - .2 Finish: Steel: 5-stage iron phosphate preparation with prime coat of white, Alkyd Baking Enamel or stainless steel type 304, No. 4 satin polish.
 - .3 Heavy duty fully concealed hinges
 - .4 Screwdriver operated, stainless steel cam latch
 - .5 Manufacturers:
 - .1 Acudoor UF-500
 - .2 CEB
 - .3 MIFAB
 - .4 Cendrex Contour
- .2 Recessed Access Doors
 - .1 Material: Steel or stainless steel, 22 gauge door, 22 gauge mounting frame. Door -recessed 5/8"
 - .2 Hinge: Continuous, concealed.
 - .3 Latch: Stainless steel screwdriver operated cam latch
 - .4 Finish: Satin coat steel
 - .5 Manufacturers:
 - .1 Acudoor UF-5015
 - .2 CEB
 - .3 MIFAB
 - .4 Cendrex Contour
- .3 Fire Rated:
 - .1 Access doors in fire separations or fire rated assemblies: ULC labelled. Refer to Architectural drawings for ratings of fire separations and assemblies. Minimum 12 gauge.
 - .2 Hinge: Continuous, concealed.

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- .3 Latch: Stainless steel screwdriver operated cam latch
- .4 Finish: Steel: 5-stage iron phosphate preparation with prime coat of white, Alkyd Baking Enamel or stainless steel type 304, No. 4 satin polish.
- .5 Manufacturers:
 - .1 Acudoor
 - .2 CEB
 - .3 MIFAB
 - .4 Cendrex Contour

2.7 ESCUTCHEONS

- .1 Finish: Polished chrome

2.8 FLASHINGS AND COUNTER FLASHINGS

- .1 Provide Thaler or equivalent mechanical/electrical flashings as recommended for specific purpose.
- .2 Provide Stainless steel flashing sleeve, integral deck flange and EPDM seal.
- .3 Vent stack flashing: Thaler SJ-31, 18" (457 mm) high Vandal proof STACK JACK Flashing; .064" (1.6 mm) mill finish 1100-0T alloy aluminum; diameter to suit vent stack; to CSA B272-93; with aluminum hood and perforated collar, thick premolded urethane insulation liner and EPDM Base Seal. Provide PVC coated deck flange or bituminous painted deck flange to suit application.

2.9 PENETRATION SEALS

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

3 EXECUTION

3.1 INSPECTION

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

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3.2 PREPARATION

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

3.3 PIPING INSTALLATION - ABOVE GROUND

- .1 Cooperate with other trades whose work affects or is affected by work of this Section, to ensure satisfactory installation and to avoid delays. Provide materials to be built-in such as sleeves, anchors, etc., together with accurate dimensions or templates, promptly.
- .2 Layout work accurately, installing piping parallel to lines of building.
- .3 Install piping, wherever possible, in partitions and above ceiling. Do not install piping in outside walls unless so shown on drawings. Wrap un-insulated piping in masonry walls with building paper.
- .4 Install concealed piping close to building structure to minimize furring dimensions.
- .5 Provide adequate space around piping to facilitate application of insulation.
- .6 Use dielectric couplings where piping of dissimilar metals connect.
- .7 Where piping passes through concrete floors, or walls, size sleeves to permit the pipe to expand freely without binding or crushing pipe insulation.
- .8 Where branch pipes are welded into main without the use of "T" connections, cut torch cut openings true, bevel and file smooth. Ensure branch pipes do not project inside of main pipe. Do not cut openings large enough to permit entry of welding metal and slag within the pipe.+
- .9 Arrange take-offs from mains to allow for expansion and contraction of pipes.
- .10 When using PVC-DWV pipe, provide for expansion and contraction of risers by using ProSet E-Z Flex Coupling in accordance with good engineering practices.

3.4 PIPING JOINTS

- .1 Make joints in piping installed under this Division using persons familiar with the

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particular materials being used and in accordance with Canadian Plumbing Code, manufacturer's instructions, and as specified herein.

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

3.5 FLUSHING AND CLEANING

- .1 Flush and sterilize domestic water mains in accordance with procedures established by AWWA Specification C601.
- .2 Flush new domestic water piping in accordance with Local and Provincial Codes.
- .3 Thoroughly flush all other piping installed by this Division.
- .4 Remove, clean and replace all strainers in systems after flushing.
- .5 Thoroughly clean all equipment and fixtures, lubricate mechanical equipment, and leave all items in perfect order ready for operation.

3.6 EQUIPMENT TESTING AND INSPECTION

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

requiring adjustment or replacement.

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

3.7 PIPING SYSTEMS TESTING AND INSPECTION

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

3.8 TESTING AND BALANCING

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

3.9 PROTECTION

- .1 Protect finished and unfinished work by tarpaulins, or other covering, from damage due to execution of work under this Division.

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- .2 Repair to satisfaction of Consultant, damage to building resulting from failure to provide such protection.

3.10 EXCAVATING AND BACKFILLING

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

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- .5 Compact each layer thoroughly at optimum moisture content with approved hand or mechanical tampers to a density equal to;
 - .1 95% of Maximum Standard Proctor Density
 - .1 Behind foundation and retaining walls on grades
 - .2 Below sodded or seeded areas
 - .2 100% of Maximum Standard Proctor Density
 - .1 Below slabs on grade within building areas up to the underside of the crushed stone underlay
 - .2 Below paved or graveled areas
- .6 Do not puddle or flood with water for consolidating backfill. Add Water during the compaction to optimum moisture content of backfilling material.

3.11 SEALANTS & CAULKING

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

3.12 FIRESTOPPING

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

3.13 FLASHINGS

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

3.14 ESCUTCHEONS AND PLATES

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

3.15 PAINTING

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

3.16 SUPPORT AND ATTACHMENT

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

3.17 DISSIMILAR METALS

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

3.18 SERVICE CONNECTIONS

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

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3.19 ADJUST AND CLEAN

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

3.20 MECHANICAL IDENTIFICATION INSTALLATION

- .1 Degrease and clean surfaces to receive adhesive for identification materials.
- .2 Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer (VOC content not to exceed 680 g/L).
- .3 Install tags with corrosion resistant chain.
- .4 Comply with standard detail drawing plate, "Detail of Piping Identification".
- .5 Install plastic tape pipe markers complete around bare pipe to manufacturer's instructions.
- .6 Identify valves in main and branch piping with tags. Consecutively number valves in each system.
- .7 Identify piping, concealed or exposed, with stenciled painting and plastic tape pipe markers. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 6 m on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.

3.21 MECHANICAL IDENTIFICATION SCHEDULES

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

Pipe Marker Legend	Valve Tag Legend	Primary Colour	Secondary Colour
Cold Water	CW	Green	None
Dom. Hot Water Supply	DHWS	Green	None

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Dom. Hot Water Recirc.	DHWR	Green	None
Sanitary Sewer	-	Green	None
Storm Sewer	-	Green	None
Vent	-	Green	None

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

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

3.22 INSTALLATION OF ACCESS DOORS

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

3.23 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.

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.1 Remove surplus materials, excess materials, rubbish, tools and equipment.

.2 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal [01 35 21 - LEED Requirements].

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

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

1.2 REFERENCE STANDARDS

- .1 American Society of Mechanical Engineers (ASME)
 - .1 ASME B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
 - .2 ASME B31.1 - Power Piping.
 - .3 ASME B31.9 – HVAC Piping.
 - .4 ASME BPVC – Boiler and Pressure Vessel Code.
- .2 ASTM International (ASTM)
 - .1 ASTM A105, Standard Specification for Carbon Steel Forgings for Piping Applications
 - .2 ASTM A106, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
 - .3 ASTM B169, Standard Specification for Aluminum Bronze Sheet, Strip, and Rolled Bar.
 - .4 ASTM A193, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - .5 ASTM A194, Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
 - .6 ASTM A240, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
 - .7 ASTM A516, Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service.
 - .8 ASTM B650, Standard Specification for Electrodeposited Engineering Chromium Coatings on Ferrous Substrates.
 - .9 ASTM F1007, Standard Specification for Pipeline Expansion Joints of the Packed Slip Type for Marine Application.
- .3 Canadian Standards Association (CSA)
 - .1 CSA B51, Boiler, Pressure Vessel and Pressure Piping Code.
- .4 Expansion Joint Manufacturers Association (EJMA)
 - .1 Standards of the Expansion Joint Manufacturers Association.
- .5 Military Specifications (MIL)

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

1.3 PERFORMANCE REQUIREMENTS

- .1 Provide structural work (i.e. anchor points) and equipment required to control expansion and contraction of piping.
- .2 Verify that anchors, guides, and expansion joints provided, adequately protect system.
- .3 Arrange piping so that expansion and contraction of any piping may take place without placing undue strain on the piping or connections to the equipment. Use swing joints and suitable expansion joints wherever necessary due to field conditions and where indicated on the drawings.
- .4 Analyze each section of pipe installed between constraints and determine the potential for expansion of the pipe based on pipe temperature at installation and pipe temperatures throughout the pipe's operating range. Pipe sections are constrained where they penetrate walls, partitions, floors, ceilings, roofs and movement of the pipe is restricted and where the pipe is anchored to the building structure.
- .5 Where potential expansion exceeds 1" (25 mm) over the length of the pipe section, provide means of expansion compensation.
- .6 Notify the Consultant in writing when additional anchoring points are recommended to divide the piping system into manageable sections for the purpose of providing a complete pipe expansion compensation installation.
- .7 Expansion Calculation Temperatures
 - .1 Use maximum operating temperatures of actual systems for calculation of piping expansion and contraction.
 - .2 Use an installation temperature of 10°C for hot piping and 20°C for cold piping.

1.4 SUBMITTALS

- .1 Refer to Division 01 & Section 22 01 01
- .2 Product Data:
 - .1 Flexible Pipe Connectors:
 - .1 Maximum temperature and pressure rating,
 - .2 Face-to-face length
 - .3 Live length
 - .4 Materials of construction
 - .5 Hose wall thickness, hose convolutions per metre and per assembly,
 - .6 Fundamental frequency of assembly,
 - .7 Braid structure, and total number of wires in braid.

- .8 Maximum allowable deflections
- .9 End fittings
- .10 Pressure test information (test pressure and duration)
- .11 MTR's
- .12 Other NDE (dye penetrant, X-ray, etc.) methods and results.
- .13 CRN.
- .2 Bellows Type Expansion Joints:
 - .1 Maximum temperature and pressure rating.
 - .2 Materials of construction.
 - .3 Type of expansion joint.
 - .4 Maximum axial, lateral and angular movements.
 - .5 Fatigue life cycles (EJMA or ASME B31.3).
 - .6 Face to face dimensions.
 - .7 End fitting connections.
 - .8 Liner ID.
 - .9 Axial, lateral and angular spring rates.
 - .10 Effective area.
 - .11 Maximum thrust force at operating pressure.
 - .12 Pressure test information (pressure and duration).
 - .13 Other NDE methods and results (dye penetrant, x-ray, etc).
 - .14 MTR's.
 - .15 Accessories.
 - .16 CRN.
- .3 Slip-type Expansion Joints
 - .1 Maximum temperature and pressure rating.
 - .2 Materials of construction.
 - .3 Maximum axial movements.
 - .4 Face to face dimensions.
 - .5 End fitting connections.
 - .6 Liner ID.
 - .7 Axial spring rate.
 - .8 Effective area.
 - .9 Maximum thrust force at operating pressure.
 - .10 Pressure test information (pressure and duration).

- .11 Other NDE methods and results (dye penetrant, x-ray, etc).
- .12 MTR's.
- .13 Accessories.
- .14 CRN.
- .3 Design Data: Submit detailed construction drawings for expansion compensation and piping anchors, signed and sealed by a professional engineer licenced in Ontario. Provide selection criteria used.
- .4 Manufacturer's Installation Instructions: Indicate special procedures, and external controls.

1.5 QUALITY ASSURANCE

- .1 Manufacturer: Company specializing in manufacturing the products specified in this section with minimum ten years' documented experience.
- .2 Design expansion compensating system under direct supervision of a Professional Engineer experienced in design of this work and licenced in the Province of Ontario.
- .3 Welding and brazing: ASME BPVC Section IX.
- .4 Metallic materials: ASME BPVC Section II
- .5 Non-destructive examination (NDE): ASME BPVC Section V
- .6 Provide products having CRN Ontario or CRN Canada where rated pressure is in excess of 14.5 psig (1 bar).
- .7 Unless otherwise specified, provide certification of hydrotesting at 150% of design pressure for 10 minutes to ASME B31.1 as a minimum.

1.6 DELIVERY, STORAGE, AND HANDLING

- .1 Transport, handle, store, and protect products.
- .2 Accept expansion joints on site in factory packing with shipping bars and positioning devices intact. Inspect for damage.
- .3 Protect equipment from exposure by leaving factory coverings, pipe end protection, and packaging in place until installation.

1.7 WARRANTY

- .1 Warranty: 5-year replacement warranty.

1.8 EXTRA MATERIALS

- .1 Section 22 01 01: Submittals for project closeout.
- .2 Provide two 340 gm containers of packing lubricant and cartridge style grease gun for slip-type expansion joints.

2 PRODUCTS

2.1 MANUFACTURERS

- .1 Metal expansion joints and compensators
 - .1 Flex-Pression Ltd.
 - .2 Senior Flexonics
 - .3 Triad Bellows
 - .4 Flextech Industries
 - .5 US Bellows
 - .6 Metraflex
- .2 Elastomeric expansion joints and compensators
 - .1 Proco Products
 - .2 Metraflex
 - .3 Flextech

2.2 PIPE ALIGNMENT GUIDES

- .1 Copper Pipe:
 - .1 Radial "spider" type, minimizing piping motions in non-axial planes.
 - .2 Constructed of carbon steel with non-metallic coating on the tube clamps, and a 360-degree two-piece bolted housing, and 360-degree two-piece bolted clamps with spider type legs.
 - .3 Provide an insulation clearance of 1.5".
 - .4 Provide from same manufacturer as any associated expansion joints or compensators.
- .2 Steel Pipe:
 - .1 Radial "spider" type, minimizing piping motions in non-axial planes.
 - .2 Constructed of carbon steel with a 360-degree two-piece bolted housing, and 360-degree two-piece bolted clamps with spider type legs.
 - .3 Provide an insulation clearance of 1.5" on sizes 6" IPS and under, and 2.0" on sizes 8" IPS and over.
 - .4 Provide from same manufacturer as any associated expansion joints or compensators.

2.3 FLEXIBLE PIPE CONNECTORS

- .1 Copper Piping:
 - .1 Inner Hose: Bronze
 - .2 Exterior Sleeve: Braided bronze.
 - .3 Pressure Rating: 125 psi (862 kPa) WSP and 450°F (232°C).
 - .4 End fittings: As specified for pipe joints.

- .2 Steel Piping, 2" (50 mm) diameter and smaller:
 - .1 Inner Hose: T316 or T321 stainless steel.
 - .2 Exterior Sleeve: T304 braided stainless steel.
 - .3 Pressure Rating: 125 psi (862 kPa) WSP and 450°F (232°C).
 - .4 End fittings: NPT threaded, ASTM A105.
- .3 Steel Piping, 2-1/2" to 3-1/2" (65mm to 90mm) diameter :
 - .1 Inner Hose: T316 or T321 stainless steel
 - .2 Exterior Sleeve: T304 braided stainless steel.
 - .3 Pressure Rating: 125 psi (862 kPa) WSP and 450°F (232°C).
 - .4 End fittings: CL150 flanged, A105, B16.5 RF one end, CL150 flanged A516-70, B16.5 drilling lap joint flange one end.
- .4 Steel Piping, 4" (100mm) diameter and larger:
 - .1 Inner Hose: T321 stainless steel.
 - .2 Exterior Sleeve: T304 braided stainless steel.
 - .3 Pressure Rating: 125 psi (862 kPa) WSP and 450°F (232°C).
 - .4 End fittings: CL150 A105 flanged B16.5 one end, CL150 A516-70 flanged B16.5 drilling lap joint flange one end.

2.4 EXPANSION JOINTS - COPPER PIPING

- .1 Bronze Bellows Type Compensator:
 - .1 Construction: 2-ply bronze externally pressurized type with anti-torque device, limit stops, internal guides.
 - .2 Pressure Rating: 125 psi (862 kPa) WSP and 400°F (204°C).
 - .3 Maximum Compression: 1-3/4" (45 mm).
 - .4 Maximum Extension: 1/4" (6 mm).
 - .5 End fittings: soldered.
 - .6 Application: Copper piping.

2.5 EXPANSION JOINTS - DESIGN 150 PSIG / 500°F – STEEL PIPING

- .1 Design Criteria
 - .1 Test Pressure: to ASME B31.1.
 - .2 EJMA Cycles: 2000
- .2 Externally Pressurized Compensator
 - .1 Pressure Rating: 150 psi (1035 kPa) WOG and 500°F (260°C).
 - .2 Maximum Compression: 1-3/4" (45 mm).
 - .3 Maximum Extension: 1/4" (6 mm).

- .4 ASTM A240 T316 or T321 stainless steel bellows.
- .5 ASTM A106 shroud and pipe.
- .6 ASTM 516-70 plate rings.
- .7 ASTM A105 3000# weld-o-let drain connection and plug.
- .8 End fittings: CL150, A105 flanged B16.5 RF each end.
- .9 Provide anchor base as required.
- .10 Application: Steel piping 2-1/2" (65 mm) and smaller.
- .3 Externally Pressurized
 - .1 Pressure Rating: 150 psi (2070 kPa) WOG and 500°F (260°C).
 - .2 Maximum Compression: 8" (200 mm).
 - .3 Maximum Extension: 2" (50 mm).
 - .4 ASTM A240 T316 or T321 stainless steel bellows.
 - .5 ASTM A106 shroud and pipe.
 - .6 ASTM 516-70 plate rings.
 - .7 ASTM A105 3000# weld-o-let drain connection and plug.
 - .8 End fittings: CL150, A105 flanged B16.5 RF each end.
 - .9 Provide anchor base as required.
 - .10 Application: Steel piping 3" (75 mm) and larger.
- .4 Controlled Flexing
 - .1 Pressure Rating: 150 psi (2070 kPa) WOG and 500°F (260°C).
 - .2 Maximum Compression: 4" (200 mm).
 - .3 Maximum Extension: 1" (25 mm).
 - .4 ASTM A240 T304 or T316 stainless steel bellows.
 - .5 Cast iron bolted control rings between each bellows corrugation and cast iron neck flanges.
 - .6 End fittings: CL150, B16.5 vanstoned A516-70 steel plate flanges each end.
 - .7 Application: Steel piping 3" (75 mm) and larger.
 - .8 Provide liner for steam service.

2.6 SLIP-TYPE EXPANSION JOINT

- .1 Pressure Rating: 150 psi (2070 kPa) WOG and 500°F (260°C).
- .2 Maximum Compression: 4" (200 mm).
- .3 Maximum Extension: 1" (25 mm).

- .4 Packed-slip type containing injectable flaked graphite packing and graphite seals. Packing ports allowing packing under full line pressure are required.
- .5 Internal and external line-bore machined guides of ASTM B169-C614 bronze.
- .6 Stainless steel extension limit stop ring covering approximately 360 degrees will be included on each slip tube.
- .7 ASTM A106 slip tube hard-chromed-plated .002" thick to ASTM B650.
- .8 One-piece body, steel construction ASTM A106 and ASTM A516-70.
- .9 Drain port on each joint.
- .10 End fittings: CL150, A105 flanged B16.5 RF each end.
- .11 Provide anchor base as required.
- .12 Joint design and manufacturing in compliance with ASTM F1007 and MIL-E-17814F.

3 EXECUTION

3.1 INSTALLATION

- .1 Install flexible pipe connectors and expansion joints to manufacturer's instructions.
- .2 Ensure ratings and bolt patterns for flanges suit design pressure and design temperature of piping system and match those of installed components.
- .3 Provide spool pieces as required.
- .4 Install flexible pipe connectors on pipes connected to equipment supported by vibration isolation. Provide line size flexible connectors.
- .5 Install flexible connectors at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor other end. Install in horizontal plane unless indicated otherwise.
- .6 Provide pipe anchors securing the piping system to the building structure to control the direction and the amount of pipe movement. Design pipe anchors to withstand expansion joint thrust forces, spring forces, and other forces experienced. Prepare calculations for each anchor and submit to Consultant for review and approval.
- .7 Provide pipe guides at spacings recommended by expansion joint manufacturer to maintain pipe alignment and ensure pipe expansion is directed along the proper axes relative to the expansion joint. Ensure two guides are provided on each side of an expansion joint.
- .8 Provide support and equipment required to control expansion and contraction of piping. Provide pipe offsets, and swing joints, or expansion joints where required.
- .9 Expansion loops in place of expansion compensators where there is adequate space to do so is acceptable subject to the approval of the Consultant. Prepare and submit detailed design calculations for each expansion loop proposed to the

Consultant for review and approval prior to installation.

3.2 MANUFACTURER'S FIELD SERVICES

- .1 Prepare and start systems to Section 22 01 01.
- .2 Provide inspection services by manufacturer's representative for final installing and certify installation is to manufacturer's recommendations and connectors are performing satisfactorily.

3.3 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

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

1.2 REFERENCE STANDARDS

- .1 American Society of Mechanical Engineers (ASME)
 - .1 ASME B31.5 - Refrigeration Piping and Heat Transfer Components.
 - .2 ASME B31.9 – Building Services Piping.
- .2 ASTM International (ASTM)
 - .1 ASTM F708 - Design and Installation of Rigid Pipe Hangers.
- .3 American National Standards Institute (ANSI)
 - .1 MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
 - .2 MSS SP69 - Pipe Hangers and Supports - Selection and Application
 - .3 MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices
- .4 CSA Group (CSA)
 - .1 CSA B51 - Boiler, pressure vessel, and pressure piping code
- .5 Underwriters Laboratories (UL)
 - .1 UL 203 - Pipe Hanger Equipment for Fire protection Service.

1.3 SUBMITTALS

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

1.4 REGULATORY REQUIREMENTS

- .1 Conform to CSA B-51 for support of piping.
- .2 Conform to the requirements of ASME B31.9.

1.5 DELIVERY, STORAGE, AND HANDLING

- .1 Deliver, store and handle in accordance with Division 01 - Common Product Requirements.

- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .3 Packaging Waste Management: remove for reuse and return by manufacturer of packaging materials in accordance with Division 01 - Waste Management and Disposal.

2 PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

- .1 Provide products conforming to applicable MSS SP standards.
- .2 Manufacturers:
 - .1 Anvil
 - .2 Myatt
 - .3 Hunt
- .3 Plumbing and Natural Gas Piping:
 - .1 Hangers for Pipe Sizes 1/2" to 1-1/2" (13 to 38 mm): Carbon steel, adjustable swivel, split ring.
 - .2 Hangers for Cold Pipe Sizes 2" (50 mm) and Over: Carbon steel, adjustable, clevis.
 - .3 Hangers for Hot Pipe Sizes 2" to 4" (50 to 100 mm): Carbon steel, adjustable, clevis.
 - .4 Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
 - .5 Wall Support for Pipe Sizes to 3" (76 mm): Cast iron hook.
 - .6 Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 - .7 Floor Support for Hot Pipe Sizes to 4" (100 mm): Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 - .8 Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

2.2 ACCESSORIES

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

2.3 SLEEVES

- .1 Materials:
 - .1 Cast iron pipe with annular fin.

- .2 Steel pipe with annular fin continuously welded at midpoint.
- .3 20-Ga galvanized steel

2.4 FLASHINGS AND COUNTERFLASHINGS

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

3 EXECUTION

3.1 INSTALLATION

- .1 Install according to manufacturer's instructions and best trade practises.
- .2 Conform to the requirements of applicable MSS SP standards supplementary to manufacturer's instructions.

3.2 INSERTS

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

3.3 PIPE HANGERS AND SUPPORTS

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

supporting force at each hanger location and the pipe weight load at each equipment connection.

- .11 Ensure hangers and supports can support the pipe in all conditions of operation allow free expansion and contraction of the piping and prevent excessive stress resulting from transferred weight being induced into the pipe or connected equipment.
- .12 Wherever possible, provide pipe clamps for pipe attachments for horizontal piping.
- .13 Wherever possible, provide beam clamps for structural attachment.
- .14 Support from top of structural members. Where structural bearings do not exist or inserts are not available in suitable locations, suspend hangers from steel channels or angles. Provide supplementary structural members as needed. Obtain approval before using vertical expansion shields. Use minimum two shields for each hanger. Do not suspend from metal deck.
- .15 Provide a means of vertical adjustment after erection. Use hangers with 1-1/2" (38 mm) minimum vertical adjustment.
- .16 Design hangers that they cannot become disengaged by movements of the supported pipe.
- .17 Where practical, support riser piping independently of the connected horizontal piping. Provide riser clamp lugs for pipe support attachments to the riser piping. Provide welded attachments of material comparable to that of the pipe and designed in accordance with governing codes.
- .18 Support vertical piping at every other floor. Support vertical cast iron pipe at each floor at hub.
- .19 Ensure hanger rods are subject to tensile loading only. At hanger locations where lateral or axial movement is anticipated, provide suitable linkage to permit swing.
- .20 Where horizontal piping movements are greater than 1/2" (13 mm), or where the hanger rod angularity from the vertical is greater than 4 degrees from the cold to hot position of the pipe, Offset the hanger pipe and structural attachments in such manner that the rod is vertical in the operating position.
- .21 Install rigid hangers with adjustable devices where ratio of pipe expansion to hanger rod length does not exceed 1:24.
- .22 Install swing hanger with adjustable devices where ratio of pipe expansion to hanger rod length does not exceed 1:6.
- .23 Install pipe rollers (roller hangers) for steam and condensate, piping 4" (100 mm) in diameter and larger and where ratios cannot be maintained.
- .24 Install spring hangers on horizontal runs where required to offset vertical expansion of risers.
- .25 Support horizontal piping in accordance with code requirements. Where there are no code requirements, provide support and spacing as shown in schedule with following exceptions:

- .1 Support plumbing piping in accordance with Ontario Building Code Part 7, Plumbing.
- .2 Support 1/2" (13 mm) gas pipe every 6' (1.8 m).
- .3 Support 1/2" (13 mm) copper pipe every 5' (1.5 m).
- .4 Support flexible joint roll grooved pipe in accordance with table below, but not less than one hanger for each joint.
- .5 Support plastic piping in accordance with manufacturer's recommendations.
- .26 Install hangers to provide minimum 1/2" (13 mm) space between finished covering and adjacent work.
- .27 Place hangers within 12" (300 mm) of each horizontal elbow.
- .28 Support horizontal cast iron pipe adjacent to each hub, with 5 feet (1.5 m) maximum spacing between hangers.

3.4 SLEEVES

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

3.5 FLASHING

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

Attach counterflashing mechanical equipment and lap base flashing on roof curbs. Flatten and solder joints.

- .7 Adjust storm collars tight to pipe with bolts, caulk around top edge. Use storm collars above roof jacks. Screw vertical flange section to face of curb.
- .8 Coordinate this work with the roofing Trades to ensure a satisfactory installation and to avoid delays.

3.6 SCHEDULES

.1 Imperial Measure (IP)

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

.2 Metric Measure (SI)

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

3.7 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

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

1.2 REFERENCE STANDARDS

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

1.3 SUBMITTALS

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

1.4 PROJECT RECORD DOCUMENTS

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

1.5 QUALITY ASSURANCE

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

1.6 QUALIFICATIONS

- .1 Agency: Company specializing in the testing, adjusting, and balancing of systems under this Section with minimum five years documented experience certified by AABC or prequalified as listed below.
- .2 Performed Work under the supervision of an AABC certified Test and Balance Engineer, an NEBB Certified Testing, Adjusting and Balancing Supervisor or a

registered Professional Engineer experienced in the performance of this work and licenced at the place where the Project is located.

1.7 PRE-BALANCING CONFERENCE

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

1.8 CO-OPERATION

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

2 PRODUCTS

2.1 REFERENCE STANDARDS

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

3 EXECUTION

3.1 EXAMINATION

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

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

3.2 PREPARATION

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

3.3 INSTALLATION TOLERANCES

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

3.4 ADJUSTING

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

3.5 DOMESTIC HOT WATER RECIRCULATION SYSTEM PROCEDURE

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

3.6 SCHEDULES

- .1 Equipment requiring testing, adjusting and balancing:
 - .1 Balancing valves
- .2 Report Forms
 - .1 Title Page:
 - .1 Name of Testing, Adjusting, and Balancing Agency
 - .2 Address of Testing, Adjusting, and Balancing Agency
 - .3 Telephone number of Testing, Adjusting, and Balancing Agency
 - .4 Project name
 - .5 Project location

- .6 Project Architect
- .7 Project Engineer
- .8 Project Contractor
- .9 Project altitude
- .10 Report date
- .2 Summary Comments:
 - .1 Design versus final performance
 - .2 Notable characteristics of system
 - .3 Description of systems operation sequence
 - .4 Nomenclature used throughout report
 - .5 Test conditions

3.7 PIPING SYSTEMS VERIFICATION

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

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

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

1.2 REFERENCE STANDARDS.

- .1 American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE)
 - .1 Standard 90.1-2013—Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings
- .2 ASTM International (ASTM)
 - .1 ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
 - .2 ASTM C177 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
 - .3 ASTM C195 - Mineral Fibre Thermal Insulating Cement.
 - .1 ASTM C335 - Steady-State Heat Transfer Properties of Horizontal Pipe Insulation.
 - .4 ASTM C449/C449M - Mineral Fibre Hydraulic-setting Thermal Insulating and Finishing Cement.
 - .5 ASTM C518 - Steady-State Thermal Transmission Properties by Means of the Heat Flow Metre Apparatus.
 - .6 ASTM C533 - Calcium Silicate Block and Pipe Thermal Insulation.
 - .7 ASTM C534 - Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
 - .8 ASTM C547 - Mineral Fibre Pipe Insulation.
 - .9 ASTM C552 - Cellular Glass Thermal Insulation.
 - .10 ASTM C578 - Rigid, Cellular Polystyrene Thermal Insulation.
 - .11 ASTM C585 - Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
 - .12 ASTM C591 - Unfaced Preformed Cellular Polyisocyanurate Thermal Insulation.
 - .13 ASTM C610 - Moulded Expanded Perlite Block and Pipe Thermal Insulation.
 - .14 ASTM C921 - Properties of Jacketing Materials for Thermal Insulation.
 - .15 ASTM D1056 - Flexible Cellular Materials - Sponge or Expanded Rubber.
 - .16 ASTM D1667 - Flexible Cellular Materials - Vinyl Chloride Polymers and Copolymers (Closed Cell Foam).
 - .17 ASTM D2842 - Water Absorption of Rigid Cellular Plastics.
 - .18 ASTM E84 - Surface Burning Characteristics of Building Materials.

- .19 ASTM E96 - Water Vapour Transmission of Materials.
- .3 Standards Council of Canada (SCC)
 - .1 CAN/ULC-S102 – Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.
- .4 National Fire Protection Association (NFPA)
 - .1 NFPA 255 - Surface Burning Characteristics of Building Materials.
- .5 Thermal Insulation Association of Canada (TIAC)
 - .1 TIAC Mechanical Insulation Best Practices Guide.
- .6 Underwriters Laboratories (UL)
 - .1 UL 723 - Surface Burning Characteristics of Building Materials.

1.3 SUBMITTALS

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

1.4 QUALITY ASSURANCE

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

1.5 QUALIFICATIONS

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

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 ENVIRONMENTAL REQUIREMENTS

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

2 PRODUCTS

2.1 GLASS FIBRE

- .1 Manufacturers:
 - .1 Manufacturer: Owens Corning Fiberglass
- .2 Other acceptable manufacturers offering equivalent products:
 - .1 Manson
 - .2 Knauf Fiber Glass
 - .3 Johns Manville
- .3 Insulation: ASTM C547; rigid moulded, noncombustible.
 - .1 'ksi' value: ASTM C335, 0.035 at 75°F (24°C).
 - .2 Minimum Service Temperature: -20°F (-28.9°C).
 - .3 Maximum Service Temperature: 302°F (150°C).
 - .4 Maximum Moisture Absorption: 0.2 percent by volume.
- .4 Vapour Barrier Jacket
 - .1 ASTM C921, White kraft paper reinforced with glass fibre yarn and bonded to aluminized film.
 - .2 Moisture Vapour Transmission: ASTM E96; 0.02 perm.
 - .3 Secure with self-sealing longitudinal laps and butt strips.
 - .4 Secure with outward clinch expanding staples and vapour barrier mastic.
- .5 Tie Wire: 1.3 mm stainless steel with twisted ends on maximum 12" (300 mm) centres.
- .6 Vapour Barrier Lap Adhesive
 - .1 Compatible with insulation.
- .7 Insulating Cement/Mastic
 - .1 ASTM C195; hydraulic setting on mineral wool, VOC content not to exceed 80 g/L.
- .8 Fibrous Glass Fabric
 - .1 Cloth: Untreated; 9 oz/sq yd (305 g/sq m) weight.
 - .2 Blanket: 1.0 lb/cu ft (16 kg/cu m) density.
- .9 Indoor Vapour Barrier Finish
 - .1 Vinyl emulsion type acrylic, compatible with insulation, white colour, VOC content not to exceed 250 g/L.
- .10 Outdoor Vapour Barrier Mastic
 - .1 Vinyl emulsion type acrylic, compatible with insulation, white colour.
- .11 Insulating Cement
 - .1 ASTM C449, VOC content not to exceed 80 g/L.

2.2 JACKETS

- .1 PVC Plastic
 - .1 Jacket: ASTM C921, One piece moulded type fitting covers and sheet material.
 - .1 Minimum Service Temperature: -31°F (-35°C).
 - .2 Maximum Service Temperature: 151°F (66°C).
 - .3 Moisture Vapour Transmission: ASTM E96; 0.03 perm inches.
 - .4 Indoor application thickness: 20 mil (0.5 mm) minimum.
 - .5 Outdoor application thickness: 30 mil (0.76mm) minimum.
 - .2 Colour: standard off-white
 - .3 Covering Adhesive Mastic
 - .1 Compatible with insulation, maximum VOC content of 50 g/L.
 - .4 Manufacturer.
 - .1 Ceel-Co 300 series
 - .2 Speedline *Smoke Safe*
- .2 Aluminum Jacket: ASTM B209.
 - .1 Thickness: 0.02" (0.40 mm) sheet.
 - .2 Finish: Smooth.
 - .3 Joining: Longitudinal slip joints and 2" (50 mm) laps.
 - .4 Fittings: 0.02" (0.40 mm) thick die shaped fitting covers with factory attached protective liner.
 - .5 Metal Jacket Bands: 3/8" (10 mm) wide; 0.01" (0.38 mm) thick aluminum.

2.3 ACCESSORIES

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

3 EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

- .1 Install piping insulations to TIAC National Installation Standards.
- .2 Apply insulation materials, accessories, jackets and finishes in accordance with manufacturers' written instructions and as specified.
- .3 On exposed piping locate insulation and cover seams in least visible locations.
- .4 Insulated dual temperature pipes or cold pipes conveying fluids below ambient temperature:
 - .1 Provide vapour barrier jackets, factory applied, or field applied.
 - .2 Insulate fittings, joints, and valves with moulded insulation of like material and thickness as adjacent pipe.
 - .3 Finish with glass cloth and vapour barrier adhesive.
 - .4 PVC fitting covers may be used.
 - .5 Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations.
 - .6 Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
- .5 For insulated pipes conveying fluids above ambient temperature:
 - .1 Provide standard jackets, with or without vapour barrier, factory applied, or field applied.
 - .2 Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe.
 - .3 Finish with glass cloth and adhesive.
 - .4 PVC fitting covers may be used.
 - .5 For hot piping conveying fluids 140°F (60°C) or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
 - .6 For hot piping conveying fluids over 140°F (60°C), insulate flanges and unions at equipment.
- .6 Inserts and Shields:
 - .1 Application: Piping 1-1/2" (40 mm) diameter or larger.
 - .2 Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
 - .3 Insert Location: Between support shield and piping under the finish jacket.

- .4 Insert Configuration: Minimum 6" (150 mm) long, of same thickness and contour as adjoining insulation; may be factory fabricated.
- .5 Insert Material: hydrous calcium silicate insulation.
- .7 Finish insulation at supports, protrusions, and interruptions.
- .8 Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapour barrier cement.

3.3 PIPE INSULATION

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

RIGID PIPE INSULATION			
Service	Operating Temperature Range °F	Pipe Diameter in.	Insulation Thickness in.
Domestic cold water	32 to 105	All sizes	1
Domestic hot water & hot water recirculation	105 to 140	1-1/2 and smaller	1
		2 and larger	1-1/2
Storm drainage	40 to 55	All sizes	1
Humidifier piping	201 to 250	3 and smaller	2-1/2

RIGID PIPE INSULATION (SI)			
Service	Operating Temperature Range °C	Pipe Diameter (mm)	Insulation Thickness (mm)
Domestic cold water	0 to 40	All sizes	25
Domestic hot water & hot water recirculation	41 to 60	38 and smaller	25
		50 and larger	38
Storm drainage	4 to 13	All sizes	25
Humidifier piping	94 to 121	75 and smaller	65

- .2 Insulate valves, flanges and pipe connections with removable / reusable insulation covers.
- .3 Wrap butt joints with a 4" (100 mm) strip of fire resistant vapour barrier jacket cemented with lagging adhesive.
- .4 Where the pipe hanger is around the insulation, provide an insulation protection shield within the pipe saddle. Coordinate with installation of hangers.

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

3.4 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 22 01 01 and Division 01 - Commissioning.

1.2 COMMISSIONING AGENT

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

1.3 DESCRIPTION OF WORK

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

1.4 RELATED DOCUMENTS

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

1.5 REFERENCE STANDARDS

- .1 American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE)
 - .1 ASHRAE Guideline 0 The Commissioning Process

1.6 SYSTEMS TO BE COMMISSIONED

- .1 The following Plumbing work shall be commissioned as part of the Work of this contract:

- .1 Fire Protection Systems
 - .1 Wall Hydrants
 - .2 Fire Extinguisher Cabinets
 - .3 Automatic Sprinkler System
- .2 Domestic Water System
 - .1 Piping
 - .2 Backflow Preventers
- .3 Drainage System
 - .1 Sanitary Drainage Piping
 - .2 Floor Drains
 - .3 Cleanouts
 - .4 Plumbing Fixtures
 - .5 Trap Seal Primers

2 PRODUCTS

2.1 COMMISSIONING AUTHORITY

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

2.2 SYSTEMS START-UP/VERIFICATION CHECKLISTS

- .1 The Appendix specification section contains the system start-up and verification checklists as listed below:
 - .1 Fire Protection Systems
 - .1 Wall Hydrants
 - .2 Fire Extinguisher Cabinets
 - .3 Automatic Sprinkler System

- .2 Domestic Water System
 - .1 Piping
 - .2 Backflow Preventers
- .3 Drainage System
 - .1 Sanitary Drainage Piping
 - .2 Floor Drains
 - .3 Cleanouts
 - .4 Plumbing Fixtures
 - .5 Trap Seal Primers

2.3 FUNCTIONAL PERFORMANCE TEST CHECKLISTS

- .1 The Appendix specification section contains functional performance test checklists as listed below:
 - .1 Fire Protection Systems
 - .1 Wall Hydrants
 - .2 Fire Extinguisher Cabinets
 - .3 Automatic Sprinkler System
 - .2 Domestic Water System
 - .1 Piping
 - .2 Backflow Preventers
 - .3 Drainage System
 - .1 Sanitary Drainage Piping
 - .2 Floor Drains
 - .3 Cleanouts
 - .4 Plumbing Fixtures
 - .5 Trap Seal Primers

3 EXECUTION

3.1 COMMISSIONING AGENT (CA) RESPONSIBILITIES

- .1 Plan, organize and implement the commissioning process as specified.
- .2 Prepare the commissioning plan, ensure its distribution for review and comment.
- .3 Revise the commissioning plan as required during construction.
- .4 Chair commissioning meetings and prepare and distribute minutes to commissioning team members.
- .5 In conjunction with the General Contractor, coordinate commissioning activities among

contractors, sub-trades and suppliers.

- .6 monitor system verification checks, and ensure the results are documented as the checks are done.
- .7 Observe start-ups and initial system operations tests and checks.
- .8 Witness functional performance tests and document the results.
- .9 Prepare and submit a commissioning report which documents checks and tests done throughout the commissioning process.
- .10 Ensure O&M manuals, instructions and demonstrations are provided to the owner's designated operating staff.

3.2 MECHANICAL ENGINEER'S RESPONSIBILITIES

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

3.3 OWNER'S RESPONSIBILITIES

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

3.4 GENERAL CONTRACTOR'S RESPONSIBILITIES

- .1 Participate as required in the Mechanical Systems Commissioning process,
- .2 Ensure the Division 22 sub-contractor performs assigned commissioning responsibilities as specified.
- .3 Ensure the testing, adjusting and balancing agency performs assigned commissioning responsibilities as specified.
- .4 Ensure the cooperation and participation in the commissioning process of other sub-contractors as applicable.
- .5 Assign a representative to the commissioning team, and submit the person's name to the commissioning agency, within one (1) month of the award of the contract. The representative shall have the authority to make decision on behalf of the general contractor as they relate to the organization and scheduling of plumbing systems commissioning. The representative shall facilitate communications among all contractors and suppliers and other commissioning team members and shall foster the necessary cooperative action. One specific responsibility shall be to attend commissioning meetings and ensure action items arising from them are attended to as required to allow the commissioning process to proceed on schedule.
- .6 In the event that any scheduled equipment or system start-ups or functional performance tests are terminated because the CA or the mechanical engineer discover deficient or

incomplete work, or due to the non-attendance of required contractor or supplier personnel, the contractor or sub-contractor responsible for the termination shall also be responsible for paying reasonable costs of time and travel expenses of any or all of the following representatives who were physically present for the purpose of witnessing the start-up or the functional performance test including the CA, the mechanical engineer, the electrical engineer, and the owner. The owner may provide a statement to the General Contractor identifying the specific activity that was terminated, the scheduled date, and a list of those in attendance, along with their reasonable time and travel expenses.

3.5 DIVISION 22 SUBCONTRACTOR'S RESPONSIBILITIES

- .1 Cooperate with the commissioning agent (CA), and other commissioning team members, to facilitate the successful completion of the commissioning process.
- .2 Assign a representative to the commissioning team, and submit the person's name to the commissioning agency, within one (1) month of the award of the contract. The representative shall have the authority to make decisions on behalf of the mechanical contractor as they relate to the organization and scheduling of plumbing systems commissioning. The representative shall ensure communications between Division 22 contractors and suppliers and all other commissioning team members and shall foster the necessary cooperative action. One specific responsibility shall be to attend commissioning meetings and ensure action items arising from them are attended to as required to allow the commissioning process to proceed on schedule.
- .3 The plumbing systems sub-contractor, and all sub-contractors and suppliers, shall cooperate with the Commissioning Agency in carrying out the plumbing systems commissioning process. In this context, the plumbing systems sub-contractor shall:
 - .1 Include in his bid price the cost of participating in the commissioning process as specified herein.
 - .2 Provide instruction and demonstrations for the Owner's designated operating staff, in conjunction with the commissioning agency and mechanical engineer, and with the participation of qualified technicians from major equipment suppliers and the controls contractor.
 - .3 Include requirements for submittal data. O&M data, and training information in each purchase order or sub-contract written.
 - .4 Attend commissioning meetings scheduled by the CA.
 - .5 Notify the CA a minimum of two weeks in advance of scheduled equipment and system start-ups, so that the CA may witness system verifications, and equipment and system start-ups.
 - .6 Provide sufficient personnel to assist the CA as required during system verification and functional performance testing.
 - .7 Prior to set-up, inspect, check and confirm the correct and complete installation of equipment and systems for which system verification checklists are included in the commissioning plan. Document the results of inspections and checks on the checklists and sign them. If deficient or incomplete work is discovered, ensure corrective action is taken and re-check until the results are satisfactory, and the system is ready for safe start-up.

- .8 Notify the CA a minimum of two weeks in advance of the time for start of the TAB work. Attend the initial TAB meeting for review of the TAB procedures.
- .9 Prepare preliminary schedule for mechanical system orientation and inspections. O&M Manual submission, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up TAB, and task completion for use by the CA. Update schedule as appropriate throughout the construction period.
- .10 Conduct plumbing systems orientation and inspection at the equipment placement completion stage.
- .11 Update drawings to as-built condition and review with the CA.
- .12 Gather O&M data on equipment and assemble in binders as specified.
- .13 Provide written notification to the general contractor (or construction manager) and CC that the following work has been completed in accordance with the contract documents and the equipment, systems and sub-systems are operating as required
 - .1 plumbing equipment including all tanks, pumps, fixtures and piping systems.
 - .2 Fire-stopping in the fire-rated construction
- .14 Provide a complete set of as-built drawings and O&M manuals to the CA.

3.6 TAB AGENCY'S RESPONSIBILITIES

- .1 Include costs for plumbing systems commissioning requirements in the quoted price.
- .2 Attend commissioning meetings scheduled by the CA prior to, and during, on-site TAB work being done.
- .3 Submit proposed TAB procedures to the CA and mechanical engineer for review and acceptance.
- .4 Attend the TAB planning meeting scheduled by the CA. Be prepared to discuss the procedures that shall be followed in testing, adjusting and balancing the plumbing systems system.
- .5 At the completion of the TAB work, submit the final TAB report to the mechanical contractor, submittal will be to the mechanical contractor, with general contractor, CA, and mechanical engineer notified.
- .6 Participate in verification of the TAB report by the CA for verification or diagnostic purposes.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

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

1.2 SECTION INCLUDES

- .1 Roof and floor drains
- .2 Interior Trench Drains & Catchbasins
- .3 Hose bibs.
- .4 Hydrants.
- .5 Trap Seal Primers
- .6 Cleanouts
- .7 Water hammer arrestors
- .8 Neutralization Tank
- .9 Water Purification System
- .10 Backflow Preventors
- .11 Interceptors
- .12 Laundry Boxes
- .13 Domestic Hot Water Mixing Valves

1.3 REFERENCE STANDARDS

- .1 American Society of Mechanical Engineers (ASME)
 - .1 ASME A112.21.1 - Floor Drains.
 - .2 ASME A112.21.2 - Roof Drains.
 - .3 ASME A112.26.1 - Water Hammer Arrestors.
- .2 ASSE International (ASSE)
 - .1 ASSE 1011 - Hose Connection Vacuum Breakers.
 - .2 ASSE 1013 - Backflow Preventers, Reduced Pressure Principle.
 - .3 ASSE 1019 - Wall Hydrants, Frost Proof Automatic Draining Anti-Backflow Types.
- .3 Plumbing & Drainage Institute (PDI)
 - .1 PDI WH-201 - Water Hammer Arrestors.

1.4 SUBMITTALS FOR REVIEW

- .1 Product Data: Provide component sizes, rough-in requirements, service sizes, and finishes.

- .2 Shop Drawings: Indicate dimensions, weights, and placement of openings and holes.

1.5 SHOP DRAWING SUBMITTALS

- .1 Submit in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Certificates:
 - .1 Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

1.6 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Division 01 - Closeout Submittals.
- .2 Project Record Documents: Record locations of equipment, cleanouts, backflow preventers, water hammer arrestors
- .3 Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views for incorporation into O&M manuals.

1.7 QUALITY ASSURANCE

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

1.8 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store products off ground, indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect products from nicks, scratches, blemishes, vermin, theft and vandalism.
 - .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.

2 PRODUCTS

2.1 GENERAL

.1 Manufacturer: Watts Drainage model indicated or equivalent by:

- .1 Zurn
- .2 Jay R. Smith
- .3 Precision Plumbing Products

2.2 FLOOR DRAINS

.1 Floor Drain (FD):

- .1 Watts FD-100-C-5
- .2 ANSI A112.21.1; lacquered cast iron two piece body with double drainage flange, weep holes, reversible clamping collar, and round, adjustable round nickel-bronze strainer with removable perforated sediment bucket.

.2 Floor Drain (FFD):

- .1 Watts Drainage Model FD-100-C-EG
- .2 ANSI A112.21.1; lacquered cast iron two piece body with double drainage flange, weep holes, reversible clamping collar, and round, adjustable nickel-bronze strainer with polished bronze elongated funnel.

.3 Floor Drain (HD):

- .1 Watts Drainage Model FD-100-C-AS-7-8
- .2 ANSI A112.21.1; lacquered cast iron two piece body with double drainage flange, weep holes, reversible clamping collar, adjustable nickel-bronze angle strainer, trap primer tapping, and backwater valve.

2.3 BACKFLOW PREVENTOR

.1 Backflow Prevention Device Applications:

Type & Purpose	Description	Installed Application
Reduced Pressure Zone Assemblies	Two independent check valves with intermediate relief valve. Supplied with shutoff valves & ball type test cocks.	Make up water for glycol fill, hot water tank, humidifier
Specialty backflow preventor with	Two independent check valves with intermediate vacuum breaker and relief vent.	Ice machine

intermediate atmospheric vent		
Atmospheric vacuum breaker	Single float and disc with atmospheric port.	Residential washing machine
Pressure vacuum breaker	Spring-loaded float and disc with independent check. Supplied with shutoff valves and ball type test cocks.	Autoclave
Dual Check Valve with intermediate vacuum breaker	Two independent check valves with intermediate vacuum breaker and relief vent.	Laboratory clean and dirty sinks, cup sinks, pathological workstation

.2 Reduced Pressure Zone Assemblies:

- .1 Watts Model LF909.
- .2 install at each cross-connection to prevent back siphonage & backpressure of hazardous materials into the portable water supply.
- .3 Consists of a pressure differential relief valve located in a zone between two positive seating check valves.
- .4 Include provision to admit air directly into the reduced pressure zone via a separate channel from the water discharge channel or via a separate vent directly into the supply pipe.
- .5 Constructed using lead free cast copper silicon materials.
- .6 Include two tightly closing shutoff valves before & after the assembly. Test cocks & a protective strainer upstream of the No. 1 shutoff valve.
- .7 Conform to the requirements of ASSE Std 1013, AWWA Std C-511-92, CSA B64.4.

.3 Specialty backflow preventor with intermediate atmospheric vent:

- .1 Watts Series 9D
- .2 Forged brass body construction
- .3 Durable tight seating rubber check valve assemblies

.4 Atmospheric Vacuum Breaker:

- .1 Watts LF288A, LF289, LFN 388
- .2 Body: lead free cast silicon copper alloy
- .3 Disc: Silicone
- .4 Spill-resistant diaphragm
- .5 Temperature Range: 82C (180F)
- .6 Max Working Pressure: 15PSI (8.6 Bar)

- .5 Pressure Vacuum Breaker:
 - .1 Watts LF800M4QT
 - .2 Springs: Stainless steel
 - .3 Bonnet: Celcon
 - .4 Vent Disc: Silicone Rubber
 - .5 Body: Lead free cast copper silicon alloy

2.4 TRAP SEAL PRIMERS

- .1 Individual Traps:
 - .1 Watts Drainage model MS-810
 - .2 Automatic cast brass body, renewable disc and seat rings, vacuum breaker and removable cover.
- .2 Groups of Traps:
 - .1 PPP Inc. P1-500 (1-4 Floor Drains), or P2-500 (1-2 Floor Drains), all brass automatic pressure drop activated trap primer valve complete with supply tube and/or distribution units DU-U. Valve requires a 10 psi (70 kpa) pressure drop across the valve to activate. Constructed of 360 brass, EPDM E70 O-rings, Dow #7 Silicone, #60 stainless steel mesh screen, stainless steel adjustment screw.

2.5 CLEANOUTS

- .1 Exterior Surfaced Areas:
 - .1 Watts Drainage model CO-200-RFC
 - .2 Round cast nickel bronze access frame and non-skid cover.
- .2 Exterior Unsurfaced Areas:
 - .1 Watts Drainage model CO-300-MF
 - .2 Extra Heavy Duty type with epoxy coated cast iron body with two fixed anchor flanges and round heavy duty ductile iron gasketed cover.
- .3 Interior Finished Floor Areas:
 - .1 Watts Drainage model CO-200-R, CO-200-U
 - .2 Lacquered cast iron body with anchor flange, reversible clamping collar, threaded top assembly, and round gasketed scored cover in service areas and round gasketed depressed cover to accept floor finish in finished floor areas.
- .4 Interior Finished Wall Areas:
 - .1 Watts Drainage model WUCO
 - .2 Line type with lacquered cast iron body and round epoxy coated gasketed cover, and round stainless steel access cover secured with machine screw.
- .5 Interior Unfinished Accessible Areas: Caulked or threaded type. Provide bolted

stack cleanouts on vertical rainwater leaders.

- .6 Line Cleanouts: lacquered cast iron Malcom type with cleanout ferrule, 1/2" (13mm) thick epoxy coated gasketed cover.
- .7 Caulking for cleanouts: VOC content not to exceed 250g/L.

2.6 WATER HAMMER ARRESTORS

- .1 Provide Zurn Wilkins model 1260XL water hammer arrester certified to NSF/ANSI 372, consist of a copper body with a low lead brass hexagonal male pipe threaded inlet, polycarbonate or PVC piston, EPDM O-rings and lead free solder. The device shall be pre-charged and sealed at the factory.
- .2 Provide Zurn WH2950XL ANSI 112.26.1 3rd party certified to comply with lead plumbing law 0.25% maximum weighted average lead content requirement, ASSE 1010, consist of a copper body with a low lead brass hexagonal male pipe threaded inlet, an acetal, polycarbonate or low lead brass piston with buna nitrile or EPDM O-rings and lead free solder. The device shall be pre-charged and sealed at the factory.
- .3 Provide properly sized Zurn Z1700 with nesting type bellows contained within casing that has sufficient displacement volume to dissipate the calculated kinetic energy generated in the piping system. Both casing and bellows constructed of 18-8 stainless steel.
- .4 For shock associated with solenoid or other quick-closing valves serving heavy equipment such as laundry machines, dishwashers, etc. provide properly sized Zurn Z1712 Accumatrol complete with floating stainless steel spherical piston, surge chamber, valve and gauge assembly, bronze surge chamber, and viton valve seat. Maximum temperature – 500°F. Maximum pressure – 200 psi.

2.7 DOMESTIC HOT WATER MIXING VALVES

- .1 Master Mixing Valve (large capacity)
 - .1 Symmons Model 5-1000B-200-PRV.
 - .2 Other acceptable manufacturers offering equivalent products.
 - .1 Powers.
 - .2 Danfoss.
 - .3 Leonard.
 - .3 Dual thermostatic controller assembly with high-low configuration, each controller contains a removable cartridge with strainer, stainless steel piston and liquid fill thermal motor with bellow element mounted out of water, inlet manifold piping, pressure reducing valve, two pressure gauges, bi-metal dial thermometer with 3" (76mm) face, range 20°-240°F (-7° to 116°C), wall bracket.
 - .4 Cabinet: 1.6 mm stainless steel back box with 12-ga. double doors with cylinder lock and key, for surface mounting with keyed lock.
 - .5 Capacity: as scheduled.

- .2 Thermostatic Tempering Valve for Hot Water Distribution (1/2" to 1")
 - .1 Powers LFLM490
 - .2 Thermostatic tempering valve shall be constructed using Lead Free* brass material which shall comply with state codes and standards, where applicable, requiring reduced lead content. The valve shall feature advanced paraffin-based actuation technology and union connections for ease of maintenance. All internal components shall be corrosion-resistant. Valve shall feature integral checks to prevent cross-flow and inlet screens to filter out debris.
 - .3 The valve shall be ASSE 1017*** certified, IAPMO cUPC certified and approved to CSA B125.3. Capacity of the valve shall be 23.0 gpm (87.0 lpm) at 45psi (310 kPa) differential.
 - .4 Valve shall perform to a minimum flow of 0.5 gpm (2 lpm) to ASSE 1017***. Control temperature shall be adjustable between 90 - 160°F (32 - 71°C) for LFLM490 and 60 - 120°F (16 - 49°C) for LFLM490-10 Series.
 - .5 The valve shall feature a vandal-resistant lockable handle to prevent tampering. The valve shall be a Powers HydroGuard Model LFLM490 (1/2"), LFLM491 (3/4"), LFLM492 (1"), LFLM490-10 (1/2"), LFLM491-10 (3/4") or LFLM492-10 (1"). Any alternate must have a written approval prior to bidding.
- .3 Under Sink Individual Lavatory Mixing Valve
 - .1 Install Thermostatic Mixing Valve on the hot water supply to the fixture.
 - .2 ASSE Standard 1070 and IAPMO cUPC listed and control the temperature of the hot water. It shall have a Lead Free* brass 4-port, "H" pattern body. Lead Free* under counter thermostatic valves shall comply with state codes and standards, where applicable, requiring reduced lead content.
 - .3 The valve shall include integral check valves, integral screens and an adjustment nut with locking feature. Provide valve with 3/8" (10mm) male compression or Quick-connect fittings.
 - .4 Watts® Series LFUSG-B-SC (satin chrome finish).

3 EXECUTION

3.1 GENERAL

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

3.2 CLEANOUTS

- .1 Provide cleanouts the same size as the pipe up to 4" (100mm) and not less than 4" (100mm) for larger pipes.
- .2 Provide cleanouts at the end of mains and branches, at changes in direction, in long straight runs and at the base of all soil stacks and rainwater leaders and where required by code.

- .3 Extend cleanouts to finished floor or wall surface.
- .4 Encase exterior cleanouts in concrete flush with grade.
- .5 Install floor cleanouts at elevation to accommodate finished floor.
- .6 Cleanouts in floors with surface membranes shall be installed with a membrane clamp and anchoring flange.
- .7 Lubricate threaded cleanout plugs with mixture of graphite and linseed oil.
- .8 Ensure clearance at cleanout for rodding of drainage system.

3.3 FLOOR DRAINS

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

3.4 WATER HAMMER ARRESTORS

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

3.5 TRAP SEAL PRIMERS

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

3.6 BACKFLOW PREVENTION

- .1 Backflow prevention includes backflow preventors, anti-siphon devices and vacuum breakers.
- .2 Install approved potable water protection devices in readily accessible areas to

facilitate inspection, field testing and maintenance on water supply lines where contamination of domestic water may occur:

- .1 Boiler feed water lines,
 - .2 Housekeeping faucets,
 - .3 Fire sprinkler systems,
 - .4 Premise isolation,
 - .5 Irrigation systems,
 - .6 Flush valves,
 - .7 Interior and exterior wall hydrants (hose bibbs).
 - .8 Where required by codes, regulations and/or standards.
- .3 The following minimum clearances shall be provided (manufacturer's recommendations shall be used if greater):
- .1 Install double check valve (DCVA/DCVAF, reduced pressure (RP/RPF) assemblies and single check valve assemblies with a centerline height of between 750 mm and 1500 mm above the floor. Provide a fixed platform for installations with a greater height.
 - .2 Install RP/RPF devices with a 300 mm minimum clearance between the bottom of the relief valve and the floor.
 - .3 Install PVB, DCVA, DCVAF, SCVAF, RP, and RPF devices with a minimum of 300 mm clearance above the assembly.
 - .4 Maintain minimum of 750 mm of clear space in front of PVB, DCVA, DCVAF, SCVAF, RP and RPF assemblies.
 - .5 Maintain a minimum of 20 mm clear space from the back side of PVB, DCVA, DCVAF, SCVAF, RP and RPF devices to the nearest wall or obstruction. Note: This clearance must be increased for devices with side-mounted test-cocks or relief valves.
- .4 Pipe relief or drain from backflow prevention device to nearest drain.
- .5 Install a strainer upstream of each backflow preventor.

3.7 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.

END OF SECTION

Part 1 General

1.1 RELATED REQUIREMENTS

- .1 Section 22 01 01.

1.2 REFERENCE STANDARDS

- .1 American Society of Mechanical Engineers (ASME)
 - .1 ASME B16.18, Cast Copper Alloy Solder Joint Pressure Fittings.
 - .2 ASME B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
 - .3 ASME B16.23, Cast Copper Alloy Solder Joint Drainage Fittings - DWV.
 - .4 ASME B16.26, Copper Alloy Bronze Fittings for Flared Copper Tubes.
 - .5 ASME B16.29, Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV.
 - .6 ASME B16.32, Cast Copper Alloy Solder Joint Fittings for Solvent Drainage Systems.
- .2 ASTM International (ASTM)
 - .1 ASTM B32, Standard Specification for Solder Metal.
 - .2 ASTM A74, Standard Specification for Cast Iron Soil Pipe and Fittings.
 - .3 ASTM B306, Standard Specification for Copper Drainage Tube (DWV).
 - .4 ASTM C564, Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
- .3 Cast Iron Soil Pipe Institute (CISPI)
 - .1 CISPI 301, Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste and Vent Piping.
 - .2 CISPI 310, Couplings for use in connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
- .4 CSA Group (CSA)
 - .1 CSA B67, Lead Service Pipe, Waste Pipe, Traps, Bends and Accessories.
 - .2 CAN/CSA-B70, Cast Iron Soil Pipe, Fittings and Means of Joining.
 - .3 CAN/CSA-B125.3, Plumbing Fittings.

- .5 National Research Council Canada (NRC)
 - .1 National Plumbing Code of Canada (NPC).
- .6 South Coast Air Quality Management District (SCAQMD), California State
 - .1 SCAQMD Rule 1168, Adhesive and Sealant Applications.

1.3 SHOP DRAWING SUBMITTALS

- .1 Provide submittals in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Provide manufacturer's printed product literature and datasheets for adhesives, and include product characteristics, performance criteria, physical size, finish and limitations.

1.4 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
 - .1 Storage and Handling Requirements:
 - .2 Store products off ground, indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .3 Store and protect products from nicks, scratches, blemishes, vermin, theft and vandalism.
- .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.

Part 2 Products

2.1 COPPER TUBE AND FITTINGS

- .1 Above ground sanitary, storm and vent Type DWV 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, type 50B, to ASTM B32.

2.2 CAST IRON PIPING AND FITTINGS

- .1 Buried sanitary, storm and vent minimum NPS 3:
 - .1 CAN/CSA-B70 and ASTM A74 extra heavy weight with one layer of protective coating of epoxy on the pipe interior and exterior.
 - .1 Joints: Hub and spigot: CISPI HSN compression type with ASTM C564, neoprene gasket system or lead and oakum.
 - .2 Fittings: Cast iron
 - .2 CISPI 301 hub-less
 - .1 Joints: CISPI 310, neoprene gasket and stainless steel clamp and shield assemblies.
 - .2 Fittings: Cast iron
- .2 Above ground sanitary and vent:
 - .1 CAN/CSA-B70 and ASTM A74 service weight.
 - .1 Joints: ASTM C564, neoprene gasket system.
 - .2 Fittings: Cast iron
 - .2 CISPI 301 hub-less, service weight.
 - .1 Mechanical joints: CISPI 310, neoprene gaskets and stainless steel clamp-and-shield assemblies.
 - .2 Fittings: Cast Iron.
- .3 Above ground storm:
 - .1 to CAN/CSA-B70 and ASTM A74 extra heavy weight.
 - .1 Joints: ASTM C564, neoprene gasket system or lead and oakum.
 - .2 Fittings: Cast iron
 - .2 CISPI 301, hub-less, service weight
 - .1 Joints: CISPI 310, neoprene gaskets and stainless steel clamp-and-shield assemblies.
 - .2 Fittings: Cast Iron.

Part 3 EXECUTION

3.1 APPLICATION

- .1 Manufacturer's Instructions: comply with manufacturer's written recommendations, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 INSTALLATION

- .1 In accordance with Section 23 05 15 - Common installation requirements for HVAC pipework.
- .2 Install in accordance with Ontario Plumbing Code and local authority having jurisdiction.

3.3 UNDERGROUND SEWER LINES

- .1 Provide qualified personnel to properly layout and establish lines and grades necessary for construction. Verify location and inverts of existing services before sewer work is started to ensure that connection of new sewers to existing can be made. Construct and maintain adequate batter boards, alignment markers and secondary benchmarks as may be required for proper execution of work.
- .2 Ensure batter boards or sight lines are set not more than 25 ft. (7.5 m) apart. Ensure a minimum of three (3) batter boards are in place at all times during laying operation.
- .3 Notify Consultant of layout work to be carried out, Consultant shall have right to check Contractor's layout at any time, but checking layout or failure to do so on part of Consultant in no way relieves Contractor of full responsibility for construction to exact alignment and grade.
- .4 Verify existing invert elevations before setting out drainage work.
- .5 Build to exact lines and grades as shown on drawings. No deviation from these lines and grades will be permitted unless approved in writing by Consultant.

3.4 EXCAVATING AND BACKFILLING

- .1 Be responsible for excavation and backfilling necessary for installation of underground work under this Division.
- .2 Excavate with suitable machinery or by hand as may be necessary and as follows:
 - .1 Excavate to the depth and dimensions shown on drawings.
 - .2 Keep excavation free of water by bailing, pumping or a system of drainage as required.
 - .3 Cut and trim banks of excavation evenly, as nearly vertical as possible, and shore if required to prevent caving-in.

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

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

3.5 TESTING

- .1 Pressure test buried systems before backfilling.
- .2 Hydraulically test to verify grades and freedom from obstructions.

3.6 PERFORMANCE VERIFICATION

- .1 Cleanouts:
 - .1 Ensure accessible and that access doors are correctly located.
 - .2 Open, cover with linseed oil and re-seal.
 - .3 Verify that cleanout rods can probe as far as the next cleanout, at least.
- .2 Test to ensure traps are fully and permanently primed.
- .3 Storm water drainage:
 - .1 Verify domes are secure.
 - .2 Ensure weirs are correctly sized and installed correctly.
 - .3 Verify provisions for movement of roof system.
- .4 Ensure that fixtures are properly anchored, connected to system and effectively vented.
- .5 Affix applicable label (storm, sanitary, vent, pump discharge etc.) c/w directional arrows every floor or 4.5 m (whichever is less).

3.7 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.

END OF SECTION

1. GENERAL

1.1 RELATED REQUIREMENTS

- .1 Section 22 01 01.

1.2 REFERENCE STANDARDS

- .1 ASTM International (ASTM)
 - .1 ASTM D2241, Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
 - .2 ASTM D2564, Standard Specification for Solvent Cements for Poly (Vinyl-Chloride) (PVC) Plastic Piping Systems.
 - .3 ASTM D2665, Standard Specification for Poly(Vinyl Chloride) (PVC) Drain, Waste, and Vent Pipe and Fittings.
 - .4 ASTM D2855, Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets
 - .5 ASTM D3034, Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
 - .6 ASTM F477, Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
 - .7 ASTM F1673, Standard Specification for Polyvinylidene Fluoride (PVDF) Corrosive Waste Drainage Systems
- .2 CSA Group (CSA)
 - .1 CAN/CSA-Series B1800, Thermoplastic Nonpressure Pipe Compendium - B1800 Series.
- .3 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Safety Data Sheets (SDS).
- .4 National Research Council Canada (NRC)
 - .1 National Plumbing Code of Canada (NPC).
- .5 Standards Council of Canada (CAN/ULC)
 - .1 CAN/ULC-S102.2, Standard Method of Test for Surface Burning Characteristics of Flooring, Floor Coverings, and Miscellaneous Materials and Assemblies.

- .6 South Coast Air Quality Management District (SCAQMD), California State
 - .1 SCAQMD Rule 1168- [A2005], Adhesive and Sealant Applications.

1.3 SHOP DRAWING SUBMITTALS

- .1 Provide submittals in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Provide manufacturer's printed product literature and datasheets for piping and adhesives, and include product characteristics, performance criteria, physical size, finish and limitations.
 - .2 Provide WHMIS SDS - Safety Data Sheets in accordance with Division 01 - Health and Safety Requirements

1.4 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
 - .1 Storage and Handling Requirements:
 - .2 Store products off ground, indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .3 Store and protect products from nicks, scratches, blemishes, vermin, theft and vandalism.
- .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.

2. PRODUCTS

2.1 MATERIAL

2.2 PIPING AND FITTINGS

- .1 For buried DWV gravity sewer drain piping to:
 - .1 CAN/CSA B1800 and ASTM D3034 (4" to 15" Diameter).
 - .2 Provide SDR 35 pipe and fittings for normal applications to a maximum burial depth of 10' (3m).

- .3 Provide lower SDR ratings (higher stiffness) for piping buried at deeper levels and/or subject to heavy traffic loads. Indicate suitability for application in this case. Conform to ASTM D2321 for classification.
- .4 Provide gasketed bell-and-spigot water-tight connections to ASTM F477 for elastomeric seals.
- .5 For pressure applications (i.e. pumped discharge) provide piping to ASTM D2241.
- .2 For above ground DWV piping to:
 - .1 CAN/CSA B1800 and CAN/ULC-S102.2.
 - .2 IPEX System 15 or XFR as per manufacturer specifications.
 - .3 Do not use in XFR vertical mechanical shafts or service spaces.
 - .4 Do not use System 15 in return air plenums or mechanical shafts or service spaces.
- .3 For laboratory acid waste sewer piping above grade to:
 - .1 ASTM F1673 PVDF, Schedule 40 with limiting oxygen index of 60. Provide IPEX Plenumline conforming to CAN/ULC-S102.2 (flame spread 25/smoke index 50).
 - .2 Fittings: PVDF, third party certified to ASTM F1673 and CAN/ULC-S102.2 (flame spread 25/smoke index 50).
 - .3 Joints: Provide elastic retaining rings designed to lock into a machined groove on mating piping.

2.3 JOINTS (STANDARD DWV).

- .1 Solvent weld for PVC: to ASTM D2564.
- .2 Elastomeric gaskets: to ASTM F477.

3. EXECUTION

3.1 APPLICATION

- .1 Manufacturer's Instructions: comply with manufacturer's written recommendations, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 INSTALLATION

- .1 In accordance with Section 23 05 15 - Common installation requirements for HVAC pipework.

- .2 Install in accordance with Ontario Plumbing Code and local authority having jurisdiction.

3.3 UNDERGROUND SEWER LINES

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

3.4 EXCAVATING AND BACKFILLING

- .1 Be responsible for excavation and backfilling necessary for installation of underground work under this Division.
- .2 Excavate with suitable machinery or by hand as may be necessary and as follows:
 - .1 Excavate to the depth and dimensions shown on drawings.
 - .2 Keep excavation free of water by bailing, pumping or a system of drainage as required.
 - .3 Cut and trim banks of excavation evenly, as nearly vertical as possible, and shore if required to prevent caving-in.
 - .4 Keep bottom of excavation clean and clear of loose material. Slope or grade as required.
 - .5 Provide shoring in accordance with The Occupational Health and Safety Act and Regulations for Construction Projects.

- .6 Notify Consultant immediately in case of encountering any unstable ground, unsuitable for bearing of pipes. Consultant will decide the method of installation of pipes in unstable ground.
- .7 Inform Consultant immediately if the excavation reveals seepage zones, springs or other unexpected sub-surface conditions which may necessitate revisions to drainage or water supply systems.
- .3 Obtain Consultant's approval prior to commencement of backfilling of trenches. Backfill the trenches carefully to prevent injury to the work and subsequent settlement and execute backfilling generally as follows:
 - .1 Provide minimum 6" (150 mm) fine gravel or coarse sand bedding (Class B) or as indicated for the bottom of trenches.
 - .2 Backfill above pipe bedding with granular material specified, hand tamp in layers of 6" (150 mm) thickness. Extend backfill 12" (300 mm) above pipe.
 - .3 Backfill and consolidate remainder of trench depth below paved or graveled areas with granular Class "B" aggregate in 6" (150 mm) layers to an elevation to allow for thickness of Class "A" aggregate and asphalt pavement.
 - .4 Backfill and consolidate remainder of trench depth below sodded or seeded areas with specified granular material or material obtained from site excavation where approved by Consultant, in 9" (225 mm) layers to an elevation 6" (150 mm) below of proposed grades in sodded/seeded areas.
 - .5 Compact each layer thoroughly at optimum moisture content with approved hand or mechanical tampers to a density equal to;
 - .1 95% of Maximum Standard Proctor Density
 - .1 Behind foundation and retaining walls on grades
 - .2 Below sodded or seeded areas
 - .2 100% of Maximum Standard Proctor Density
 - .1 Below slabs on grade within building areas up to the underside of the crushed stone underlay
 - .2 Below paved or graveled areas
 - .6 Do not puddle or flood with water for consolidating backfill. Add Water during the compaction to optimum moisture content of backfilling material.

3.5 ACID WASTE SANITARY PIPING

- .1 Install system free of stress and in proper alignment.

- .2 Ensure horizontal supports provide a wide bearing area and are free of burrs and sharp edges.
- .3 Ensure vertical piping has riser clamps on each floor.
- .4 Testing with compressed air including air booster over water is prohibited.

3.6 TESTING

- .1 Pressure test buried systems before backfilling.
- .2 Hydraulically test to verify grades and freedom from obstructions.

3.7 PERFORMANCE VERIFICATION

- .1 Cleanouts:
 - .1 Ensure accessible and that access doors are correctly located.
 - .2 Open, cover with linseed oil and re-seal.
 - .3 Verify cleanout rods can probe as far as the next cleanout, at least.
- .2 Test to ensure traps are fully and permanently primed.
- .3 Storm water drainage:
 - .1 Verify domes are secure.
 - .2 Ensure weirs are correctly sized and installed correctly.
 - .3 Verify provisions for movement of roof system.
- .4 Ensure fixtures are properly anchored, connected to system and effectively vented.
- .5 Affix applicable label (storm, sanitary, vent, pump discharge) c/w directional arrows every floor or 4.5 m (whichever is less).

3.8 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01- Waste Management and Disposal.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

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

1.2 SECTION INCLUDES

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

1.3 REFERENCE STANDARDS

- .1 American Society of Mechanical Engineers (ASME)
 - .1 ASME B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
 - .2 ASME B16.5, Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
 - .3 ASME B16.10, Face-to-Face and End-to-End Dimensions of Valves.
 - .4 ASME B16.18, Cast Copper Alloy Solder Joint Pressure Fittings.
 - .5 ASME B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
 - .6 ASME B16.23, Cast Copper Alloy Solder Joint Drainage Fittings - DWV.
 - .7 ASME B16.26 - Copper Alloy Bronze Fittings for Flared Copper Tubes.
 - .8 ASME B16.32 - Cast Copper Alloy Solder Joint Fittings for Solvent Drainage Systems.
- .2 ASTM International (ASTM)
 - .1 ASTM B32, Solder Metal.

- .2 ASTM B42, Standard Specification for Seamless Copper Pipe, Standard Sizes.
- .3 ASTM B61, Standard Specification for Steam or Valve Bronze Castings.
- .4 ASTM B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
- .5 ASTM B68, Seamless Copper Tube, Bright Annealed.
- .6 ASTM B75, Seamless Copper Tube.
- .7 ASTM B88, Seamless Copper Water Tube.
- .8 ASTM A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
- .9 ASTM B283, Standard Specification for Copper and Copper-Alloy Die Forgings (Hot-Pressed).
- .10 ASTM B251, General Requirements for Wrought Seamless Copper and Copper-Alloy Tube.
- .11 ASTM B302, Threadless Copper Pipe, Standard Sizes.
- .12 ASTM C1053, Borosilicate Glass Pipe and Fittings for Drain, Waste, and Vent (DWV) Applications.
- .13 ASTM D2239, Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.
- .14 ASTM D2447, Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter.
- .15 ASTM E814, Fire Tests of Through-Penetration Fire Stops.
- .16 ASTM F708, Design and Installation of Rigid Pipe Hangers.
- .17 ASTM F876, Standard Specification for Crosslinked Polyethylene (PEX) Tubing/
- .18 ASTM F877, Standard Specification for Crosslinked Polyethylene (PEX) Hot- and Cold-Water Distribution Systems
- .19 ASTM F1960, Standard Specification for Cold Expansion Fittings with PEX Reinforcing Rings for Use with Cross-linked Polyethylene (PEX) and Polyethylene of Raised Temperature (PE-RT) Tubing
- .3 American Water Works Association (AWWA)
 - .1 AWWA C110, Ductile - Iron and Gray - Iron Fittings, 3" - 48" (76 mm - 1219 mm), for Water.
 - .2 AWWA C111, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - .3 AWWA C151, Ductile-Iron Pipe, Centrifugally Cast, for Water.
 - .4 AWWA C651, Disinfecting Water Mains.
 - .5 AWWA C900, Polyvinyl Chloride (PVC) Pressure Pipe (and Fabricated Fittings), 4" - 12" (100 mm - 300 mm), for Water Distribution.

- .6 AWWA C901, Polyethylene (PE) Pressure Pipe and Tubing, 1/2" - 3" (13 mm - 76 mm) for Water Service.
- .7 AWWA C902, Polybutylene (PB) Pressure Pipe and Tubing, 1/2" - 3" (13 mm - 76 mm) for Water.
- .8 AWWA C905, Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14" - 48" (350 mm - 1200mm).
- .4 American National Standards Institute (ANSI)
 - .1 MSS SP-58, Pipe Hangers and Supports - Materials, Design and Manufacturer.
 - .2 MSS SP-69, Pipe Hangers and Supports - Selection and Application.
 - .3 MSS SP-80, Bronze Gate, Globe, Angle, and Check Valves
 - .4 MSS SP-89, Pipe Hangers and Supports - Fabrication and Installation Practices.
 - .5 MSS SP-110, Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.
- .5 CSA Group (CSA)
 - .1 CSA B137.5, Crosslinked polyethylene (PEX) tubing systems for pressure applications
- .6 National Sanitation Foundation (NSF)
 - .1 NSF/ANSI 14, Plastic Piping System Components and Related Materials.
 - .2 NSF/ANSI 61, Drinking Water System Components – Health Effects.
- .7 Standards Council of Canada (SCC)
 - .1 CAN/ULC S101: Standard Methods of Fire Endurance Tests of Building Construction Materials
 - .2 CAN/ULC-S102.2-07, Standard Method Of Test For Surface Burning Characteristics Of Flooring, Floor Coverings, And Miscellaneous Materials And Assemblies
 - .3 CAN/ULC-S115:2023, Standard Method Of Fire Tests Of Firestop Systems

1.4 SHOP DRAWINGS SUBMITTALS

- .1 Provide submittals in accordance with Division 01 - Submittal Procedures.
- .2 Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalogue information. Indicate valve data and ratings.

1.5 CLOSEOUT SUBMITTALS

- .1 Provide submittals in accordance with Division 01 - Submittal Procedures.
- .2 Project Record Documents: Record actual locations of valves.

1.6 QUALITY ASSURANCE

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

1.7 REGULATORY REQUIREMENTS

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

1.8 DELIVERY, STORAGE, AND PROTECTION

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store products off ground, indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect products from nicks, scratches, blemishes, vermin, theft and vandalism.
- .4 Replace defective or damaged materials with new.
- .5 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.
- .6 Accept valves on site in shipping containers with labelling in place. Inspect for damage.
- .7 Provide temporary protective coating on cast iron and steel valves.
- .8 Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- .9 Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.9 WARRANTY

- .1 PEX Manufacturer's warranty:
 - .1 The assembly of manufacturer's tubing and fittings shall carry a twenty-five (25) year non-prorated warranty on maintaining a leak-proof seal.

- .2 Warranty shall provide for repair or replacement of any tube, fittings or connection, which are proven to be defective and pay for consequential damages.

1.10 ENVIRONMENTAL REQUIREMENTS

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

2 PRODUCTS

2.1 WATER PIPING, BURIED WITHIN 1.5m OF BUILDING

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

2.2 WATER PIPING, ABOVE GRADE

- .1 Copper Tubing: ASTM B88M, Type L, hard drawn.
 - .1 Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.
 - .2 Joints: ASTM B32, solder, Grade 95TA.
- .2 Ductile Iron Pipe: AWWA C151.
 - .1 Fittings: Ductile iron, standard thickness.
 - .2 Lining: cement
 - .3 Joints: AWWA C111, rubber gasket with 3/4" (19 mm) diameter rods.
- .3 Cross-linked Polyethylene: ASTM F876/F877 and CAN/CSA B137.5 - PEX-A.
 - .1 Fittings: by tubing manufacturer, Engineered Plastic (EP) PEX-A cold expansion type to ASTM F1960 consisting of insert and cold expansion ring.
 - .2 Regulatory Requirements:
 - .1 2" diameter and less: maximum 25 flame spread / 50 smoke developed rating to CAN/ULC-S102.2

- .2 2-1/2" and 3": maximum 25 flame spread / 50 smoke developed rating when covered with rated fibreglass insulation to CAN/ULC-S102.2.
- .3 PEX tubing contained within a fire separation – listed per CAN/ULC-S101.

2.3 WATER PURIFICATION PIPING, ABOVE GRADE

- .1 Pipe: Georg Fischer PROGEF Standard
 - .1 Material: Beta PP-H 100; Beta Polypropylene Homopolymer
 - .2 Colour: RAL 7032 pebble grey
 - .3 Density: ASTM D792. 0.9g/cm³
 - .4 Expansion Coeff: 0.16mm/Mk
 - .5 Thermal Conductivity: 0.23 W/mk
- .2 Fittings: Injection moulded, or segment welded
- .3 Valves: Supplied by piping manufacturer

2.4 FLANGES, UNIONS, AND COUPLINGS

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

2.5 VALVES - GENERAL

- .1 Conform to requirements of ANSI, ASTM, ASME, and applicable MSS standards.
- .2 Provide valves of the same manufacturer where possible.
- .3 Manufacturer's name and pressure rating clearly marked on body to MSS-SP-25.
- .4 Valid CRN (Canadian Registration Number) issued by Province of Ontario required for each valve.

- .5 Materials:
 - .1 Bronze: ASTM B62 or B61 as applicable
 - .2 Brass: ASTM B283 C3770
 - .3 Cast Iron: ASTM A126 Class B
 - .4 Forged Steel: ASTM A105N
 - .5 Cast Steel: ASTM A216 WCB
- .6 End Connections:
 - .1 Flanged ends: ANSI B16.1 (Class 125), ANSI B16.5 (Class 150).
 - .2 Face-to-face dimensions: ANSI B16.10
 - .3 Threaded ends: ASME B1.20.1
 - .4 Solder ends: ASME B16.18.
 - .5 Butt weld ends: ASME B16.25
 - .6 Socket weld ends: ASME B16.11
- .7 Design and Testing:
 - .1 MSS-SP-80 - Bronze, Gate & Check Valves.
 - .2 MSS-SP-110 - Ball Valves.
 - .3 MSS –SP-70, 85, 71 - Cast Iron Gate, Globe & Check Valve.
 - .4 MSS-SP-72 - American Valve
 - .5 MSS-SP-67 – Kitz, MAS, Butterfly Valves.
 - .6 API 602 – Forge Steel Valves (Design)
 - .7 API 598 – Cast Steel Valves, Forge Steel Valves (Testing)
 - .8 API 600 – Cast Steel Valves (Design)

2.6 ISOLATION VALVES

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

2.7 CHECK VALVES

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

2.8 DRAIN VALVES

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

2.9 CIRCUIT BALANCING VALVES

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

2.10 DISINFECTION CHEMICALS

- .1 Chemicals: AWWA B300, Hypochlorite,

3 EXECUTION

3.1 EXAMINATION

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

3.2 PREPARATION

- .1 Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- .2 Remove scale and dirt, inside and outside, before assembly.

- .3 Prepare piping connections to equipment with flanges or unions.

3.3 INSTALLATION

- .1 Install to manufacturer's instructions.
- .2 Provide non-conducting dielectric connections wherever jointing dissimilar metals.
- .3 Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.
- .4 Install piping to maintain headroom, conserve space, and not interfere with use of space.
- .5 Group piping whenever practical at common elevations.
- .6 Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- .7 Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
- .8 Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with general trades.
- .9 Establish elevations of buried piping outside the building to ensure not less than 5'6" (1.6 m) of cover.
- .10 Install vent piping penetrating roofed areas to maintain integrity of roof assembly; coordinate with roof and waterproofing specification.
- .11 Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer (maximum VOC content of 80 g/L) to welding.
- .12 Provide support for utility meters to requirements of utility companies.
- .13 Prepare exposed, unfinished pipe, fittings, supports, and accessories ready for finish painting where required. Coordinate with general trades.
- .14 Excavate and backfill as required for work of this Section.
- .15 Install bell and spigot pipe with bell end upstream.
- .16 Install valves with stems upright or horizontal, not inverted.
- .17 Pipe vents from gas pressure reducing valves to outdoors and terminate in weatherproof hood.
- .18 Sleeve pipes passing through partitions, walls and floors.
- .19 Inserts:
 - .1 Provide inserts for placement in concrete formwork.
 - .2 Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - .3 Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4" (100 mm).

- .4 Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
- .5 Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- .20 Pipe Hangers and Supports:
 - .1 Install to OBC (Plumbing Code)
 - .2 Support horizontal piping as scheduled.
 - .3 Install hangers to provide minimum 1/2" (15 mm) space between finished covering and adjacent work.
 - .4 Place hangers within 12" (300 mm) of each horizontal elbow.
 - .5 Use hangers with 1-1/2" (40 mm) minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
 - .6 Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
 - .7 Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
 - .8 Provide copper plated hangers and supports for copper piping.
 - .9 Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
 - .10 Provide hangers adjacent to motor driven equipment with vibration isolation.
 - .11 Support cast iron drainage piping at every joint.

3.4 PEX INSTALLATION

- .1 Ensure installing contractor is manufacturer trained and certified.
- .2 Expansion and Contraction Provisions
 - .1 Utilize a continuous support tray such as Uponor PEX-a Pipe Support to mitigate thermal expansion and contraction. Natural corners and offsets may also be used. In conjunction with the above options, anchor points must also be used every 65-ft for hydronic systems on continuous runs without jogs. Refer to manufacturer's installation instructions
 - .2 PEX-a Piping Hanger Spacing: Install hangers for PEX-a piping with the following maximum spacing:
 - .1 NPS 3/4 (DN 20) and Smaller: 32 inches (815mm) with 3/8-inch (10mm) rod
 - .2 NPS 1 to NPS 3 (DN 25 to DN 75): 48 inches (1200mm) with 3/8-inch (10mm) rod
 - .3 NPS 4 (DN 110) and Smaller: Continuously supported by PEX-a Pipe Support or metallic V-channels that:

- .1 Are supported every 6 feet (1.8m) for NPS $\frac{3}{4}$ (DN 20) and smaller
- .2 Are supported every 8 feet (2.4m) for NPS 1 to 4 (DN 25 to DN 110)
- .4 Have a maximum cantilever, measured from the support to the end of the CTS support channel, of 1.5 feet (0.5m)
- .5 PEX-a Riser Supports: Install CTS riser clamps at the base of each floor and at the top of every other floor. Install mid-story guides between each floor

3.5 APPLICATION

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

3.6 ERECTION TOLERANCES

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

3.7 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

- .1 Disinfect new and altered water distribution piping.
- .2 Verify that piping system is complete and has been flushed, cleaned, inspected, and pressure tested.
- .3 Isolate existing piping to full extent possible. Ensure that fixtures, existing and new that are served from piping being disinfected, are taken out of service and signs are placed at each fixture prohibiting use during the disinfection period.
- .4 Schedule and perform disinfecting activities with start-up, testing, adjusting, balancing, and demonstration procedures. Coordinate with related systems.
- .5 Ensure Ph of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).
- .6 Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/L residual.

- .7 Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15 percent of outlets.
- .8 Maintain disinfectants in system for 24 hours.
- .9 If final disinfectant residual tests less than 25 mg/L, repeat treatment.
- .10 Flush disinfectants from system until residual equal to that of incoming water or 1.0 mg/L.
- .11 Take samples no sooner than 24 hours after flushing, from 10 percent of outlets and from water entry, and analyze them to AWWA C651.

3.8 SCHEDULES

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

3.9 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.

END OF SECTIONS

1. GENERAL

1.1 GENERAL REQUIREMENTS

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

1.2 SECTION INCLUDES

- .1 Water closets, seats, tanks, flush valves, supplies, carriers
- .2 Urinals, tanks, flush valves
- .3 Lavatories, faucets, spouts, waste, carriers
- .4 Stainless steel sinks, faucets, spouts,
- .5 Service sinks, traps, faucets, spouts, accessories
- .6 Flushing rim sinks, faucets, flush valves, base
- .7 Mop sinks, faucets, spouts, accessories
- .8 Laundry Tubs, faucets, traps
- .9 Bathtubs, drains, faucets, spouts, accessories
- .10 Showers, head-arm-flange, valves, accessories
- .11 Packaged shower cabinets, walls, base, accessories, trim, door, fittings
- .12 Wash fountains,
- .13 Eyewash stations.
- .14 Emergency showers.

1.3 REFERENCE STANDARDS

- .1 American National Standard Institute (ANSI)
 - .1 ANSI Z124.1 - Gel-Coated Glass-Fibre Reinforced Polyester Resin Bathtub Units.
 - .2 ANSI Z124.2 - Gel-Coated Glass-Fibre Reinforced Polyester Resin Shower Receptor and Shower Stall Units.
 - .3 ANSI Z358.1 - Emergency Eye Wash and Shower Equipment.
- .2 American Refrigeration Institute (ARI)
 - .1 ARI 1010 - Self-Contained Mechanically Refrigerated Drinking Water Coolers.
- .3 American Society of Mechanical Engineers (ASME)
 - .1 ASME A112.6.1 - (Floor Affixed) Supports for Off-the-Floor Plumbing Fixtures for Public Use.
 - .2 ASME A112.18.1 - Plumbing Fixture Fittings.

- .3 ASME A112.19.1 - Enameled Cast Iron Plumbing Fixtures.
- .4 ASME A112.19.2 - Vitreous China Plumbing Fixtures.
- .5 ASME A112.19.3 - Stainless Steel Plumbing Fixtures (Designed for Residential Use).
- .6 ASME A112.19.4 - Porcelain Enameled Formed Steel Plumbing Fixtures.
- .7 ASME A112.19.5 - Trim for Water-Closet Bowls, Tanks, and Urinals.
- .4 CSA Group (CSA)
 - .1 CAN/CSA-B45.0 General Requirements for Plumbing Fixtures
 - .2 CAN/CSA-B45.1 Ceramic Plumbing Fixtures
 - .3 CAN/CSA-B45.2 Enameled Cast Iron Plumbing Fixtures
 - .4 CAN/CSA-B45.3 Porcelain-Enameled Steel Plumbing Fixtures
 - .5 CAN/CSA-B45.4 Stainless Steel Plumbing Fixtures
 - .6 CAN/CSA-B125.1 Plumbing Supply Fittings
 - .7 CAN/CSA-B125.2 Plumbing Waste Fittings
 - .8 CAN/CSA-B125.3 Plumbing Fittings
 - .9 CAN/CSA-B125.6 Flexible Water Connectors

1.4 SHOP DRAWING SUBMITTALS

- .1 Submit in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for fixtures and include product characteristics, performance criteria, physical size, finish and limitations.
 - .2 Indicate 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.
 - .4 Provide catalogue illustrations of fixtures

1.5 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Division 01 - Submittal Procedures.
- .2 Description of fixtures and trim, giving manufacturer's name, type, model, year, capacity.
- .3 Details of operation, servicing, maintenance.
- .4 List of recommended spare parts.

- .5 Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.6 QUALITY ASSURANCE

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

1.7 REGULATORY REQUIREMENTS

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

1.8 MOCK-UP

- .1 Refer to Division 01: Requirements for mock-up.
- .2 Provide mock-up of typical bathroom group.
- .3 Mock-up may remain as part of the Work, if approved by Consultant.

1.9 DELIVERY, STORAGE, AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials off ground indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect specified materials from nicks, scratches, blemishes, theft vandalism and vermin.
 - .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal .
- .5 Accept fixtures on site in factory packaging. Inspect for damage.
- .6 Protect installed fixtures from damage by securing areas and by leaving factory packaging in place to protect fixtures and prevent use.

2. PRODUCTS

2.1 MANUFACTURERS

- .1 Provide plumbing fixtures, fixture trim and accessories from manufacturer to the extent that this is possible.

- .2 Vitreous China fixtures:
 - .1 Manufacturer: American Standard.
 - .2 Other acceptable manufacturers offering equivalent products.
 - .1 Kohler
 - .2 Toto
 - .3 Zurn
- .3 Stainless Steel fixtures:
 - .1 Manufacturer: Acorn.
 - .2 Other acceptable manufacturers offering equivalent products.
 - .1 Bradley
 - .2 Willoughby
- .4 Seats
 - .1 Manufacturer: Centoco
 - .2 Other acceptable manufacturers offering equivalent products.
 - .1 Benecke
 - .2 Kohler
 - .3 Bemis
- .5 Mechanical Flush Valves
 - .1 Manufacturer: Sloan "Regal"
 - .2 Other acceptable manufacturers offering equivalent products:
 - .1 Zurn
 - .2 Powers/Watts
- .6 Electronic Flush Valves
 - .1 Manufacturer: Sloan Regal 153-1.6 WB ES-S [153-1.6 ES-S]
 - .2 Other acceptable manufacturers offering equivalent products.
 - .1 Zurn
 - .2 Powers/Watts
 - .3 Nepitek
 - .4 DMP Electronics
- .7 Bedpan Cleansers
 - .1 Manufacturer: Chicago Faucets
 - .2 Other acceptable manufacturers offering equivalent products.
 - .1 Powers/Watts
 - .2 Kohler

- .3 American Standard
 - .4 Zurn
 - .8 Diverter Valves
 - .1 Manufacturer: Powers/Watts
 - .2 Other acceptable manufacturers offering equivalent products.
 - .1 Kohler
 - .2 Sloan
 - .9 Carriers
 - .1 Manufacturer: Watts
 - .2 Other acceptable manufacturers offering equivalent products.
 - .1 Zurn
 - .2 J. R. Smith
 - .3 MIFAB.

2.2 LAVATORY, WALL HUNG, ELECTRONIC, TEMPERATURE CONTROL LEVER

- .1 Lavatory: sealed overflow, center hole only, 20-1/2" x 18-1/4" x 8-1/8" (521mm x 464mm x 206mm) deep, wall hung, vitreous china, integral back splash, self-draining deck area with contoured back and side splash shields, 'D' shaped bowl, contoured back and side splash shields for concealed arm carrier.
- .2 Faucet: Single Application, C.P., single hole, deck mounted, all metal spout with integral proximity sensors, external temperature mixer, vandal-resistant, 1.9 LPM (0.5 GPM) flow spray pressure compensating outlet, solenoid and circuitry located in spout above deck with back checks includes, Plug-In Power Supply and Transformer 120VAC/6VDC. Provide electrical duplex box with Ground Fault Protector.
- .3 Drain: C.P., cast brass 1 pc. top, open grid less overflow holes and 17ga. (1.5mm), 1-1/4" (32mm) tailpiece. Full assembly shall be treated inside and out with 'SANIGUARD' antimicrobial compound.
- .4 Supplies: C.P., polished brass, rigid horizontal nipple 3/8" (9.5mm) x 5" (127mm) long I.P.S., heavy all brass angle stops, with V.P. loose key, escutcheons and flexible copper risers.
- .5 Trap: C.P., polished, cast brass adjustable body, 1-1/4" (32mm) with cleanout plug, seamless brass wall bend and escutcheon. Full Assembly shall be treated inside and out with 'SANIGUARD' antimicrobial compound.
- .6 Carrier: concealed arms and steel pipe legs, welded to block base feet support. (For narrow wall installation provide 'Z' type sleeve for arms).
- .7 Manufacturers:
 - .1 Lavatory: American Standard #0356.921 'LUCERNE' Basin with Sealed Overflow
 - .2 Faucet: Sloan #EAF-100-P-ISM/EAF-12 'OPTIMA' Electronic 'No Touch'

Faucet

- .3 Drain: McGuire #155ASAN-LO Basin Drain
- .4 Supplies: McGuire #H165LKN5
- .5 Trap: McGuire #8872CBSAN 'P' Trap
- .6 Carrier: Jay R. Smith #0700-Z Basin Carrier

2.3 EYEWASH

- .1 Eyewash: Haws 7360BT-7460BT-9102 Wall mounted emergency eyewash or eye/face wash, anti-surge AXION MSRTM (Medically Superior Response) inverted laminar flow eyewash streams with zero vertical velocity, 279 mm (11") stainless steel receptor, green ABS eyewash head with impregnated antimicrobial protection, water pressure activated yellow plastic pop-up dust cover, integral 14 L/min (3.7 usgpm) flow control, chrome-plated brass stay-open ball valve equipped with stainless steel ball and stem, push flag activated sign, 50 x 50 stainless mesh screen in-line filter, DN 1/2" water supply, cast-aluminum chromate protected wall bracket, satin finish chrome plated DN 1 1/2" P-trap. Operating pressure is 30 - 90 psi. Universal pictogram. Stainless steel hinged dust cover for all receptors, push flag activated.
- .2 Mixing Valve: Haws 9201EW Thermostatic mixing valve that mixes hot and cold water to supply tempered water to emergency eyewash fixtures requiring flow up to 37.9 L/min. (10 guspm) at a pressure of 207 kPa (30 psi). Unit employs a paraffin filled thermostatic mixing element. Lowest internal pressure drop where supply pressure is low, and a high Cold Water Bypass flow rate of 14.4 lpm (3.8 gpm). The modular brass design with a one piece casting uses internal check stops, oversized valve seats, a shuttle design that eliminates valve binding, and a funnel design to improve temperature control with better mixing at low flow rates. Lime and calcium resistant components are used throughout. Factory set at 29°C (85°F). Maximum operating pressure: 125 psi (8.62 Bar). Temperature adjustment range 60-95 °F (15 - 35 °C). Recommended inlet temperature: 140 °F (60 °C). Inlet 1/2" NPT(F). Outlet 1/2" NPT(F).

3. EXECUTION

3.1 EXAMINATION AND PREPARATION

- .1 Verify that walls and floor finishes are prepared and ready for installation of fixtures.
- .2 Verify that electric power is available and of the correct characteristics.

3.2 PREPARATION

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

3.3 INSTALLATION

- .1 Install each fixture with trap, easily removable for servicing and cleaning.

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

3.4 ADJUSTING

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

3.5 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.

3.6 PROTECTION OF FINISHED WORK

- .1 Do not permit use of fixtures.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Read and conform to:
 - .1 The Contract CCDC 2-2020, Stipulated Price Contract as amended,
 - .2 Division 1 requirements and documents referred to therein.
- .2 Section 23 01 01 applies to and governs the work of Division 23.
- .3 The technical Sections of this Division are generally divided into units of work for the purpose of ready reference.
- .4 The division of the work among subcontractors is not the Consultant's responsibility and the Consultant assumes no responsibility to act as an arbiter and/or to establish subcontract limits between any Sections of the work.
- .5 The specifications are integral with the drawings which accompany them. Neither is to be used alone. Any item or subject omitted from one but implied in the other is fully and properly required.
- .6 Wherever differences occur in the tender documents, the most onerous condition governs. Base the bid on the costliest arrangement.

1.2 DEFINITIONS

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

1.3 WORK INCLUDED

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

1.4 RELATED WORK

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

1.5 SUBMITTALS

- .1 Approval Drawings: Prepare and submit drawings necessary for approval to any authority having jurisdiction and obtain two (2) copies of approved drawings for retention by Consultant prior to commencement of work under this Division.
- .2 Shop Drawings: Prepare and submit two (2) hard copies and one (1) electronic copy of shop drawings of major equipment items (including those items specifically indicated under Part 1: General of each Section), to the Consultant for review. The Consultant will return one copy, marked with comments and his review stamp as he deems appropriate. Prepare the necessary number of copies of the returned set and distribute to the Owner, the Prime Consultant, the General Contractor, the site, and to subcontractors and suppliers.
 - .1 Clearly indicate manufacturer's and supplier's names, catalogue model numbers, details of construction, accurate dimensions, capacities and

performance. Prior to submission check and certify as correct, shop drawings and data sheets. Do not order equipment until a copy of the shop drawings, reviewed by Consultant, has been returned to Contractor.

- .2 Clearly indicate the weight, location, method of support and anchor point forces and locations for each piece of equipment on shop drawings.
- .3 The Consultant will not review shop drawings that fail to bear the Contractor's stamp of approval or certification.
- .4 Read the following in conjunction with the wording on the shop drawing review stamp applied to each and every drawing submitted:

"This review by the Consultant is for the sole purpose of ascertaining conformance with general design concept. This review shall not mean that the Consultant approves the detail design inherent in the shop drawings, responsibility for which shall remain with the Contractor submitting same, and such review shall not relieve the Contractor of his responsibility for errors or omissions in the shop drawings or of his responsibility for meeting all requirements of the Contract Documents. The Contractor is responsible for dimensions to be confirmed and correlated at the job site, for information that pertains solely to fabrication processes or to techniques of construction and installation and for coordination of the work of all sub trades."

- .3 Composite Wiring Diagrams: Prepare and submit three (3) copies of complete composite wiring diagrams of each specific mechanical system. Indicate all electrical equipment and wiring, both internal and external, for review and coordination of trades.
- .4 Contractor's Material and Test Certificates: Prepare and submit certificates for each system installed. Where certificates are prescribed by regulations, codes or standards ensure they conform to the requirements of those documents. Include a copy of each certificate in the Operation and Maintenance manual. Certificates shall include the following:
 - .1 description of the system (description and type),
 - .2 description of the tests conducted, and results observed, including re-testing, where necessary,
 - .3 description of any corrective measures undertaken,
 - .4 description of materials used (pipe and fittings),
 - .5 list of witnesses for each test conducted,
 - .6 date system left ready for service,
 - .7 signature of installing Contractor.
- .5 Directories & Schematics
 - .1 Submit five (5) copies of a neat typewritten directory indicating the valve number, related service, and location of each valve under this Division.
 - .2 Submit five (5) copies of system control schematics for each mechanical system indicating relative locations of equipment and control devices.

- .3 Enclose one (1) copy of each directory/schematic under glass in a neat polished 18" x 24" (460 mm x 610 mm) metal frame, complete with mounting clips.
- .6 Maintenance Data and Operating Instructions
 - .1 Submit three (3) copies of Operation and Maintenance Manual individually bound in hard backed three-ring binders.
 - .2 Ensure the binder spines have typewritten lettering as follows:
OPERATION & MAINTENANCE MANUAL
for
[Insert project name]
[Insert date of submission]
Division 23 00 00
 - .3 Provide a list of names, addresses and telephone numbers of equipment suppliers, installing contractors, general contractors, architect and Consultant. Include special telephone numbers for service departments on normal and emergency call basis.
 - .4 Provide descriptive literature (shop drawings) of each manufactured item. Include a bill of material with purchase order numbers and vendor's identification of equipment orders for each item.
 - .5 Include copies of start-up reports and checklists and all certificates issued with respect to this contract.
 - .6 Ensure operating instructions include the following:
 - .1 General description of each mechanical system.
 - .2 Step by step procedure to follow in putting each piece of equipment into service.
 - .3 Schematic control diagrams for each separate mechanical system, control thermometers, freezestats, firestats, pressure gauges, automatic valves, and refrigeration accessories. Mark correct operating settings for each control device on these diagrams.
 - .4 Diagram of the electrical control system indicating the wiring of related electrical components such as PE and EP switches, firestats, freezestats, fuses, interlocks, electrical switches and relays.
 - .5 Drawings of each control panel including temperature control and electrical panels, completely identifying components on the panels and their function.
 - .7 Ensure maintenance instructions include the following:
 - .1 Manufacturer's maintenance instructions for each item of mechanical equipment installed under this Division. Instructions shall include installation instructions, parts numbers and lists,

- name of supplier and maintenance and lubrication instructions.
- .2 Summary list of each item of mechanical equipment requiring lubrication, indicating the name of the equipment item, location of all points of lubrication, type of lubricant recommended, and frequency of lubrication.
- .3 Equipment directory indicating name, model, serial number and nameplate data of each item of equipment supplied, and system with which it is associated.
- .4 Balancing and testing reports.
- .5 Copy of valve directory.
- .7 As-Built Records: Prepare and submit complete as-built records prior to Substantial Performance of the Contract. Refer to Division 1 regarding requirements. Submit two sets of as-builts drawings in AutoCAD format showing changes & concealed services dimensioned. AutoCAD files can be provided to the contractor by the Consultant at a fee of \$300.00 plus \$25.00 per sheet upon request.

1.6 QUALITY ASSURANCE

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

1.7 PRODUCT DELIVERY, HANDLING AND STORAGE

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

1.8 JOB CONDITIONS

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

1.9 WARRANTY

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

1.10 INTERRUPTIONS

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

1.11 EXTRAS AND CREDITS

- .1 Accompany price submissions requested by Consultant for extra work, or work to be deleted, with a complete cost breakdown as follows:
 - .1 Materials, quantities, and unit costs including any applicable contractors trade discount clearly identified. Provide supplier quotations.
 - .2 Labour hours and unit costs.

- .3 Total materials and labour costs.
- .4 Overhead and profit mark-ups in accordance with the General Conditions of the Contract.
- .2 Quotations from software such as Allpriser will not be accepted. Provide actual material costs.

1.12 PHASING AND SCHEDULING

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

2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

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

2.2 ACCEPTABLE PRODUCTS

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

2.3 EQUIVALENTS AND ALTERNATIVES

- .1 Suppliers wishing approval for additional equipment items or alternatives as equivalent to those specified **must submit complete description, technical and performance data to Consultant at least twelve (12) working days prior to Bid closing date.** Equivalent equipment, if accepted, must conform to specifications with regard to details, accessories, modifications, features and performance. Deviations from specifications must be stated in writing at time of submission for approval.
- .2 Bid Prices shall include only products specified or approved equivalents. Contractors may propose unsolicited alternatives to the products specified. Alternative proposals shall be submitted in sealed envelope at time of general contract Bid submission and shall include full description and technical data, and a statement of the related increase or decrease in Bid Price should alternatives be accepted. All additional costs associated with unsolicited alternative proposals such as larger motor starters, larger power feeders, space revisions to associated equipment, controls, etc. shall be included in alternative price. Prior approval by Consultant is not required for unsolicited alternative proposals.
- .3 Where the Contractor uses equipment other than that first named, on which the design is based, he shall be responsible for the details of installation including equipment size, arrangement, fit, and maintenance of required clearances. Contractor shall prepare and submit revised layouts to indicate arrangement of affected piping, ductwork, conduit, lighting, equipment, etc. Failure by Contractor to provide such drawings will be considered indication that original arrangements and space allocations are adequate.
- .4 Include in the Bid Price for additional costs associated with equivalent equipment such as larger motor starters, larger power feeders, space revisions to associated equipment, controls, changes to ductwork, piping, etc. No extras for changes arising from alternatives, equivalents (approved or otherwise) or substitutions will be considered.

2.4 SUBSTITUTIONS DURING PROGRESS OF WORK

- .1 Refer to Division 01

2.5 CONSULTANT'S REVIEW

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

3 EXECUTION

3.1 RELATIONSHIP WITH OTHER TRADES

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

3.2 INSTALLATION REQUIREMENTS

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

3.3 CONTRACT DRAWINGS

- .1 The drawings of this Division are performance drawings and indicate general arrangement of the work. They are diagrammatic except where specific details are given.
- .2 Obtain accurate dimensions from the architectural and structural drawings, or by

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

3.4 CONSTRUCTION DRAWINGS

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

3.5 RECORD DRAWINGS

- .1 Maintain project "as-built" record drawings. Obtain white prints from the Consultant for this purpose and pay printing costs. Identify each set as "Project Record Copy".

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

3.6 USE OF SYSTEMS

- .1 For the duration of this contract, do not use any piece of equipment provided under this contract for the purposes of heating, ventilation, or air conditioning without the specific authorization of the Owner and Consultant. Ensure the building is "broom clean" and painting is finished before asking permission for testing to commence.
- .2 Where specific written authorization is given for the use of equipment while work is still in progress, seal off ductwork, grilles, diffusers, and registers or other openings to the air distribution systems or air handling equipment that is not in use.
- .3 Use of new and/or existing permanent heating and/or ventilating systems for supplying temporary heat or ventilation is [not permitted] [permitted only under following conditions:]
 - .1 Entire system is complete, pressure tested, cleaned, flushed out.
 - .2 Specified water treatment systems have been commissioned, and water treatment is being continuously monitored.
 - .3 Building has been closed in, areas to be heated/ventilated are clean and will not thereafter be subjected to dust-producing processes.
 - .4 There is no possibility of damage.
 - .5 Supply ventilation systems are protected by 60 % filters, inspected daily, changed every week or more frequently as required.
 - .6 Return systems have approved filters over openings, inlets, and outlets.
 - .7 Operate systems as per manufacturer's recommendations and instructions.
 - .8 Monitor systems continuously.
 - .9 Warranties and guarantees are not relaxed.
 - .10 Perform regular preventive and other manufacturers recommended maintenance routines under supervision of Consultant.
 - .11 Refurbish entire system before static completion; clean internally and externally, restore to "as- new" condition, replace filters in air systems.
- .4 Filters specified in this Section are over and above those specified in other

Sections of this project.

- .5 Exhaust systems are not included in approvals for temporary heating and ventilation.

3.7 SPECIAL TOOLS AND SPARE PARTS

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

3.8 INSTRUCTION

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

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

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

1.2 WORK INCLUDED

- .1 Identification of existing services and utility connections.
- .2 Installation, protection and maintenance of temporary services as required to support continuing operation of the facility.
- .3 Disconnection and making safe of various mechanical systems and equipment in areas to be demolished and/or renovated.
- .4 Disposal of waste materials in accordance with waste management requirements.
- .5 Re-certification and inspection of changes made to any equipment, machine or apparatus by authorities having jurisdiction including requirements for marking of equipment.

1.3 REGULATORY REQUIREMENTS

- .1 Notify authorities of intent to demolish and the schedule for the work. Obtain required permits from authorities.
- .2 Conform to codes for demolition work, dust control, products requiring disconnection and re-connection.
- .3 Do not close or obstruct egress width to any building or site exit.
- .4 Do not disable or disrupt building fire or life safety systems without 3 days prior written notice to Owner.
- .5 Conform to procedures applicable when hazardous or contaminated materials are discovered.
- .6 Arrange for re-certification and inspection of changes made to any equipment, machine or apparatus by authorities having jurisdiction. This includes requirements for marking equipment under rules 2-100 and 2-102 of the Ontario Electrical Safety Code.

1.4 JOB CONDITIONS

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

1.5 INTERRUPTIONS

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

1.6 PHASING AND SCHEDULING

- .1 Refer to Division 1 phasing and scheduling of the work.
- .2 Coordinate the work of all Sections of Division 23 with other trades and assist in the development of the Phasing Strategy.

2 PRODUCTS Not Applicable

3 EXECUTION

3.1 PREPARATION

- .1 Prior to start of work under this Section, ensure:
 - .1 Provide, erect, and maintain temporary barriers at locations indicated.
 - .2 Erect and maintain weatherproof closures for exterior openings.
 - .3 Erect and maintain temporary partitions to prevent spread of dust, odors, and noise to permit continued Owner occupancy.
 - .4 Prevent movement of structure; provide bracing and shoring.
- .2 Install, protect and maintain temporary services as required to support continuing operation of the facility.
- .3 Protect services and equipment which are not to be demolished.
- .4 Coordinate service shutdowns with Owner's project coordinator. Provide notice as required by Owner and submit schedule for the work.
- .5 Notify affected utility companies before starting work and comply with their requirements.
- .6 Mark location and termination of utilities.

- .7 Provide appropriate temporary signage including signage for exit or building egress.

3.2 RELATIONSHIP WITH OTHER TRADES

- .1 Cooperate with other trades whose work affects or is affected by work of this Division to ensure satisfactory installation and to avoid delays.
- .2 Remove and dispose of built-in items such as sleeves, anchors, and inserts.
- .3 Remove and dispose of bases, supports and anchors for piping, equipment and ductwork mounted on or in walls, and/or suspended from the structure.

3.3 PROTECTION

- .1 Protect existing and new work to remain free from damage due to execution of work under this Division with tarpaulins and other protective coverings as necessary.
- .2 Repair damage to the building and components resulting from failure to provide sufficient protection, to the satisfaction of the Consultant.
- .3 Fit existing air intake and exhaust openings that may be affected by dust and/or debris from the construction work with appropriate filter media to protect against entry of dust and/or debris into the building and its air distribution systems. Closely monitor filters and replace them when necessary. Replace existing filters that become contaminated with dust and/or debris from construction work with new filters.
- .4 If dust and debris from construction work does penetrate the building and/or its air distribution systems, clean the affected areas and/or systems.
- .5 Remove temporary filters on completion of the construction works.

3.4 DEMOLITION

- .1 Notify authorities of intent to demolish and the schedule for the work.
- .2 Conform to codes, regulations, standards and bylaws applicable to the work.
- .3 Protect existing equipment and services to remain from debris and unwanted materials. Clean as necessary to maintain service during demolition period and on completion of the work.
- .4 Coordinate service shutdowns with Owner's project coordinator. Provide notice as required by Owner and submit schedule for the work.
- .5 Remove and dispose of redundant mechanical services and equipment within the limits of the demolition site and where demolished systems extend beyond these limits.
- .6 Conform to Occupational Health & Safety and Environmental regulations. Ensure that parties are familiar with requirements and experienced in the work to be undertaken.
- .7 Conform to the requirements of Division 01, municipal By-Laws and Ministry of the Environment regulations and standards for waste disposal.

- .8 Fit existing air intake and exhaust openings that may be affected by dust and/or debris from the demolition work with appropriate filter media to protect against entry of dust and/or debris into the building and its air distribution systems. Closely monitor filters and replace them when necessary. Replace existing filters that become contaminated with dust and/or debris from demolition work with new filters.
- .9 If dust and debris from demolition work does penetrate the building and/or its air distribution systems, clean the affected areas and/or systems.
- .10 Disconnect remove, cap and identify all utilities within demolition areas.
- .11 Demolish in an orderly and careful manner. Protect existing supporting structural members.
- .12 Remove demolished materials from site except where specifically noted otherwise. Do not burn or bury materials on site.
- .13 Remove materials as Work progresses. Upon completion of Work, leave areas in clean condition.
- .14 Remove temporary Work.

3.5 RENOVATIONS

- .1 Isolate and drain systems as required to effect renovations, modifications and/or repairs. On completion of renovations, modifications and/or repairs, test entire system as if it was new. Report repairs or replacements required of existing equipment, piping, fittings or devices that are not included in contract to Consultant and Owner for instruction. Flush, clean and refill renovated systems as specified for new.
- .2 Relocate or remove existing items so designated unless specifically indicated to be relocated or removed under other Sections.
- .3 Clean and repair existing items to be relocated. Alter as required to suit new location. Replace damaged or ineffective parts to make items "as new".
- .4 Existing items to be removed remain the property of the owner and shall be delivered to a location on site designated by the owner. If the owner declares no interest in the removed items, assume ownership and remove the items from the site.
- .5 Make good surfaces and finishes in areas from which items have been removed and in which items are relocated. Cap existing services required to be severed to effect alterations and do other work necessary to make good such areas to satisfaction of consultant.
- .6 Temporarily seal openings in existing floor assemblies and vertical fire separations necessitated by installation of equipment and systems or construction with fire barrier materials such as mineral wool or other noncombustible insulation.
- .7 If during alteration work existing asbestos material, other than known asbestos, is discovered (e.g. fireproofing, acoustic or thermal insulation, tank covering), stop work in the affected area and immediately notify consultant.

- .8 Fit existing air intake and exhaust openings that may be affected by dust and/or debris from the construction work with appropriate filter media to protect against entry of dust and/or debris into the building and its air distribution systems. Closely monitor filters and replace them when necessary. Replace existing filters that become contaminated with dust and/or debris from construction work with new filters.
- .9 If dust and debris from renovation work does penetrate the building and/or its air distribution systems, clean the affected areas and/or systems.
- .10 Remove temporary filters on completion of the renovation work.

3.6 INSPECTION AND RE-CERTIFICATION

- .1 Where equipment, machine or apparatus is modified, rebuilt or rewound with any change resulting in its performance or capacity rating and characteristics ensure it is inspected and re-certified as required by authorities having jurisdiction.
- .2 Provide and affix a nameplate giving the name of the person or firm making the change and the resulting changes in performance or capacity to the equipment, machine or apparatus adjacent to the original nameplate. Where the original nameplate is removed, add the original manufacturer's name and original identifying data, such as serial numbers to the nameplate.
- .3 Refer to rules 2-100 and 2-102 of the Ontario Electrical Safety Code.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

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

1.2 COMMON WORK RESULTS

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

1.3 REFERENCE STANDARDS

- .1 Provide Work in accordance with requirements of Regulatory Agencies and conform to:
 - .1 Local and district by-laws, regulations and published engineering standards.
 - .2 the Ontario Building Code as amended,
 - .3 the Ontario Gas Utilization Code as amended
 - .4 Regulations for Construction Projects under The Occupational Health and Safety Act.
 - .5 Fire Code made under the Fire Marshal's Act.
- .2 CSA Group (CSA):
 - .1 CAN/CSA-B149.1, Natural Gas & Propane Installation Code.
 - .2 CAN/CSA B139, Installation Code for Oil Burning Equipment.
 - .3 CSA B242 Groove and Shoulder Type: Mechanical Pipe Couplings.
 - .4 CSA B51, Boiler, Pressure Vessel and Pressure Piping Code.
- .3 National Research Council Canada:
 - .1 National Building Code of Canada and Supplements to National Building Code of Canada
 - .2 National Fire Code of Canada.
 - .3 Canadian Plumbing Code.
- .4 American Society for Testing and Materials (ASTM):
 - .1 ASTM E1 - Specification for ASTM Thermometers.
 - .2 ASTM E77 - Inspection and Verification of Thermometers.
- .5 American Society of Mechanical Engineers (ASME)
 - .1 ASME B31.1 – ASME Code for Power Piping
 - .2 ASME B31.9 – ASME Code for Building Services Piping.
- .6 National Electrical Manufacturers Association (NEMA):
 - .1 MG 1 - Motors and Generators.
- .7 Canadian General Standards Board (CGSB)

- .1 CAN/CGSB-1.181-99, Ready-Mixed Organic Zinc-Rich Coating.
- .8 Provide work where indicated in conformance with guide Specification of the Victaulic System for Building Services, G-100.

1.4 SHOP DRAWING SUBMITTALS

- .1 Provide submittals in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Provide manufacturer's printed product literature and datasheets, and include product characteristics, performance criteria, physical size, finish and limitations.

1.5 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Division 01 - Submittal Procedures.
- .2 Provide details of operation, servicing, maintenance.
- .3 Provide list of recommended spare parts.
- .4 Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.6 QUALITY ASSURANCE

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

1.7 DELIVERY, STORAGE, AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store products off ground, indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect products from nicks, scratches, blemishes, vermin, theft and vandalism.
- .4 Replace defective or damaged materials with new.
- .5 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction

Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.

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

2 PRODUCTS

2.1 PIPING SPECIALTIES

- .1 Provide cast brass, pressure, copper to copper unions with seamless copper tubing smaller than 3" (75 mm).
- .2 Provide cast brass flanges with seamless copper tubing, type L for tubing 3" (75 mm) and larger.
- .3 Provide dart type, 125 lb. (860 kPa) black malleable iron unions used with steel pipe 2-1/2" (65 mm) and smaller.
- .4 Provide RFSO, 150 lb. carbon steel flanges with 1/16" (4 mm) raised face steel pipe for carbon steel piping larger than 2-1/2" (65 mm).
- .5 Provide 1/16" (4 mm) Cranite ring type gaskets for RFSO flanges.
- .6 Line size piping specialties including backflow preventers, strainers, valves etc. unless indicated otherwise on drawings.

2.2 ACCESS DOORS

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

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

2.3 SLEEVES

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

2.4 FLASHINGS AND COUNTERFLASHINGS

- .1 Provide Thaler or equivalent mechanical/electrical flashings as recommended for specific purpose.
- .2 Stainless steel flashing sleeves, integral deck flange and EPDM seal.
- .3 Hot pipe flashing: Provide Thaler MEF-3A Hot Pipe Flashing 18" (457 mm) high with 1/4" (6 mm) dia. perforations at top of flashing, integral deck flange and matching two piece collar. 0.31" (0.79 mm) 22 ga. Type 304 stainless steel diameter to suit hot pipe; galvanized steel sleeve deck protection; PVC coated deck flange.
- .4 "B" Vent flashing: Thaler MEF-4A "B" Vent flashing, 12" (305 mm) high with integral deck flange and matching two piece collar with EPDM Triple Pressure Grommet Seal; .064" (1.6 mm) mill finish 1100-OT alloy aluminum; diameter to suit "B" Vent diameter; PVC coated deck flange.
- .5 Gas pipe flashings: Thaler MEF-9 Modcon Gas Pipe Flashing 18" (457 mm)] high flashing with perforated neck; removable cap with EPDM Triple Pressure Grommet Seal; .031" (0.79 mm) 22 ga. Type 304 stainless steel; PVC coated deck flange.

3 EXECUTION

3.1 INSPECTION

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

3.2 PREPARATION

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

3.3 ELECTRICAL COMPONENTS AND WIRING

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

3.4 SUPPORT AND ATTACHMENT

- .1 Support and attach piping, ductwork fixtures and equipment from load bearing structures such as beams, joists, reinforced concrete slabs and concrete block walls, and do not support from or attach to steel roof deck and/or wall or ceiling finishes.
- .2 Anchor roof mounted mechanical equipment and services to the roof structure to

resist both lateral and uplift wind forces in accordance with requirements of the Ontario Building Code.

3.5 PAINTING

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

3.6 DISSIMILAR METALS

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

3.7 EQUIPMENT BASES AND CURBS

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

3.8 SERVICE CONNECTIONS

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

3.9 FIELD QUALITY CONTROL

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

- by agency,
.4 notify TAB Agency of tests being conducted.

3.10 ADJUST AND CLEAN

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

3.11 INSTALLATION OF ACCESS DOORS

- .1 Provide access doors for access to equipment requiring service, lubrication or adjustment and concealed valves, cleanouts, trap primers, control and volume dampers, and other such equipment.
- .2 Turn over access doors to the appropriate general trade for installation under other Sections.
- .3 Include for drywall, etc. for inset-type access doors.
- .4 Refer to architectural drawings for ratings of fire separations and assemblies. install fire rated access doors in fire rated partitions, walls, and ceilings.
- .5 Provide minimum 24" x 24" (600mm x 600mm) in ceilings, unless otherwise approved by the Consultant.
- .6 Provide concealed access doors in GWB ceilings and coordinate in-fill with general trades.

3.12 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.

END OF SECTION

1. GENERAL**1.1 SUMMARY**

- .1 This Section includes requirements for selective demolition and removal of heating, ventilation and air conditioning systems, controls and automated automation components, and related mechanical components and incidentals required to complete work described in this Section.

1.2 RELATED REQUIREMENTS

- .1 Division 2 – Demolition
- .2 Division 2 – Removal and Salvage of Construction Materials
- .3 Division 2 – Hazardous Materials and Abatement
- .4 Section 21 05 05 – Selective Demolition for Fire Protection
- .5 Section 22 05 05 - Selective Demolition for Plumbing
- .6 Section 26 05 05 - Selective Demolition for Electrical

1.3 REFERENCE STANDARDS

- .1 CSA Group (CSA)
 - .1 CSA S350 M1980 (R2003), Code of Practice for Safety in Demolition of Structures.

1.4 DEFINITIONS

- .1 Demolish: Detach items from existing construction and legally dispose of items off site, unless indicated as removed and salvaged, or removed and reinstalled.
- .2 Remove: Planned deconstruction and disassembly of electrical items from existing construction including removal of conduit, junction boxes, cabling and wiring from electrical component to panel taking care not to damage adjacent assemblies designated to remain; legally dispose of items off site, unless indicated as removed and salvaged, or removed and reinstalled.
- .3 Remove and Salvage: Detach items from existing construction and deliver them to Consultant ready for reuse.
- .4 Remove and Reinstall: Detach items from existing construction, prepare them for reuse, and reinstall them where indicated.
- .5 Existing to Remain: Existing items of construction that are not removed and that are not otherwise indicated as being removed and salvaged, or removed and reinstalled.

- .6 Hazardous Substances: Dangerous substances, dangerous goods, hazardous commodities and hazardous products may include asbestos, mercury and lead, PCB's, poisons, corrosive agents, flammable substances, radioactive substances, or other material that can endanger human health or wellbeing or environment if handled improperly as defined by the Federal Hazardous Products Act (RSC 1985) including latest amendments.

1.5 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Action Submittals: Provide the following in accordance with Section 01 33 00 - Submittal Procedures before starting work of this Section:
 - .1 Construction Waste Management Plan (CWM Plan): Submit plan addressing opportunities for reduction, reuse, or recycling of materials prepared in accordance with Division 01 - Waste Management and Disposal.
 - .2 Landfill Records: Indicate receipt and acceptance of selective demolition waste and hazardous wastes by a landfill facility licensed to accept hazardous wastes.

1.6 ADMINISTRATIVE REQUIREMENTS

- .1 Coordination: Coordinate work of this Section to avoid interference with work by other Sections.
- .2 Scheduling: Account for Owner's continued occupancy requirements during selective demolition with Division 02 and schedule staged occupancy and worksite activities as defined in Division 01.

1.7 QUALITY ASSURANCE

- .1 Regulatory Requirements: Perform work of this Section in accordance with the following
 - .1 Ontario Workers' Compensation Boards/Commissions
 - .2 Ontario Occupational Health and Safety Standards and Programs

1.8 SITE CONDITIONS

- .1 Existing Conditions: Condition of materials identified as being salvaged or demolished are based on their observed condition on date that tender is accepted.
- .2 Existing Hazardous Substances: A hazardous substances assessment was performed and it is not expected that hazardous substances will be encountered in the Work.
 - .1 Hazardous substances will be removed by a hazardous abatement specialist engaged by the Owner before start of the Work.

- .3 Existing Hazardous Substances: A hazardous substances assessment was performed and identified materials requiring abatement as follows:
 - .1 []
 - .2 Hazardous substances will be removed by the [Contractor] as a part of the Contract before starting Work in accordance with work results described in Related Requirements listed above.
- .4 Discovery of Hazardous Substances: It is not expected that Hazardous Substances will be encountered in the Work; immediately notify Consultant if materials suspected of containing hazardous substances are encountered and perform the following activities:
 - .1 Refer to Division 01 - Regulatory Requirements for directives associated with specific material types.
 - .2 Hazardous substances will be as defined in the Hazardous Products Act.
 - .3 Stop work in the area of the suspected hazardous substances.
 - .4 Take preventative measures to limit users' and workers' exposure, provide barriers and other safety devices and do not disturb.
 - .5 Hazardous substances will be removed under a separate contract or as a change to the Work.
 - .6 Proceed only after written instructions have been received from Consultant.

1.9 SALVAGE AND DEBRIS MATERIALS

- .1 Demolished items become Contractor's property and will be removed from Project site; except for items indicated as being reused, salvaged, or otherwise indicated to remain Owner's property.
- .2 Carefully remove materials and items designated for salvage and store in a manner to prevent damage or devaluation of materials in accordance with Division 02 - Removal and Salvage of Construction Materials.

2. PRODUCTS

2.1 MATERIAL

- .1 General Patching and Repair Materials: Refer to Division 02 - Selective Building Demolition and Division 02 - Selective Interior Demolition for listing of patching and repair materials incidental to removal or demolition of components associated with work of this Section.

- .2 HVAC Repair Materials: Use only new materials required for completion or repair matching materials damaged during performance of work of this Section; new materials are required to meet assembly or system characteristics as existing systems indicated to remain and carry CSA approval labels required by the Authority Having Jurisdiction.
- .3 Fire stopping Repair Materials: Use fire stopping materials compatible with existing fire stopping systems where removal or demolition work affects rated assemblies, restore to match existing fire rated performance.

3. EXECUTION

3.1 EXAMINATION

- .1 Verification of Existing Conditions: Visit site, thoroughly examine and become familiar with conditions that may affect the work of this Section before tendering the Bid; Consultant will not consider claims for extras for work or materials necessary for proper execution and completion of the contract that could have been determined by a site visit.

3.2 PREPARATION

- .1 Protection of Existing Systems to Remain: Protect systems and components indicated to remain in place during selective demolition operations and as follows:
 - .1 Prevent movement and install bracing to prevent settlement or damage of adjacent services and parts of existing buildings scheduled to remain.
 - .2 Notify Consultant and cease operations where safety of buildings being demolished, adjacent structures or services appears to be endangered and await additional instructions before resuming demolition work specified in this Section.
 - .3 Prevent debris from blocking drainage inlets.
 - .4 Protect mechanical systems that must remain in operation.
- .2 Protection of Building Occupants: Sequence demolition work so that interference with the use of the building by the Owner and users is minimized and as follows:
 - .1 Prevent debris from endangering the safe access to and egress from occupied buildings.
 - .2 Notify Consultant and cease operations where safety of occupants appears to be endangered and await additional instructions before resuming demolition work specified in this Section.

3.3 EXECUTION

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- .1 Coordinate requirements of this Section with information contained in Division 2 - Selective Building Demolition and Division 02 - Selective Interior Demolition and as follows:
 - .1 Disconnect and cap gas supply and electrical services in accordance with requirements of local Authority Having Jurisdiction.
 - .2 Do not disrupt active or energized utilities without approval of the Consultant.
 - .3 Erect and maintain dust proof and weather tight partitions to prevent the spread of dust and fumes to occupied building areas; remove partitions when complete.
 - .4 Demolish parts of existing building to accommodate new construction and remedial work as indicated.
 - .5 At end of each day's work, leave worksite in safe condition.
 - .6 Perform demolition work in a neat and workmanlike manner:
 - .1 Remove any tools or equipment after completion of work, and leave site clean and ready for subsequent renovation work.
 - .2 Repair and restore damages caused as a result of work of this Section to match existing materials and finishes.

3.4 CLOSEOUT ACTIVITIES

- .1 Demolition Waste Disposal: Arrange for legal disposal and remove demolished materials to accredited provincial landfill site or alternative disposal site (recycle centre) except where explicitly noted otherwise for materials being salvaged for re use in new construction in accordance with Division - Removal and Salvage of Construction Materials.
- .2 Hazardous Substances Disposal: Arrange for disposal of hazardous substances in accordance with requirements of Division 2 - Asbestos Abatement - Intermediate Precautions and Division 2 - Hazardous Materials.

END OF SECTION

1. GENERAL

1.1 SUMMARY

- .1 Section Includes:
 - .1 Electrical motors, drives and guards for mechanical equipment and systems.
 - .2 Supplier and installer responsibility indicated in Motor, Control and Equipment Schedule on electrical drawings and related mechanical responsibility is indicated on Mechanical Equipment Schedule on mechanical drawings.
 - .3 Control wiring and conduit is specified in Division 26 except for conduit, wiring and connections below 50 V which are related to control systems specified in Division 22 and 23. Refer to Division 26 for quality of materials and workmanship.
- .2 Related Requirements
 - .1 Section 23 01 01.

1.2 REFERENCE STANDARDS

- .1 American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)
 - .1 ASHRAE 90.1-13, Energy Standard for Buildings Except Low-Rise Residential Buildings (IESNA cosponsored; ANSI approved; Continuous Maintenance Standard).
- .2 Electrical Equipment Manufacturers' Association Council (EEMAC)
- .3 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Safety Data Sheets (SDS).

1.3 SHOP DRAWING SUBMITTALS

- .1 Submittals: in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Division 01 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.
 - .1 Submit [two] copies of Workplace Hazardous Materials Information System (WHMIS) Safety Data Sheets (SDS) in accordance with Division 01 - Submittal Procedures.
- .3 Quality Control: in accordance with Division 01 - Quality Control.
 - .1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

- .2 Instructions: submit manufacturer's installation instructions.
- .4 Closeout Submittals
 - .1 Provide maintenance data for motors, drives and guards for incorporation into manual specified in Division 01 - Closeout Submittals.

1.4 QUALITY ASSURANCE

- .1 Regulatory Requirements: work to be performed in compliance with applicable Provincial /Territorial regulations.
- .2 Health and Safety Requirements: do construction occupational health and safety in accordance with Division 01 - Health and Safety Requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store products off ground, indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect products from nicks, scratches, blemishes, vermin, theft and vandalism.
- .4 Replace defective or damaged materials with new.

2. PRODUCTS

2.1 GENERAL

- .1 Motors: high efficiency, in accordance with local Hydro company standards and to ASHRAE 90.1.
- .2 Provide internal wiring, relays, contactors, switches, transformers, motor starters, and controls necessary for the intended operation, furnished with terminals and external controls suitable for connection to power source at a single easily accessed location for items that are supplied with motors and/or electrical or electronic components under this division.

2.2 MOTORS

- .1 Provide motors for mechanical equipment as specified.
- .2 Motors under 1/2 HP: speed as indicated, continuous duty, built-in overload protection, resilient mount, single phase, 120 V, unless otherwise specified or indicated. Provide continuously rated squirrel cage induction type with capacitor start, EEMAC 'N' starting characteristics and a minimum of Class 'A' insulation.

- .3 Motors 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, 3 phase, unless otherwise indicated. Provide continuously rated squirrel cage induction type with EEMAC 'B' starting characteristics and a minimum of Class 'B' insulation.
- .4 Do not provide motors with class F or H insulation for TENV enclosure ratings. Do not provide class H insulation motors for all other enclosure ratings.
- .5 If providing a motor with an insulation class that increases the temperature rating of the wiring, bear the associated cost for the electrical changes at no additional cost to the project.

2.3 TEMPORARY MOTORS

- .1 If delivery of specified motor will delay completion or commissioning work, install motor approved by Consultant for temporary use. Work will only be accepted when specified motor is installed.

2.4 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 indicated.
- .3 For motors under 10 HP: standard adjustable pitch drive sheaves, having plus or minus 10% range. Use mid-position of range for specified r/min.
- .4 For motors 10 HP and over: sheave with split tapered bushing and keyway having fixed pitch unless specifically required for item concerned. Provide sheave of correct size to suit balancing.
- .5 Correct size of sheave determined during commissioning.
- .6 Minimum drive rating: 1.5 times nameplate rating on motor. Keep overhung loads within manufacturer's design requirements on prime mover shafts.
- .7 Motor slide rail adjustment plates to allow for centre line adjustment.
- .8 Supply one set of spare belts for each set installed in accordance with Division 01 - Closeout Submittals.

2.5 DRIVE GUARDS

- .1 Provide guards for unprotected drives.
- .2 Guards for belt drives.
 - .1 Expanded metal screen welded to steel frame.
 - .2 Minimum 1.2 mm thick sheet metal tops and bottoms.
 - .3 [38] mm dia 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 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, 19 mm mesh.
 - .2 Net free area of guard: not less than 80% of fan openings.
 - .3 Securely fasten in place.
 - .4 Removable for servicing.

2.6 MOTOR STARTERS

- .1 Unless stated otherwise, direct-online (DOL) starting shall only be used where specified in the documents. Compatible soft starters or VFD's must be provided based on the following:
 - .1 Up to 120v 1-phase system voltage, motorised equipment rated ¼ hp and higher.
 - .2 Up to 240v 1-phase system voltage, motorised equipment rated ½ hp and higher.
 - .3 Up to 230v (I-I) 3-phase system voltage, motorised equipment rated ¾ hp and higher.
 - .4 Up to 575v (I-I) 3-phase system voltage, motorised equipment rated 1½ hp and higher.

3. EXECUTION

3.1 GENERAL

- .1 Provide motors required for equipment supplied by this division.
- .2 Provide variable frequency drives for motors and equipment supplied by this division.
- .3 Provide internal wiring, relays, contactors, switches, transformers, motor starters, and controls necessary for the intended operation, furnished with terminals and external controls suitable for connection to power source at a single easily accessed location for items that are supplied with motors and/or electrical or electronic components under this division.

- .4 Unless stated otherwise, direct-online (DOL) starting shall only be used where specified in the documents. Compatible soft starters or VFD's must be provided based on the following:
 - .1 Up to 120v 1-phase system voltage, motorized equipment rated ¼ hp and higher.
 - .2 Up to 240v 1-phase system voltage, motorized equipment rated ½ hp and higher.
 - .3 Up to 230v (I-I) 3-phase system voltage, motorized equipment rated ¾ hp and higher.
 - .4 Up to 575v (I-I) 3-phase system voltage, motorized equipment rated 1½ hp and higher.
- .5 Comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

- .1 Fasten securely in place.
- .2 Make removable for servicing, easily returned into, and positively in position.

3.3 FIELD QUALITY CONTROL

- .1 Manufacturer's Field Services:
 - .1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in PART 1 - SUBMITTALS.
 - .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
 - .3 Schedule site visits, to review Work, as directed in PART 1 - QUALITY ASSURANCE.

3.4 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.

END OF SECTION

1. GENERAL

1.1 RELATED REQUIREMENTS

- .1 Section 23 01 01.

1.2 REFERENCE STANDARDS

- .1 Canadian General Standards Board (CGSB)
 - .1 CAN/CGSB-1.181-99, Ready-Mixed Organic Zinc-Rich Coating.
- .2 CSA Group (CSA)
 - .1 CAN/CSA B139-04, Installation Code for Oil Burning Equipment.
- .3 National Research Council Canada (NRC)
 - .1 National Fire Code of Canada 2015 (NFC).
- .4 South Coast Air Quality Management District (SCAQMD), California State, Regulation XI. Source Specific Standards
 - .1 SCAQMD Rule 1113-A2007, Architectural Coatings.
 - .2 SCAQMD Rule 1168-A2005, Adhesive and Sealant Applications.
- .5 American Society of Mechanical Engineers (ASME)
 - .1 ASME B31.1 – ASME Code for Power Piping
 - .2 ASME B31.9 – ASME Code for Building Services Piping.

1.3 SHOP DRAWING SUBMITTALS

- .1 Provide submittals in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Provide manufacturer's printed product literature, specifications and datasheets for piping and equipment and include product characteristics, performance criteria, physical size, finish and limitations.

1.4 QUALITY ASSURANCE

- .1 Sustainability Standards Certification:
 - .1 Low-Emitting Materials: provide listing of sealants and coatings used in building, comply with VOC and chemical component limits or restriction requirements.

1.5 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:

- .1 Store products off ground, indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
- .2 Store and protect products from nicks, scratches, blemishes, vermin, theft and vandalism.
- .4 Replace defective or damaged materials with new.
- .5 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.

2. PRODUCTS

2.1 MATERIAL

- .1 Paint: zinc-rich to CAN/CGSB-1.181.
 - .1 Primers, paints, and coatings: Provide in accordance with manufacturer's recommendations for surface conditions to SCAQMD Rule 1113:
 - .2 Primer: maximum VOC limit 250 g/L
 - .3 Paints: maximum VOC limit 150 g/L
 - .4 Adhesives for Mechanical Identification: maximum VOC emission of 70g/L
 - .5 Sealants for service penetrations: maximum VOC emission of 650g/L clear and 350 g/L pigmented
 - .6 Sealants for Firestopping: max. VOC emission of 650g/L clear and 350 g/L pigmented
 - .7 Acrylic Sealant for supports and anchors: maximum VOC emission of 250g/L
 - .8 Insulation Vapour Barrier Lap Adhesive: maximum VOC emission of 80g/L
 - .9 Insulation Joint Sealer: maximum VOC emission of 250g/L
 - .10 Insulation Vapour Barrier Mastic: maximum VOC emission of 400g/L
 - .11 Flame Retardant Adhesive: maximum VOC emission of 650g/L clear and 350 g/L pigmented.
- .2 Sealants: in accordance with Division 07 - Joint Sealants.
 - .1 Sealants: maximum VOC limit to SCAQMD Rule 1168.
- .3 Sealants: maximum VOC limit to SCAQMD Rule 1168.
- .4 Adhesives: maximum VOC limit to SCAQMD Rule 1168.
- .5 Fire Stopping: in accordance with Division 07 - Fire Stopping.

3. EXECUTION

3.1 APPLICATION

- .1 Manufacturer's Instructions: comply with manufacturer's written recommendations, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 CONNECTIONS TO EQUIPMENT

- .1 In accordance with manufacturer's instructions unless otherwise indicated.
- .2 Use valves and either unions or flanges for isolation and ease of maintenance and assembly.
- .3 Use double swing joints when equipment mounted on vibration isolation and when piping subject to movement.

3.3 CLEARANCES

- .1 Provide clearance around systems, equipment and components for observation of operation, inspection, servicing, maintenance and as recommended by manufacturer and National Fire Code of Canada and CAN/CSA B139.
- .2 Provide space for disassembly, removal of equipment and components as recommended by manufacturer, CAN/CSA B139, and as indicated without interrupting operation of other system, equipment, components.

3.4 DRAINS

- .1 Install piping with grade in direction of flow except as indicated.
- .2 Install drain valve at low points in piping systems, at equipment and at section isolating valves.
- .3 Pipe each drain valve discharge separately to above floor drain.
 - .1 Discharge to be visible.
- .4 Drain valves: NPS 3/4 gate or globe valves unless indicated otherwise, with hose end male thread, cap and chain.

3.5 AIR VENTS

- .1 Install air vents to CAN/CSA B139 for oil piping and at high points in piping systems.
- .2 Install isolating valve at each automatic air valve.
- .3 Install drain piping to approved location and terminate where discharge is visible.

3.6 DIELECTRIC COUPLINGS

- .1 General: compatible with system, to suit pressure rating of system.
- .2 Locations: where dissimilar metals are joined.
- .3 NPS 2 and under: isolating unions or bronze valves.
- .4 Over NPS 2: isolating flanges.

3.7 PIPEWORK INSTALLATION

- .1 Install pipework to CAN/CSA B139, ASME B31.1 or ASME B31.9 as applicable.
- .2 Screwed fittings jointed with Teflon tape.
- .3 Protect openings against entry of foreign material.
- .4 Install to isolate equipment and allow removal without interrupting operation of other equipment or systems.
- .5 Assemble piping using fittings manufactured to ANSI standards.
- .6 Saddle type branch fittings may be used on mains if branch line is no larger than half size of main.
 - .1 Hole saw (or drill) and ream main to maintain full inside diameter of branch line prior to welding saddle.
 - .2 Ensure openings are cut true, beveled and filed smooth.
- .7 Install exposed piping, equipment, rectangular cleanouts and similar items parallel or perpendicular to building lines.
- .8 Install concealed pipework to minimize furring space, maximize headroom, conserve space.
- .9 Install piping, wherever possible, in partitions and above ceiling. Do not install piping in outside walls unless so shown on drawings. Wrap uninsulated piping in masonry walls with building paper.
- .10 Slope piping, except where indicated, in direction of flow for positive drainage and venting.
- .11 Install, except where indicated, to permit separate thermal insulation of each pipe.
- .12 Group piping wherever possible and as indicated.
- .13 Ream pipes, remove scale and other foreign material before assembly.
- .14 Use eccentric reducers at pipe size changes to ensure positive drainage and venting.
- .15 Provide for thermal expansion as indicated.
- .16 Valves:
 - .1 Install in accessible locations.
 - .2 Remove interior parts before soldering.
 - .3 Install with stems above horizontal position unless indicated.
 - .4 Valves accessible for maintenance without removing adjacent piping.
 - .5 Install globe valves in bypass around control valves.
 - .6 Use gate, ball or butterfly valves at branch take-offs for isolating purposes except where specified.
 - .7 Install butterfly valves on chilled water and related condenser water systems only.

- .8 Install butterfly valves between weld neck flanges to ensure full compression of liner.
- .9 Install plug cocks or ball valves for glycol service.
- .10 Use chain operators on valves NPS 2 1/2 and larger where installed more than 2400 mm above floor in Mechanical Rooms.
- .17 Check Valves:
 - .1 Install silent check valves on discharge of pumps and in vertical pipes with downward flow and as indicated.
 - .2 Install swing check valves in horizontal lines on discharge of pumps and as indicated.
- .18 Arrange all take-offs from mains to allow for expansion and contraction of pipes. Take hot water branches serving down feed risers from lower sides or bottom of mains and grade down slightly to risers. Take branches which serve units above the mains from the top or sides of mains.

3.8 PIPING JOINTS

- .1 Make joints in piping installed under this Division using persons familiar with the particular materials being used and in accordance with CSA B51 and CSA B52, manufacturer's instructions, and as specified herein.
- .2 Use silver solder or Silfos for joining copper tubing 4" (100 mm) and larger in size.
- .3 Carefully ream joints in threaded pipe and paint with approved graphite type joint sealer on male connections only. Make connections with proper wrench to suit pipe size. Where leaks occur, disassemble the joint and correct if possible or replace. Do not over-tightening, caulk or peen leaking joints.
- .4 Victaulic Grooved Piping Method:
 - .1 Make joints in grooved piping with couplings and gaskets in accordance with Victaulic Company of Canada Ltd, General Catalogue G-100, latest edition. Cut or roll grooves using tools specifically designed for that purpose.
 - .2 Use Zero-flex or Rigidlok couplings in locations where rigidity is required, such as in mechanical rooms on coils, headers and pumps.
 - .3 Vic-Boltless couplings may be used.
- .5 Install unions or welding flanges at connections to valves, etc. to facilitate removal.

3.9 SLEEVES AND CURBS

- .1 General: install where pipes pass through masonry, concrete structures, fire rated assemblies, and as indicated.
- .2 Material: schedule 40 black steel pipe.

- .3 Construction: use annular fins continuously welded at mid-point at foundation walls and where sleeves extend above finished floors.
- .4 Sizes: 6 mm minimum clearance between sleeve and uninsulated pipe or between sleeve and insulation.
- .5 Installation:
 - .1 Concrete, masonry walls, concrete floors on grade: terminate flush with finished surface.
 - .2 Other floors: terminate 25 mm above finished floor.
 - .3 Before installation, paint exposed exterior surfaces with heavy application of zinc-rich paint to CAN/CGSB-1.181.
- .6 Sealing:
 - .1 Foundation walls and below grade floors: fire retardant, waterproof non-hardening mastic.
 - .2 Elsewhere:
 - .1 Provide space for fire stopping.
 - .2 Maintain the fire-resistance rating integrity of the fire separation.
 - .3 Sleeves installed for future use: fill with lime plaster or other easily removable filler.
 - .4 Ensure no contact between copper pipe or tube and ferrous sleeve.
- .7 Provide watertight concrete curb 4" (100 mm) high around mechanical services (pipes, ducts, conduits) which rise through mechanical (service) room floors. Provide minimum 4" (100 mm) clearance between openings for services within curbs.
- .8 For pipes passing through roofs, use cast iron sleeves with caulking recess and flashing clamp device. Anchor sleeves in roof construction, caulk between sleeve recess and pipe, fasten roof flashing to clamp device, make water-tight durable joint. Co-ordinate with roofing Section.

3.10 ESCUTCHEONS

- .1 Install on pipes passing through walls, partitions, floors, and ceilings in finished areas.
- .2 Construction: one piece type with set screws.
 - .1 Chrome or nickel plated brass or type 302 stainless steel.
- .3 Sizes: outside diameter to cover opening or sleeve.
 - .1 Inside diameter to fit around pipe or outside of insulation if so provided.
 - .2 Where sleeve extends above finished floor, escutcheon or plates shall clear sleeve extension.
- .4 Secure to pipe or finished surface, but not insulation.

3.11 FLASHINGS

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

3.12 PREPARATION FOR FIRE STOPPING

- .1 Coordinate the installation of fire stopping around pipes, insulation and adjacent fire separation in accordance with Division 07 - Fire Stopping.
- .2 Pipes subject to movement: conform to fire stop system design listing to ensure pipe movement without damaging fire stopping material or installation.
- .3 Insulated pipes: ensure integrity of insulation and vapour barriers.

3.13 FLUSHING OUT OF PIPING SYSTEMS

- .1 Flush system in accordance with Section 23 08 16 - Cleaning and Start-Up of HVAC Piping Systems.
- .2 Before start-up, clean interior of piping systems in accordance with requirements of Division 01 - Cleaning supplemented as specified in relevant mechanical sections.
- .3 Preparatory to acceptance, clean and refurbish equipment and leave in operating condition, including replacement of filters in piping systems.
- .4 Remove, clean and replace all strainers in systems after flushing.
- .5 Thoroughly clean and lubricate HVAC equipment and leave all items in perfect order ready for operation.

3.14 PRESSURE TESTING OF EQUIPMENT AND PIPEWORK

- .1 Pework: test as specified in relevant sections of heating, ventilating and air conditioning work.
- .2 Maintain specified test pressure without loss for 4 hours minimum unless specified for longer period of time in relevant mechanical sections.
- .3 Prior to tests, isolate equipment and other parts which are not designed to withstand test pressure or media.
- .4 Repair leaks exposed during testing and retest. If defects in pipe or fittings are discovered in the system, removed and replace.
- .5 Pay costs for repairs or replacement, retesting, and making good. Consultant to determine whether repair or replacement is appropriate.
- .6 Insulate or conceal work only after approval and certification of tests by Consultant.
- .7 Prior to tests, isolate equipment or other parts which are not designed to withstand test pressures.
- .8 Test piping at the completion of roughing-in, before connecting to existing systems, and prior to concealment, insulation or covering of piping.

- .9 Make tests, that are required by any authority having jurisdiction, in the presence of the authority's authorized inspector and shall be certified by him.
- .10 Conduct tests in the presence of:
 - .1 Authorized inspector(s) for authorities having jurisdiction.
 - .2 The Commissioning Agent
 - .3 The Owner's Representative
 - .4 The Consultant
- .11 Give notification at least 48 hours in advance of tests being conducted, to persons required to be present.
- .12 Certify tests not required by authorities having jurisdiction.

3.15 EQUIPMENT TESTING AND INSPECTION

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

3.16 EXISTING SYSTEMS

- .1 Connect into existing piping systems at times approved Consultant.
- .2 Request written approval by Consultant ten (10) days minimum, prior to commencement of work.
- .3 Be responsible for repair of damage to existing plant by this work.

3.17 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.

- .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.

END OF SECTION

1. GENERAL**1.1 GENERAL REQUIREMENTS**

- .1 Refer to Section 23 01 01.

1.1 REFERENCE STANDARDS

- .1 American Society of Mechanical Engineers (ASME)
 - .1 ASME B31.1-07, Power Piping.
- .2 ASTM International (ASTM)
 - .1 ASTM A125-1996(2007), Standard Specification for Steel Springs, Helical, Heat-Treated.
 - .2 ASTM A307-07b, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 - .3 ASTM A563-07a, Standard Specification for Carbon and Alloy Steel Nuts.
- .3 Canada Green Building Council (CaGBC)
 - .1 LEED Canada-NC Version 1.0-2004, LEED (Leadership in Energy and Environmental Design): Green Building Rating System Reference Package for New Construction and Major Renovations (including Addendum 2007).
 - .2 LEED Canada-CI Version 1.0-2007, LEED (Leadership in Energy and Environmental Design): Green Building Rating System Reference Guide for Commercial Interiors.
- .4 Factory Mutual (FM)
- .5 Manufacturer's Standardization Society of the Valves and Fittings Industry (MSS)
 - .1 MSS SP58-2002, Pipe Hangers and Supports - Materials, Design and Manufacture.
- .6 National Research Council Canada (NRC)
 - .1 National Plumbing Code of Canada 2015 (NPC).
- .7 Underwriter's Laboratories of Canada (ULC)

1.2 SUBMITTALS

- .1 Provide submittals in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Provide manufacturer's printed product literature and data sheets for hangers and supports and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:

- .1 Submit drawings stamped and signed by professional engineer registered or licensed in Ontario.
- .2 Submit shop drawings for:
 - .1 Bases, hangers and supports.
 - .2 Connections to equipment and structure.
 - .3 Structural assemblies.
- .4 Certificates:
 - .1 Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .5 Manufacturers' Instructions:
 - .1 Provide manufacturer's installation instructions.
 - .1 Consultant will make available one copy of systems supplier's installation instructions.
- .6 Sustainable Design Submittals:
 - .1 LEED Canada-[NC Version 1.0] [CI Version 1.0] Submittals: in accordance with [Division 01 35 21 - LEED Requirements].

1.3 CLOSEOUT SUBMITTALS

- .1 Provide maintenance data for incorporation into manual specified in Division 01 - Closeout Submittals.

1.4 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store products off ground, indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect products from nicks, scratches, blemishes, vermin, theft and vandalism.
 - .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.

2. PRODUCTS

2.1 SYSTEM DESCRIPTION

- .1 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 SP58.
 - .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 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 in accordance with MSS SP58.
- .2 Performance Requirements:
 - .1 Design supports, platforms, catwalks, hangers to withstand seismic events as specified Section 23 05 48.

2.2 SUSTAINABLE REQUIREMENTS

- .1 Materials and products in accordance with Division [01 47 15 - Sustainable Requirements: Construction].
 - .1 [].

2.3 GENERAL

- .1 Fabricate hangers, supports and sway braces in accordance with MSS SP58. ANSI B31.1 and
- .2 Use components for intended design purpose only. Do not use for rigging or erection purposes.

2.4 PIPE HANGERS

- .1 Finishes:
 - .1 Pipe hangers and supports: galvanized or painted with zinc-rich paint after manufacture.
 - .2 Use electroplated or hot dipped galvanizing process.
 - .3 Ensure steel hangers in contact with copper piping are copper plated or epoxy coated.

- .2 Upper attachment structural: suspension from lower flange of I-Beam:
 - .1 Cold piping NPS 2 maximum: malleable iron C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip.
 - .1 Rod: 13 mm FM approved.
- .3 Cold piping NPS 2 1/2 or greater, hot piping: malleable iron beam clamp, eye rod, jaws and extension with carbon steel retaining clip, tie rod, nuts and washers, FM approved to MSS-SP58 Upper attachment structural: suspension from upper flange of I-Beam:
 - .1 Cold piping NPS 2 maximum: ductile iron top-of-beam C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip, FM approved to MSS SP58.
 - .2 Cold piping NPS 2 1/2 or greater, hot piping: malleable iron top-of-beam jaw-clamp with hooked rod, spring washer, plain washer and nut FM approved..
- .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 minimum greater than rod diameter.
 - .2 Concrete inserts: wedge shaped body with knockout protector plate FM approved to MSS SP58.
- .5 Shop and field-fabricated assemblies:
 - .1 Trapeze hanger assemblies: to ASME B31.1 and MSS SP 58.
 - .2 Steel brackets: to ASME B31.1 and MSS SP 58.
 - .3 Sway braces for seismic restraint systems: to Section 23 05 48.
- .6 Hanger rods: threaded rod material to MSS SP58:
 - .1 Ensure that hanger rods are subject to tensile loading only.
 - .2 Provide linkages where lateral or axial movement of pipework is anticipated.
 - .3 Do not use 22 mm or 28 mm rod.
- .7 Pipe attachments: material to MSS SP58:
 - .1 Attachments for steel piping: carbon steel galvanized.
 - .2 Attachments for copper piping: copper plated black steel.
 - .3 Use insulation shields for hot pipework.
 - .4 Oversize pipe hangers and supports on insulated pipe to suit insulation and to avoid penetrating vapour retarders.
- .8 Adjustable clevis: material to MSS SP58 FM approved clevis bolt with nipple spacer and vertical adjustment nuts above and below clevis.

- .1 Ensure "U" has hole in bottom for riveting to insulation shields.
- .2 Use clevis style hangers where horizontal movement is no greater than 25mm. Otherwise, provide roller-type.
- .9 Yoke style pipe roll: carbon steel yoke, rod and nuts with cast iron roll, to MSS SP58.
- .10 U-bolts: carbon steel to MSS SP58 with 2 nuts at each end to ASTM A563.
 - .1 Finishes for steel pipework: galvanized.
 - .2 Finishes for copper, glass, brass or aluminum pipework: galvanized with formed portion plastic coated epoxy coated.
- .11 Pipe rollers: cast iron roll and roll stand with carbon steel rod to MSS SP58.

2.5 RISER CLAMPS

- .1 Steel or cast iron pipe: galvanized carbon steel to MSS SP58, type 42, FM approved.
- .2 Copper pipe: carbon steel copper plated to MSS SP58, type 42.
- .3 Bolts: to ASTM A307.
- .4 Nuts: to ASTM A563.

2.6 INSULATION PROTECTION SHIELDS

- .1 Insulated cold piping:
 - .1 64 kg/m³ density insulation plus insulation protection shield to: MSS SP58, galvanized sheet carbon steel. Length designed for maximum 3 m span.
- .2 Insulated hot piping:
 - .1 Curved plate 300 mm long, with edges turned up, welded-in centre plate for pipe sizes NPS 12 and over, carbon steel to comply with MSS SP58.

2.7 CONSTANT SUPPORT SPRING HANGERS

- .1 Springs: alloy steel to ASTM A125, shot peened, magnetic particle inspected, with +/-5% spring rate tolerance, tested for free height, spring rate, loaded height and provided with Certified Mill Test Report (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 minimum.

- .6 Individually calibrated scales on each side of support calibrated prior to shipment, complete with calibration record.

2.8 VARIABLE SUPPORT SPRING HANGERS

- .1 Vertical movement: 13 mm minimum, 50 mm maximum, use single spring pre-compressed variable spring hangers.
- .2 Vertical movement greater than 50 mm: use double spring pre-compressed variable spring hanger with 2 springs in series in single casing.
- .3 Variable spring hanger complete with factory calibrated travel stops. Provide certificate of calibration for each hanger.
- .4 Steel alloy springs: to ASTM A125, shot peened, magnetic particle inspected, with +/-5 % spring rate tolerance, tested for free height, spring rate, loaded height and provided with CMTR.

2.9 EQUIPMENT SUPPORTS

- .1 Fabricate equipment supports not provided by equipment manufacturer from structural grade steel meeting requirements of Division 05 - Structural Steel for Buildings. Submit calculations with shop drawings.

2.10 EQUIPMENT ANCHOR BOLTS AND TEMPLATES

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

2.11 PLATFORMS AND CATWALKS

- .1 To Division 05 - Metal Fabrications.

2.12 HOUSE-KEEPING PADS

- .1 Provide 100 mm high concrete housekeeping pads for base-mounted equipment; size pads 150 mm larger than equipment on all sides. Chamfer pad edges.
- .2 Concrete: to Division 03 - Cast-in-Place Concrete.

2.13 OTHER EQUIPMENT SUPPORTS

- .1 Fabricate equipment supports from structural grade steel meeting requirements of Division 05 - Structural Steel for Buildings.
- .2 Submit structural calculations with shop drawings.

3. EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 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, and 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 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, one 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 13 mm 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.

3.3 HANGER SPACING

- .1 Plumbing piping: to Ontario Plumbing Code.
- .2 Fire protection: to applicable fire code.
- .3 Gas and fuel oil piping: up to NPS 1/2: every 1.8 m.
- .4 Copper piping: up to NPS 1/2: every 1.5 m.

- .5 Flexible joint roll groove pipe: in accordance with table below for steel, but not less than one hanger at joints. Table listings for straight runs without concentrated loads and where full linear movement is not required.
- .6 Within 300 mm of each elbow.
- .7 Pipework greater than NPS 12: to MSS SP58.

3.4 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.

3.5 HORIZONTAL MOVEMENT

- .1 Angularity of rod hanger resulting from horizontal movement of pipework from cold to hot position not to exceed 4 degrees from vertical.
- .2 Where horizontal pipe movement is less than 13 mm, offset pipe hanger and support so that rod hanger is vertical in the hot position.

3.6 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.

3.7 FIELD QUALITY CONTROL

- .1 Site Tests: conduct following tests in accordance with Division 01 - Quality Control and submit report as described in PART 1 - ACTION AND INFORMATIONAL SUBMITTALS.
 - .1 [REDACTED].

.2 Manufacturer's Field Services:

- .1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in PART 1 - ACTION AND INFORMATIONAL SUBMITTALS.
- .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
- .3 Schedule site visits, to review Work, as directed in PART 1 - QUALITY ASSURANCE.

.3 Verification requirements in accordance with Division 01 33 29 - Sustainable Design Reporting, include:

- .1 Materials and resources.
- .2 Storage and collection of recyclables.
- .3 Construction waste management.
- .4 Resource reuse.
- .5 Recycled content.
- .6 Local/regional materials.
- .7 Certified wood.
- .8 Low-emitting materials.

3.8 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal [01 35 21 - LEED Requirements].

END OF SECTION

1. GENERAL**1.1 SUMMARY**

- .1 Section Includes:
 - .1 Materials and requirements for the identification of piping systems, duct work, valves and controllers, including the installation and location of identification systems.
 - .2 Sustainable requirements for construction and verification.
- .2 Related Requirements
 - .1 Section 21 13 13
 - .2 Section 23 01 01
 - .3 Section 23 05 15.

1.2 REFERENCE STANDARDS

- .1 Canadian Standards Association (CSA)
 - .1 CSA 53, Identification of Piping Systems.
 - .2 CSA/CGA B149.1, Natural Gas and Propane Installation Code.
- .2 Canadian General Standards Board (CGSB)
 - .1 CAN/CGSB-1.60-97, Interior Alkyd Gloss Enamel.
 - .2 CAN/CGSB-24.3-92, Identification of Piping Systems.
- .3 National Fire Protection Association (NFPA)
 - .1 NFPA 13-2002, Standard for the Installation of Sprinkler Systems.
 - .2 NFPA 14-2003, Standard for the Installation of Standpipe and Hose Systems.

1.3 SHOP DRAWING SUBMITTALS

- .1 Product Data:
- .2 Submittals: in accordance with Division 01 - Submittal Procedures.
- .3 Product data to include paint colour chips, other products specified in this section.
- .4 Samples:
 - .1 Submit samples in accordance with Division 01 - Submittal Procedures.
 - .2 Samples to include nameplates, labels, tags, lists of proposed legends.

1.4 QUALITY ASSURANCE

- .1 Quality assurance submittals: submit following in accordance with Division 01 - Submittal Procedures.

- .2 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Division 01 - Health and Safety Requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store products off ground, indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect products from nicks, scratches, blemishes, vermin, theft and vandalism.
 - .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.

2. PRODUCTS

2.1 SUSTAINABLE REQUIREMENTS

- .1 Materials and products in accordance with Division [01 47 15 - Sustainable Requirements: Construction].
 - .1 [].

2.2 MANUFACTURER'S EQUIPMENT NAMEPLATES

- .1 Metal or plastic laminate nameplate mechanically fastened to each piece of equipment by manufacturer.
- .2 Lettering and numbers 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.

2.3 SYSTEM NAMEPLATES

- .1 Colours:
 - .1 Hazardous: red letters, white background.

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- .2 Elsewhere: black letters, white background (except where required otherwise by applicable codes).
- .2 Construction:
 - .1 3 mm thick laminated plastic matte finish, with square corners, letters accurately aligned and machine engraved into core.
- .3 Sizes:
 - .1 Conform to following table:

Size # mm	Sizes (mm)	No. of Lines	Height of Letters (mm)
1	10 x 50	1	3
2	13 x 75	1	5
3	13 x 75	2	3
4	20 x 100	1	8
5	20 x 100	2	5
6	20 x 200	1	8
7	25 x 125	1	12
8	25 x 125	2	8
9	35 x 200	1	20

- .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.
- .5 Fasten nameplates securely in conspicuous place. Where nameplates cannot be mounted on cool surface, provide standoffs.
- .6 Identify equipment type and number and service of areas or zone of building served.
- .7 For each item of equipment which may be started automatically or remotely, add a red lamacoid plate, 2-1/2" x 9" (65 x 230 mm), reading: "WARNING. THIS EQUIPMENT IS AUTOMATICALLY CONTROLLED AND MAY START AT ANY TIME."

2.4 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.

2.5 PIPING SYSTEMS GOVERNED BY CODES

- .1 Identification:
 - .1 Natural gas: to CSA/CGA B149.1 and authority having jurisdiction.

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- .2 Propane gas: to CSA/CGA B149.1 and authority having jurisdiction.
- .3 Sprinklers: to NFPA 13.
- .4 Standpipe and hose systems: to NFPA 14.

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 Pictograms:
 - .1 Where required: Workplace Hazardous Materials Information System (WHMIS) regulations.
- .3 Legend:
 - .1 Block capitals to sizes and colours listed in CAN/CGSB 24.3.
- .4 Arrows showing direction of flow:
 - .1 Outside diameter of pipe or insulation less than 75 mm: 100 mm long x 50 mm high.
 - .2 Outside diameter of pipe or insulation 75 mm and greater: 150 mm long x 50 mm high.
 - .3 Use double-headed arrows where flow is reversible.
- .5 Extent of background colour marking:
 - .1 To full circumference of pipe or insulation.
 - .2 Length to accommodate pictogram, full length of legend and arrows.
- .6 Materials for background colour marking, legend, arrows:
 - .1 Pipes and tubing 20 mm and smaller: waterproof and heat-resistant pressure sensitive plastic marker tags.
 - .2 Other pipes: pressure sensitive plastic-coated cloth or vinyl with protective overcoating, waterproof contact adhesive undercoating, suitable for ambient of 100% RH and continuous operating temperature of 150 degrees C and intermittent temperature of 200 degrees C.
- .7 Colours and Legends:
 - .1 Where not listed, obtain direction from Consultant.
 - .2 Colours for legends, arrows: to following table:

Background colour:	Legend, arrows:
Yellow	BLACK
Green	WHITE
Red	WHITE

- .3 Background colour marking and legends for piping systems:

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Contents	Background colour marking	Legend
Raw water	Green	RAW WATER
River water	Green	RIVER WATER
Sea water	Green	SEA WATER
City water	Green	CITY WATER
Treated water	Green	TREATED WATER
Brine	Green	BRINE
Condenser water supply	Green	COND. WTR. SUPPLY
Condenser water return	Green	COND. WTR. RETURN
Chilled water supply	Green	CH. WTR. SUPPLY
Chilled water return	Green	CH. WTR. RETURN
Hot water heating supply	Yellow	HEATING SUPPLY
Hot water heating return	Yellow	HEATING RETURN
High temp HW Htg. supply	Yellow	HTHW HTG. SUPPLY++
High temp HW Htg. return	Yellow	HTHW HTG. RETURN++
Make-up water	Yellow	MAKE-UP WTR
Boiler feed water	Yellow	BLR. FEED WTR
Steam [] kPa	Yellow	[] kPa STEAM
Steam condensate (gravity)	Yellow	ST.COND.RET (GRAVITY)
Steam condensate (pumped)	Yellow	ST.COND.RET (PUMPED)
Safety valve vent	Yellow	STEAM VENT
Intermittent blow-off	Yellow	INT. BLOW-OFF
Continuous blow-off	Yellow	CONT. BLOW-OFF
Chilled drinking water	Green	CH. DRINK WTR
Drinking water return	Green	CH. DRINK WTR. CIRC
Domestic hot water supply	Green	DOM. HW SUPPLY
Dom. HWS recirculation	Green	DOM. HW CIRC
Domestic cold water supply	Green	DOM. CWS
Waste water	Green	WASTE WATER
Contaminated lab waste	Yellow	CONT. LAB WASTE
Acid waste	Yellow	ACID WASTE (add source)
Storm water	Green	STORM
Sanitary	Green	SAN
Plumbing vent	Green	SAN. VENT
Refrigeration suction	Yellow	REF. SUCTION
Refrigeration liquid	Yellow	REF. LIQUID
Refrigeration hot gas	Yellow	REF. HOT GAS
No. [] fuel oil suction	Yellow	# [] FUEL OIL
No. [] fuel oil return	Yellow	# [] FUEL OIL
Engine exhaust	Yellow	ENGINE EXHAUST
Lubricating oil	Yellow	LUB. OIL
Hydraulic oil	Yellow	HYDRAULIC OIL
Gasoline	Yellow	GASOLINE
Natural gas	to Codes	
Propane	to Codes	
Gas regulator vents	to Codes	

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Distilled water	Green	DISTILL. WTR
Demineralized water	Green	DEMIN. WATER
Chlorine	Yellow	CHLORINE
Nitrogen	Yellow	NITROGEN
Oxygen	Yellow	OXYGEN
Compressed air (<700kPa)	Green	COMP. AIR [] kPa
Compressed air (>700kPa)	Yellow	COMP. AIR [] kPa
Vacuum	Green	VACUUM
Fire protection water	Red	FIRE PROT. WTR
Sprinklers	Red	SPRINKLERS
Carbon dioxide	Red	CO2
Instrument air	Green	INSTRUMENT AIR

2.7 IDENTIFICATION DUCTWORK SYSTEMS

- .1 50 mm high stencilled letters and directional arrows 150 mm long x 50 mm high.
- .2 Colours: back, or co-ordinated with base colour to ensure strong contrast.

2.8 VALVES, CONTROLLERS

- .1 Brass tags with 12 mm 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.

2.9 CONTROLS COMPONENTS IDENTIFICATION

- .1 Identify systems, equipment, components, controls, sensors with system nameplates specified in this section.
- .2 Inscriptions to include function and (where appropriate) fail-safe position.

3. EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 TIMING

- .1 Provide identification only after painting specified Division 09 - Interior Painting has been completed.

3.3 INSTALLATION

- .1 Perform work in accordance with CAN/CGSB-24.3 except as specified otherwise.

- .2 Provide NRTL (UL, CSA, ETL) registration plates as required by respective agency.

3.4 NAMEPLATES

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

3.5 LOCATION OF IDENTIFICATION ON PIPING AND DUCTWORK SYSTEMS

- .1 On long straight runs in open areas in boiler rooms, equipment rooms, galleries, tunnels: at not more than 17 m 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, confined spaces, at entry and exit points, and at access openings.
- .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, and dampers. Where this is not possible, place identification as close as possible, preferably on upstream side.
- .9 Identification easily and accurately readable from usual operating areas and from access points.
 - .1 Position of identification 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.

3.6 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.

3.7 FIELD QUALITY CONTROL

- .1 Verification requirements in accordance with Division 01 33 29 - Sustainable Design Reporting, include:
 - .1 Materials and resources.
 - .2 Storage and collection of recyclables.
 - .3 Construction waste management.
 - .4 Resource reuse.
 - .5 Recycled content.
 - .6 Local/regional materials.
 - .7 Certified wood.
 - .8 Low-emitting materials.

3.8 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.

END OF SECTION

1. GENERAL

1.1 SUMMARY

- .1 TAB is used throughout this Section to describe the process, methods and requirements of testing, adjusting and balancing for HVAC.
- .2 TAB means to test, adjust and balance to perform in accordance with requirements of Contract Documents and to do other work as specified in this section.

1.2 QUALIFICATIONS OF TAB PERSONNEL

- .1 Submit names of personnel to perform TAB to Consultant within 90 days of award of contract.
- .2 Provide documentation confirming qualifications, successful experience.
- .3 TAB: performed in accordance with the requirements of standard under which TAB Firm's qualifications are approved:
 - .1 Associated Air Balance Council, (AABC) National Standards for Total System Balance, MN-1-2002.
 - .2 National Environmental Balancing Bureau (NEBB) TABES, Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems-1998.
 - .3 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), HVAC TAB HVAC Systems - Testing, Adjusting and Balancing-2002.
- .4 Recommendations and suggested practices contained in the TAB Standard: mandatory.
- .5 Use TAB Standard provisions, including checklists, and report forms to satisfy Contract requirements.
- .6 Use TAB Standard for TAB, including qualifications for TAB Firm and Specialist and calibration of TAB instruments.
- .7 Where instrument manufacturer calibration recommendations are more stringent than those listed in TAB Standard, use manufacturer's recommendations.
- .8 TAB Standard quality assurance provisions such as performance guarantees form part of this contract.
 - .1 For systems or system components not covered in TAB Standard, use TAB procedures developed by TAB Specialist.
 - .2 Where new procedures, and requirements, are applicable to Contract requirements have been published or adopted by body responsible for TAB Standard used (AABC, NEBB, or TABB), requirements and recommendations contained in these procedures and requirements are mandatory.

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 and low loads using actual or simulated loads
- .2 Adjust and regulate equipment and systems to meet specified performance requirements and to achieve specified interaction with other related systems under normal and emergency loads and operating conditions.
- .3 Balance systems and equipment to regulate flow rates to match load requirements over full operating ranges.

1.4 EXCEPTIONS

- .1 TAB of systems and equipment regulated by codes, standards 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 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.

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 other aspects of design and installation pertinent to success of TAB.
- .2 Review specified standards and report to Consultant in writing proposed procedures which vary from standard.
- .3 During construction, co-ordinate location and installation of TAB devices, equipment, accessories, measurement ports and fittings.

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 Division 23.

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 7 days prior to start of TAB.
- .2 Start TAB when building is essentially completed, including:
- .3 Installation of ceilings, doors, windows, other construction affecting TAB.
- .4 Application of weatherstripping, sealing, and caulking.

- .5 Pressure, leakage, other tests specified elsewhere Division 23.
- .6 Provisions for TAB installed and operational.
- .7 Start-up, verification for proper, normal and safe operation of 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 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.

1.10 APPLICATION TOLERANCES

- .1 Do TAB to following tolerances of design values:
 - .1 Laboratory HVAC systems: plus 10 %, minus 0 %.
 - .2 Other HVAC systems: plus 5 %, minus 5 %.
 - .3 Hydronic systems: plus or minus 10 %.

1.11 ACCURACY TOLERANCES

- .1 Measured values accurate to within plus or minus 2 % of actual values.

1.12 INSTRUMENTS

- .1 Prior to TAB, submit to Consultant list of instruments 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 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submit, prior to commencement of TAB:
- .2 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 in accordance with referenced standard.
- .2 TAB report to show results in units matching drawings and to include:
 - .1 Project record drawings.
 - .2 System schematics.
- .3 Submit 2 copies of TAB Report to Consultant for verification and approval, in in D-ring binders, complete with index tabs if hard copies are requested.

1.16 VERIFICATION

- .1 Reported results subject to verification by Consultant.
- .2 Provide personnel and instrumentation to verify up to 30 % of reported results.
- .3 Number and location of verified results as directed by Consultant.
- .4 Pay costs to repeat TAB as required to satisfaction of Consultant.

1.17 SETTINGS

- .1 After TAB is completed to satisfaction Consultant, replace drive guards, close access doors, lock devices in set positions, ensure sensors are at required settings.
- .2 Permanently mark settings to allow restoration at any time during life of facility. Do not eradicate or cover markings.

1.18 COMPLETION OF TAB

- .1 TAB considered complete when final TAB Report received and approved by Consultant.

1.19 AIR SYSTEMS

- .1 Standard: TAB to most stringent of this section or TAB standards of AABC NEBB, SMACNA, or ASHRAE.
- .2 Do TAB of systems, equipment, components, controls specified Division 23

- .3 Qualifications: personnel performing TAB current member in good standing of AABC or NEBB.
- .4 Quality assurance: perform TAB under direction of supervisor qualified by AABC or NEBB.
- .5 Measurements: to include 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 as appropriate:
 - .1 Inlet and outlet of dampers, filter, coil, humidifier, fan, other equipment causing changes in conditions.
 - .2 At controllers, controlled device.
- .7 Locations of systems measurements to include as appropriate: main ducts, main branch, sub-branch, run-out (or grille, register or diffuser).

1.20 OTHER TAB REQUIREMENTS

- .1 General requirements applicable to 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.
- .2 Zone pressure differences:
 - .1 Adjust HVAC systems, equipment, controls to establish specified air pressure differentials, with systems in every possible combinations of normal operating modes.

1.21 POST-OCCUPANCY TAB

- .1 Measure DBT, WBT (or %RH), air velocity, air flow patterns, NC levels, in occupied zone of sound sensitive areas such as studios, offices, and broadcasting areas.
- .2 Emergency evacuation: participate in full scale emergency evacuation exercises. Repeat smoke management tests at this time.
- .3 Participate in systems checks twice during Warranty Period - #1 approximately 3 months after acceptance and #2 within 1 month of termination of Warranty Period.

2. PRODUCTS

2.1 NOT USED

- .1 Not used.

3. EXECUTION

3.1 NOT USED

.1 Not used.

END OF SECTION

1. GENERAL

1.1 SUMMARY

- .1 Section Includes:
 - .1 Materials and methods for pressure testing ducts over 5 m in length, forming part of a supply, return or exhaust ductwork system directly or indirectly connected to air handling equipment.
- .2 Related Requirements
 - .1 Section 23 01 01.
 - .2 Section 23 31 00.
 - .3 Section 23 33 00.

1.2 REFERENCE STANDARDS

- .1 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Safety Data Sheets (SDS).
- .2 Sheet Metal and Air Conditioning Contractor's National Association (SMACNA)
 - .1 SMACNA HVAC Air Duct Leakage Test Manual, 1985.

1.3 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Make submittals in accordance with Division 01 - Submittal Procedures.
- .2 Test Reports: submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties. Include pressure test information and results as follows:
 - .1 Submit proposed report form and test report format to Consultant for approval at least three months before proposed date of first series of tests. Do not start tests until approval received in writing from Consultant.
 - .2 Prepare report of results and submit to Consultant within 24 hours of completion of tests. Include:
 - .1 Schematic of entire system.
 - .2 Schematic of section under test showing test site.
 - .3 Required and achieved static pressures.
 - .4 Orifice differential pressure at test sites.
 - .5 Permissible and actual leakage flow rate for test sites.
 - .6 Witnessed certification of results.
 - .3 Include test reports in final TAB report.
 - .4 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

- .5 Instructions: submit manufacturer's installation instructions.

1.4 QUALITY ASSURANCE

- .1 Pre-Installation Meetings:
 - .1 Verify project requirements.
 - .2 Review installation and substrate conditions.
 - .3 Co-ordination with other building subtrades.
 - .4 Review manufacturer's installation instructions and warranty requirements.
- .2 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Division 01 - Health and Safety Requirements.

2. PRODUCTS

2.1 TEST INSTRUMENTS

- .1 Test apparatus to include:
 - .1 Fan capable of producing required static pressure.
 - .2 Duct section with calibrated orifice plate mounted and accurately located pressure taps.
 - .3 Flow measuring instrument compatible with the orifice plate.
 - .4 Calibration curves for orifice plates used.
 - .5 Flexible duct for connecting to ductwork under test.
 - .6 Smoke bombs for visual inspections.
- .2 Test apparatus: accurate to within +/- 3 % of flow rate and pressure.
- .3 Submit details of test instruments to be used to Consultant at least three months before anticipated start date.
- .4 Test instruments: calibrated and certificate of calibration deposited with Consultant no more than 28 days before start of tests.
- .5 Re-calibrated every six months thereafter.

2.2 EQUIPMENT LEAKAGE TOLERANCES

- .1 Equipment and system components such as VAV boxes, duct heating leakage: 2 %.

3. EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 TEST PROCEDURES

- .1 Ensure maximum lengths of ducts to be tested consistent with capacity of test equipment.
- .2 Section of duct to be test will be selected at random by the Consultant and will include:
 - .1 At least five transverse joints
 - .2 Typical seams
 - .3 An access door
 - .4 At least two typical branch connections
 - .5 At least one elbow.
- .3 Leakage exceeding the allotted amount for the pressure class or the allotted amount for the section of duct whichever is applicable will be deemed failing the test.
- .4 Repeat tests until specified pressures are attained. Bear costs for repairs and repetition to tests.
- .5 Base partial system leakage calculations on SMACNA HVAC Air Duct Leakage Test Manual.
- .6 Follow the outlines and classifications in the SMACNA HVAC Air Duct Leakage Test Manual for leakage test procedures.
- .7 Seal leaks that can be heard or felt, regardless of their contribution to total leakage.
- .8 Ensure tests and repairs are completed and accepted prior to concealment of ductwork.

3.3 SITE TOLERANCES

- .1 System leakage tolerances specified are stated as percentage of total flow rate handled by system. Pro-rate specified system leakage tolerances. Leakage for sections of duct systems: not to exceed total allowable leakage.
- .2 Evaluation of test results to use surface area of duct and pressure in duct as basic parameters.

3.4 TESTING

- .1 Test ducts before installation of insulation or other forms of concealment.
- .2 Test after seals have cured.
- .3 Test when ambient temperature will not affect effectiveness of seals, and gaskets.

- .4 Isolate flexible connections to VAV boxes and other ductwork components that cannot be subjected to test pressure

3.5 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.

END OF SECTION

1. GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Refer to Section 23 01 01.
- .2 Refer to Section 23 31 00.
- .3 Refer to Section 23 32 48.
- .4 Refer to Section 23 33 53.

1.1 REFERENCE STANDARDS

- .1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - .1 ANSI/ASHRAE/IESNA 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings.
- .2 ASTM International (ASTM)
 - .1 ASTM B209M, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric).
 - .2 ASTM C335, Standard Test Method for Steady State Heat Transfer Properties of Pipe Insulation.
 - .3 ASTM C411, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.
 - .4 ASTM C449/C449M, Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.
 - .5 ASTM C547, Standard Specification for Mineral Fiber Pipe Insulation.
 - .6 ASTM C553, Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
 - .7 ASTM C612, Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
 - .8 ASTM C795, Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
 - .9 ASTM C921, Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
- .3 Canadian General Standards Board (CGSB)
 - .1 CGSB 51-GP-52, Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
- .4 Thermal Insulation Association of Canada (TIAC): National Insulation Standards.
- .5 Underwriters Laboratories of Canada (ULC)
 - .1 CAN/ULC-S102, Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.
 - .2 CAN/ULC-S701, Standard for Thermal Insulation, Polystyrene, Boards and Pipe Covering.

1.2 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" - means "not concealed" as previously defined.
 - .3 Insulation systems - insulation material, fasteners, jackets, and other accessories.
- .2 TIAC Codes:
 - .1 CRD: Code Round Ductwork,
 - .2 CRF: Code Rectangular Finish.

1.3 SHOP DRAWING SUBMITTALS

- .1 Provide submittals in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Provide manufacturer's printed product literature and datasheets for duct insulation, and include product characteristics, performance criteria, physical size, finish and limitations.
 - .1 Description of equipment giving manufacturer's name, type, model, year and capacity.
 - .2 Details of operation, servicing and maintenance.
 - .3 Recommended spare parts list.
- .3 Samples:
 - .1 Submit for approval: complete assembly of each type of insulation system, insulation, coating, and adhesive proposed.
 - .2 Mount sample on 12 mm plywood board.
 - .3 Affix typewritten label beneath sample indicating service.
- .4 Manufacturers' Instructions:
 - .1 Provide manufacture's written duct insulation jointing recommendations and special handling criteria, installation sequence, cleaning procedures.

1.4 QUALITY ASSURANCE

- .1 Qualifications:
 - .1 Installer: specialist in performing work of this section and have at least 3 years successful experience in this size and type of project, member of TIAC.

1.5 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:

- .1 Store products off ground, indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
- .2 Store and protect products from nicks, scratches, blemishes, vermin, theft and vandalism.
- .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.

2. PRODUCTS

2.1 FIRE AND SMOKE RATING

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

2.2 INSULATION

- .1 Mineral fibre: as specified includes glass fibre, rock wool, slag wool.
- .2 Thermal conductivity ("k" factor) not to exceed specified values at 24 degrees C mean temperature when tested in accordance with ASTM C335.
- .3 TIAC Code C-1: Rigid mineral fibre board to ASTM C612, with or without factory applied vapour retarder jacket to CGSB 51-GP-52Ma (as scheduled in PART 3 of this Section).
- .4 TIAC Code C-2: Mineral fibre blanket to ASTM C553 faced with or without factory applied vapour retarder jacket to CGSB 51-GP-52Ma (as scheduled in PART 3 of this section).
 - .1 Mineral fibre: to ASTM C553.
 - .2 Jacket: to CGSB 51-GP-52Ma.
 - .3 Maximum "k" factor: to ASTM C553.

2.3 FIRE PROTECTION DUCT WRAP

- .1 Provide 3M Fire Master Duct Wrap consisting of a 38 mm (1-1/2") thick non-combustible, flexible fireproof blanket, fully encapsulated in a foil scrim and supplied in roll form. The wrap material shall be applied directly onto the installed ductwork Guide No. 40 U21, 'Fire Resistant Ducts', as tested to ISO Standard 6944. Royal Quickstop and CL4 Fire Protection Thermal Insulation Quickwrap also acceptable.
 - .1 Color: White blanket, aluminum foil encapsulated.
 - .2 Weight: 0.9 psf (4.38 kg/m²).
 - .3 Density: 6 pcf nominal.

- .4 Thermal Conductivity (k-value) at 500 Degrees F (260 Degrees C) (ASTM C411, ASTM C518): 0.48 Btu/(ft² × h × F) (0.07 W/(m × K)).
- .5 R-Value per ASTM C 518 at ambient (77 F/ 25 C): at least 6.3 (F-ft²-hr / Btu)
- .6 Service range up to 2000°F (1093°C)
- .7 Fire Resistance: For use in 3 hour fire resistant systems.
- .8 Product complies with ASTM E 2336 test standard.
- .9 Product complies with ISO 6944 test standard.
- .10 Through-penetration per ASTM E 814 (UL 1479)
- .11 Non-combustible per ASTM E 136
- .2 Accessories
 - .1 Tape:
 - .1 High performance filament tape, 3M No. 898 1 inch (25mm) wide.
 - .2 FSK Facing Tape with aluminum foil, fiberglass scrim, kraft paper backing: nominal 3 inches (76mm) or 4 inches (102mm) wide (for sealing cut blanket edges and seams), 3M No. 3320.
 - .2 Banding Material: Stainless or carbon steel banding: 1/2 inch (13mm) wide X 0.015 inch (0.4mm) thick, as stated in duct wrap Design Listing.
 - .3 Insulation pins and clips:
 - .1 Copper-coated steel pins, 12 gauge with a minimum length of 4 inches (102mm) with square galvanized steel speed clips: 2.5 inch (64mm).
 - .2 12 gauge insulated cup head steel pins.
 - .4 Through-penetration firestop materials:
 - .1 Packing materials: Pieces of 3M Fire Barrier Duct Wrap, or 4 pcf mineral wool.
 - .2 Sealants: 3M Fire Barrier: 1000 NS non-slump silicone sealant, 1003 SL self-leveling silicone sealant, 2000+ premium non-slump silicone sealant, or CP 25WB+ premium intumescent latex caulk, as stated in firestop Design Listing.

2.4 JACKETS

- .1 Canvas:
 - .1 220 gm/m² cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.
- .2 Lagging adhesive: compatible with insulation.
 - .1 Maximum VOC limit 250 g/L to SCAQMD Rule 1168.
- .3 PVC:
 - .1 To ASTM D1785, CAN S102, and CGSB 51-GP-53M
 - .2 Thickness 0.8mm (30 mil)

- .3 Finish: white gloss
- .4 Flame spread/smoke developed ratings: 25/50 maximum.
- .5 UV-resistant
- .6 Minimum 50mm overlap with weather-sealed joints and expansion joints every 7.5m for outdoor applications.
- .4 Aluminum:
 - .1 To ASTM B209 with and without moisture barrier as scheduled in PART 3 of this section.
 - .2 Thickness: 0.50 mm sheet.
 - .3 Finish: Smooth, Stucco embossed or Corrugated.
 - .4 Jacket banding and mechanical seals: 19 mm wide, 0.5 mm thick stainless steel.
- .5 Stainless steel:
 - .1 Type: 316
 - .2 Thickness: 0.50 mm sheet.
 - .3 Finish: Smooth, Stucco embossed or Corrugated.
 - .4 Jacket banding and mechanical seals: 19 mm wide, 0.5 mm thick stainless steel.

2.5 ACCESSORIES

- .1 Vapour retarder lap adhesive:
 - .1 Water based, fire retardant type, compatible with insulation.
 - .1 Maximum VOC limit: to SCAQMD Rule 1168.
- .2 Indoor Vapour Retarder Finish:
 - .1 Vinyl emulsion type acrylic, compatible with insulation.
- .3 Insulating Cement: hydraulic setting on mineral wool, to ASTM C449.
- .4 ULC Listed Canvas Jacket:
 - .1 220 gm/m² cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.
- .5 Outdoor Vapour Retarder Mastic:
 - .1 Vinyl emulsion type acrylic, compatible with insulation.
 - .2 Reinforcing fabric: Fibrous glass, untreated 305 g/m².
- .6 Tape: self-adhesive, aluminum, reinforced, 75 mm wide minimum.
- .7 Contact adhesive: quick-setting
 - .1 Maximum VOC limit: to SCAQMD Rule 1168.
- .8 Canvas adhesive: washable.
 - .1 Maximum VOC limit: to SCAQMD Rule 1168.
- .9 Tie wire: 1.5mm stainless steel.

- .10 Banding: 19 mm wide, 0.5 mm thick stainless steel.
- .11 Facing: 25 mm stainless steel hexagonal wire mesh stitched on both faces of insulation.
- .12 Fasteners: 4 mm diameter pins with 35 mm diameter round or square clips, length to suit thickness of insulation.

3. EXECUTION

3.1 APPLICATION

- .1 Manufacturer's Instructions: comply with manufacturer's written recommendations, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 PRE-INSTALLATION REQUIREMENTS

- .1 Pressure test ductwork systems complete, witness and certify.
- .2 Ensure surfaces are clean, dry, free from foreign material.

3.3 INSTALLATION

- .1 Install in accordance with TIAC National Standards.
- .2 Apply materials in accordance with manufacturers instructions and as indicated.
- .3 Use 2 layers with staggered joints when required nominal thickness exceeds 75 mm.
- .4 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
 - .1 Ensure hangers and supports are outside vapour retarder jacket.
- .5 Hangers and supports in accordance with Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.
 - .1 Apply high compressive strength insulation where insulation may be compressed by weight of ductwork.
- .6 Fasteners: install at 300 mm on centre in horizontal and vertical directions, minimum 2 rows each side.
- .7 Provide PVC jacketing on exterior insulated ductwork.

3.4 DUCTWORK INSULATION SCHEDULE

- .1 Insulation types and thicknesses: conform to following table:

Service	Insulation Type	Thickness
Air Supply – Rectangular	Rigid	See below
Air Supply – Round	Flexible	See below

Exhaust Within 6' (1.5m) of Exterior – Rectangular				Rigid	See below (Exterior)
Exhaust Within 6' (1.5m) of Exterior – Round				Flexible	See below (Exterior)
Fresh Air Intake – Rectangular				Rigid	See below (Exterior)
Fresh Air Intake – Round				Flexible	See Below (Exterior)
Exhaust Air Plenums				Rigid	See below (Exterior)
Supply Runouts to Terminal Units – Rectangular				Rigid	See below
Supply Runouts to Terminal Units – Round				Flexible	See below
Duct Mounted Coils				Rigid	See below (unconditioned space)
Duct Location	Heating Only Ducts	Cooling Only Ducts	Return Ducts	Combined Heating & Cooling Ducts	
Exterior	R-12	R-12	R-12	R-12	
Ventilated Attic	R-6	R-1.9	R-3.5	R-6	
Unventilated Attic Above Insulated Ceiling	R-12	R-12	R-12	R-12	
Unventilated Attic with Roof Insulation	None	R-1.9	None	R-1.9	
Unconditioned Space	R-12	R-12	R-12	R-12	
Indirectly Conditioned Space	None	None	None	None	
Buried	R-6	None	None	R-3.5	

.2 Exposed round ducts 600 mm and larger, smaller sizes where subject to abuse:

.1 Use TIAC code C-1 insulation, scored to suit diameter of duct.

.1 Finishes: conform to following table:

	TIAC Code	
	Rectangular	Round
Indoor, concealed	none	none
Indoor, exposed within mechanical room	CRF/1	CRD/2
Indoor, exposed elsewhere	CRF/2	CRD/3
Outdoor, exposed to precipitation	CRF/3	CRD/4
Outdoor, elsewhere	CRF/4	CRD/5

3.5 FIRE PROTECTION DUCT WRAP

- .1 Do not installation until substrates have been properly prepared.
- .2 Conduct tests according to manufacturer's written recommendations to verify that substrates are free of oil, grease, rolling compounds, incompatible primers, loose mill scale, dirt and other foreign substances capable of impairing bond of firestopping.
- .3 Verify that items penetrating fire rated assemblies are securely attached, including sleeves, supports, hangers, and clips.
- .4 Verify that openings and adjacent areas are not obstructed by construction that would interfere with installation of firestopping, including ducts, piping, equipment, and other suspended construction.
- .5 Verify that environmental conditions are safe and suitable for installation of firestopping.
- .6 If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.
- .7 Prepare substrates in accordance with manufacturer's instructions and recommendations.
- .8 Install masking and temporary coverings as required to prevent contamination or defacement of adjacent surfaces due to firestopping installation.
- .9 Install in strict accordance with manufacturer's detailed installation instructions and procedures.
- .10 Install so that openings are completely filled and material is securely adhered.
- .11 Where firestopping surface will be exposed to view, finish to a smooth, uniform surface flush with adjacent surfaces.
- .12 After installation is complete, remove combustible forming materials and accessories that are not part of the listed system.
- .13 Repair or replace defective installations to comply with requirements.
- .14 At each through penetration, attach identification labels on both sides in location where label will be visible to anyone seeking to remove penetrating items or firestopping.

- .15 Clean firestop materials off surfaces adjacent to openings as work progresses, using methods and cleaning materials approved in writing by firestop system manufacturer and which will not damage the surfaces being cleaned.
- .16 Notify authority having jurisdiction when firestopping installation is ready for inspection; obtain advance approval of anticipated inspection dates and phasing, if any, required to allow subsequent construction to proceed.
- .17 Do not cover firestopping with other construction until approval of authority having jurisdiction has been received.
- .18 Kitchen Exhaust Grease Ducts to NFPA 96
 - .1 Install fire resistive duct wrap insulation in direct contact with ductwork to Manufacturer's instructions and referenced standards, to applicable Omega Point Laboratories design numbers, including listed penetration firestop system. For kitchen exhaust grease ducts, regardless of fire rating, provide two layers of 3M Fire Barrier Duct Wrap 615+ per layer with 3 inch (76mm) overlaps.
 - .2 Fire resistive duct wrap insulation to be continuous through wall or floor penetrations. Minimum 0.5 inch (13mm), maximum 4.5 inch (114mm) clearance permitted between outer layer of duct wrap insulation and edge of opening. Fill annular space between edge of opening and wrapped duct with pieces of 3M duct wrap insulation or mineral wool insulation firmly packed into opening. Compress to percentage stated and minimum depth stated in firestop listing. Recess packing material below surface on both sides of walls or top side only for floors to depth stated in firestop listing. Seal over packing material using 3M firestop sealant to depth stated in firestop listing, flush with top side of floor and both sides of wall surfaces.

3.6 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.

END OF SECTION

1. GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Refer to Section 23 01 01.

1.1 REFERENCE STANDARDS

- .1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - .1 ANSI/ASHRAE 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings.
- .2 ASTM International (ASTM)
 - .1 ASTM C335-05ae1, Standard Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation.
 - .2 ASTM C449/C449M-07, Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.
 - .3 ASTM C533-07, Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
 - .4 ASTM C547-07, Standard Specification for Mineral Fiber Pipe Insulation.
 - .5 ASTM C553-02, Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
 - .6 ASTM C612-04e1, Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
 - .7 ASTM C795-03, Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
 - .8 ASTM C921-03a, Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
- .3 Canadian General Standards Board (CGSB)
 - .1 CGSB 51-GP-52MA-89, Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
 - .2 CAN/CGSB 51.53-95, Poly (Vinyl Chloride) Jacketing Sheet, for Insulated Pipes, Vessels and Round Ducts.
- .4 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Safety Data Sheets (SDS).
- .5 South Coast Air Quality Management District (SCAQMD), California State
 - .1 SCAQMD Rule 1168-A2005, Adhesive and Sealant Applications.
- .6 Thermal Insulation Association of Canada (TIAC)
 - .1 National Insulation Standards 2005.
- .7 Underwriters Laboratories of Canada (ULC)
 - .1 CAN/ULC-S102-07, Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.

1.2 SHOP DRAWING SUBMITTALS

- .1 Provide submittals in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Provide manufacturer's printed product literature and datasheets for insulation and adhesives, include product characteristics, performance criteria, physical size, finish and limitations.
 - .2 Provide two copies WHMIS SDS - Safety Data Sheets in accordance with Division 01 - Health and Safety Requirements.
- .3 Samples:
 - .1 Provide for review: complete assembly of each type of insulation system, insulation, coating, and adhesive proposed.
 - .1 Mount sample on 12 mm plywood board.
 - .2 Affix typewritten label beneath sample indicating service.
- .4 Manufacturer's Instructions:
 - .1 Include procedures to be used and installation standards to be achieved.
- .5 Qualifications:
 - .1 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, member of TIAC.

1.3 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store products off ground, indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect products from nicks, scratches, blemishes, vermin, theft and vandalism.
 - .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.

2. PRODUCTS

2.1 FIRE AND SMOKE RATING

- .1 Fire and smoke ratings to CAN/ULC-S102:

- .1 Maximum flame spread rating: 25.
- .2 Maximum smoke developed rating: 50.

2.2 INSULATION

- .1 Mineral fibre: includes glass fibre, rock wool, slag wool.
- .2 Thermal conductivity ("k" factor) not to exceed specified values at 24 degrees C mean temperature when tested in accordance with ASTM C335.
- .3 TIAC Code A-1: rigid moulded mineral fibre without factory applied vapour retarder jacket.
 - .1 Mineral fibre: ASTM C547.
 - .2 Maximum "k" factor: ASTM C547.
- .4 TIAC Code A-3: rigid moulded mineral fibre with factory applied vapour retarder jacket.
 - .1 Mineral fibre: ASTM C547.
 - .2 Jacket: to CGSB 51-GP-52MA.
 - .3 Maximum "k" factor: ASTM C547.
- .5 TIAC Code C-1: rigid mineral fibre board, unfaced.
 - .1 Mineral fibre: ASTM C612.
 - .2 Maximum "k" factor: ASTM C612.
- .6 TIAC Code C-4: rigid mineral fibre board faced with factory applied vapour retarder jacket.
 - .1 Mineral fibre: ASTM C612.
 - .2 Jacket: to CGSB 51-GP-52MA.
 - .3 Maximum "k" factor: ASTM C612.
- .7 TIAC Code C-2: mineral fibre blanket unfaced or faced with factory applied vapour retarder jacket (as scheduled in PART 3 of this section).
 - .1 Mineral fibre: ASTM C553.
 - .2 Jacket: to CGSB 51-GP-52MA.
 - .3 Maximum "k" factor: ASTM C553.
- .8 TIAC Code A.6: flexible unicellular tubular elastomer.
 - .1 Insulation: with vapour retarder jacket.
 - .2 Jacket: to CGSB 51-GP-52MA.
 - .3 Maximum "k" factor.
 - .4 Certified by manufacturer free of potential stress corrosion cracking corrodents.
- .9 TIAC Code A-2: rigid moulded calcium silicate in sections and blocks, and with special shapes to suit project requirements.
 - .1 Insulation: ASTM C533.
 - .2 Maximum "k" factor: ASTM C533.

- .3 Design to permit periodic removal and re-installation.

2.3 CEMENT

- .1 Thermal insulating and finish
 - .1 To: ASTM C449/C449M.
 - .2 Hydraulic setting or air drying on mineral wool, to ASTM C449.

2.4 JACKETS

- .1 Polyvinyl Chloride (PVC):
 - .1 One-piece moulded type and sheet to CAN/CGSB 51.53 with pre-formed shapes as required.
 - .2 Colours: to match adjacent finish paint for existing construction or selected by Consultant for new construction.
 - .3 Minimum service temperatures: -20 degrees C.
 - .4 Maximum service temperature: 65 degrees C.
 - .5 Moisture vapour transmission: 0.02 perm.
 - .6 Thickness: 0.5 mm.
 - .7 Fastenings:
 - .1 Use solvent weld adhesive compatible with insulation to seal laps and joints.
 - .2 Tacks.
 - .3 Pressure sensitive vinyl tape of matching colour.
 - .8 Special requirements:
 - .1 Outdoor: UV rated material at least 0.5 mm thick.
 - .9 Covering adhesive: compatible with insulation.
 - .1 Maximum VOC limit to SCAQMD Rule 1168.
- .2 ABS Plastic:
 - .1 One-piece moulded type and sheet with pre-formed shapes as required.
 - .2 Colours: to match adjacent finish paint for existing construction or selected by Consultant for new construction.
 - .3 Minimum service temperatures: -40 degrees C.
 - .4 Maximum service temperature: 82 degrees C.
 - .5 Moisture vapour transmission: 0.012 perm.
 - .6 Thickness: 0.75 mm.
 - .7 Fastenings:
 - .1 Solvent weld adhesive compatible with insulation to seal laps and joints
 - .2 Tacks.
 - .3 Pressure sensitive vinyl tape of matching colour.
 - .8 Locations:
 - .1 For outdoor use ONLY.

- .3 Canvas:
 - .1 220 gm/m² cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.
 - .2 Lagging adhesive: compatible with insulation.
 - .1 Maximum VOC limit to SCAQMD Rule 1168.
- .4 Aluminum:
 - .1 To ASTM B209.
 - .2 Thickness: 0.5 mm sheet.
 - .3 Finish: smooth, stucco embossed or corrugated (match existing where applicable).
 - .4 Joining: longitudinal and circumferential slip joints with 50 mm laps.
 - .5 Fittings: 0.5 mm thick die-shaped fitting covers with factory-attached protective liner.
 - .6 Metal jacket banding and mechanical seals: stainless steel, 19 mm wide, 0.5 mm thick at 300 mm spacing.
- .5 Stainless steel:
 - .1 Type: 316.
 - .2 Thickness: 0.25 mm.
 - .3 Finish: smooth, stucco embossed or corrugated (match existing where applicable).
 - .4 Joining: longitudinal and circumferential slip joints with 50 mm laps.
 - .5 Fittings: 0.5 mm thick die-shaped fitting covers with factory-attached protective liner.
 - .6 Metal jacket banding and mechanical seals: stainless steel, 19 mm wide, 0.5 mm thick at 300 mm spacing.

2.5 INSULATION SECUREMENTS

- .1 Tape: self-adhesive, aluminum, reinforced, 50 mm wide minimum.
- .2 Contact adhesive: quick setting.
 - .1 Maximum VOC limit to SCAQMD Rule 1168.
- .3 Canvas adhesive: washable.
 - .1 Maximum VOC limit to SCAQMD Rule 1168.
- .4 Tie wire: 1.5 mm diameter stainless steel.
- .5 Bands: Stainless steel, 19 mm wide, 0.5 mm thick.
- .6 Facing: 25 mm galvanized steel hexagonal wire mesh on both faces of insulation.
Fasteners: 4mm diameter pins with 35 mm diameter round or square clips.
Length of pin to suit thickness of insulation.

2.6 VAPOUR RETARDER LAP ADHESIVE

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

- .1 Maximum VOC limit to SCAQMD Rule 1168.

2.7 INDOOR VAPOUR RETARDER FINISH

- .1 Vinyl emulsion type acrylic, compatible with insulation.

2.8 OUTDOOR VAPOUR RETARDER MASTIC

- .1 Vinyl emulsion type acrylic, compatible with insulation.
- .2 Reinforcing fabric: Fibrous glass, untreated 305 g/m².

3. EXECUTION

3.1 APPLICATION

- .1 Manufacturer's Instructions: comply with manufacturer's written recommendations, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 PRE- INSTALLATION REQUIREMENTS

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

3.3 INSTALLATION

- .1 Install in accordance with TIAC National Standards
 - .1 Hot equipment: To TIAC code 1503-H.
 - .2 Cold equipment: to TIAC code 1503-C.
- .2 Elastomeric Insulation: to remain dry. Overlaps to manufacturer's instructions. Joints tight and sealed properly.
- .3 Provide vapour retarder as recommended by manufacturer.
- .4 Apply materials in accordance with insulation and equipment manufacturer's instructions and this specification.
- .5 Use two layers with staggered joints when required nominal wall thickness exceeds 75 mm.
- .6 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
 - .1 Hangers, supports outside vapour retarder jacket.
- .7 Supports, Hangers:
 - .1 Apply high compressive strength insulation, suitable for service, at oversized saddles and shoes where insulation saddles have not been provided.

3.4 REMOVABLE, PRE-FABRICATED, INSULATION AND ENCLOSURES

- .1 Application: At expansion joints, valves, primary flow measuring elements, flanges and unions at equipment.
- .2 Installation to permit movement of expansion joint and to permit periodic removal and replacement without damage to adjacent insulation.

3.5 FIRE SUPPRESSION EQUIPMENT INSULATION SCHEDULES

- .1 Includes valves, valve bonnets, strainers, flanges and fittings unless otherwise specified.
- .2 Hot Equipment:
 - .1 TIAC code A-1 or C-1 with mechanical fastenings or wire or bands and 13 mm cement reinforced with one layer of reinforcing mesh.
 - .2 TIAC code C-2 unfaced with wire or bands and 13 mm cement precede by one layer of reinforcing mesh.
 - .3 Thicknesses:

	Unfired Domestic hot water storage tanks: R12.5 equivalent thickness.
	Heat exchangers to 93°C: 50 mm
	Steam condensate receivers to 121°C: 75 mm
	Deaerator-feedwater heaters to 121°C: 75 mm

- .3 Breechings, engine exhausts and mufflers:
 - .1 TIAC code A-2 with 25 mm air gap, mechanical fastenings or wire or bands and 13 mm cement reinforced with one layer of reinforcing mesh.
- .4 Cold equipment:
 - .1 TIAC A-3 or C-4 with mechanical fastenings or wire or bands and 13 mm cement reinforced with one layer of reinforcing mesh.
 - .2 TIAC C-2 faced with vapour retardant jacket and with wire or bands and 13 mm cement preceded by one layer of reinforcing mesh.
 - .3 TIAC A-6 or C-4 with mechanical fastenings or wire or bands.
- .5 Finishes:
 - .1 Engine exhaust piping and muffler: To TIAC code CRF-4.
 - .2 Equipment in mechanical rooms: TIAC code CEF/1 with PVC jacket.
 - .3 Equipment elsewhere: TIAC code CEF/2 with 13 mm cement jacket.

3.6 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.

END OF SECTION

1. GENERAL

1.1 SUMMARY

- .1 Section Includes:
 - .1 Thermal insulation for piping and piping accessories in commercial type applications.
- .2 Related Requirements
 - .1 Section 23 01 01.

1.2 REFERENCE STANDARDS

- .1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - .1 ASHRAE Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings (IESNA co-sponsored; ANSI approved; Continuous Maintenance Standard).
- .2 ASTM International (ASTM)
 - .1 ASTM B209M-04, Standard Specification for Aluminum and Aluminum Alloy Sheet.
 - .2 ASTM C335-04, Standard Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation.
 - .3 ASTM C411-04, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.
 - .4 ASTM C449/C449M-00, Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.
 - .5 ASTM C533-2004, Calcium Silicate Block and Pipe Thermal Insulation.
 - .6 ASTM C547-2003, Mineral Fiber Pipe Insulation.
 - .7 ASTM C795-03, Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
 - .8 ASTM C921-03a, Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
- .3 Canadian General Standards Board (CGSB)
 - .1 CGSB 51-GP-52Ma-89, Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
 - .2 CAN/CGSB-51.53-95, Poly (Vinyl Chloride) Jacketing Sheet, for Insulated Pipes, Vessels and Round Ducts
- .4 Department of Justice Canada (Jus)
 - .1 Canadian Environmental Assessment Act (CEAA), 1995, c. 37.
 - .2 Canadian Environmental Protection Act (CEPA), 1999, c. 33.
 - .3 Transportation of Dangerous Goods Act (TDGA), 1992, c. 34.
- .5 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Safety Data Sheets (SDS).

- .6 Manufacturer's Trade Associations
 - .1 Thermal Insulation Association of Canada (TIAC): National Insulation Standards (Revised 2004).
- .7 Underwriters' Laboratories of Canada (ULC)
 - .1 CAN/ULC-S102-03, Surface Burning Characteristics of Building Materials and Assemblies.
 - .2 CAN/ULC-S701-01, Thermal Insulation, Polystyrene, Boards and Pipe Covering.
 - .3 CAN/ULC-S702-1997, Thermal Insulation, Mineral Fibre, for Buildings
 - .4 CAN/ULC-S702.2-03, Thermal Insulation, Mineral Fibre, for Buildings, Part 2: Application Guidelines.

1.3 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 specified.
- .2 TIAC ss:
 - .1 CRF: Code Rectangular Finish.
 - .2 CPF: Code Piping Finish.

1.4 SHOP DRAWING SUBMITTALS

- .1 Submittals: in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Division 01 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.
 - .1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Safety Data Sheets (SDS) in accordance with Division 01 - Submittal Procedures.
- .3 Shop Drawings:
 - .1 Submit shop drawings in accordance with Division 01 - Submittal Procedures.
- .4 Samples:
 - .1 Submit samples in accordance with Division 01 - Submittal Procedures.
 - .2 Submit for approval: complete assembly of each type of insulation system, insulation, coating, and adhesive proposed. Mount sample on 12 mm plywood board. Affix label beneath sample indicating service.
- .5 Quality assurance submittals: submit following in accordance with Division 01 - Submittal Procedures.

- .1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .2 Instructions: submit manufacturer's installation instructions.

1.5 QUALITY ASSURANCE

- .1 Qualifications:
- .2 Installer: specialist in performing work of this Section and have at least 3 years successful experience in this size and type of project, member of TIAC.
- .3 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Division 01 - Health and Safety Requirements.

1.6 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store products off ground, indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect products from nicks, scratches, blemishes, vermin, theft and vandalism.
 - .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.

2. PRODUCTS

2.1 FIRE AND SMOKE RATING

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

2.2 INSULATION

- .1 Mineral fibre specified includes glass fibre, rock wool, slag wool.
- .2 Thermal conductivity ("k" factor) not to exceed specified values at 24 degrees C mean temperature when tested in accordance with ASTM C335.

- .3 TIAC Code A-1: rigid moulded mineral fibre without factory applied vapour retarder jacket.
 - .1 Mineral fibre: to CAN/ULC-S702 and ASTM C547.
 - .2 Maximum "k" factor: to CAN/ULC-S702.
- .4 TIAC Code A-3: rigid moulded mineral fibre with factory applied vapour retarder jacket.
 - .1 Mineral fibre: to CAN/ULC-S702 and ASTM C547.
 - .2 Jacket: to CGSB 51-GP-52Ma.
 - .3 Maximum "k" factor: to CAN/ULC-S702 and ASTM C547.
- .5 TIAC Code C-2: mineral fibre blanket faced with factory applied vapour retarder jacket (as scheduled in PART 3 of this section).
 - .1 Mineral fibre: to CAN/ULC-S702 and ASTM C547.
 - .2 Jacket: to CGSB 51-GP-52Ma.
 - .3 Maximum "k" factor: to CAN/ULC-S702 and ASTM C547.
- .6 TIAC Code A-6: flexible unicellular tubular elastomer.
 - .1 Insulation: with vapour retarder jacket.
 - .2 Jacket: to CGSB 51-GP-52Ma.
 - .3 Certified by manufacturer: free of chemicals with potential to cause stress corrosion cracking in steel and stainless steel.
- .7 TIAC Code A-2: rigid moulded calcium silicate in sections and blocks, and with special shapes to suit project requirements.
 - .1 Insulation: to ASTM C533.
 - .2 Design to permit periodic removal and re-installation.

2.3 INSULATION SECUREMENT

- .1 Tape: self-adhesive, aluminum, reinforced, 50 mm wide minimum.
- .2 Contact adhesive: quick setting.
- .3 Canvas adhesive: washable.
- .4 Tie wire: 1.5 mm diameter stainless steel.
- .5 Bands: stainless steel, 19 mm wide, 0.5 mm thick.

2.4 CEMENT

- .1 Thermal insulating and finishing cement:
 - .1 Hydraulic setting or air drying] on mineral wool, to ASTM C449/C449M.

2.5 VAPOUR RETARDER LAP ADHESIVE

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

2.6 INDOOR VAPOUR RETARDER FINISH

- .1 Vinyl emulsion type acrylic, compatible with insulation.

2.7 OUTDOOR VAPOUR RETARDER FINISH

- .1 Vinyl emulsion type acrylic, compatible with insulation.
- .2 Reinforcing fabric: fibrous glass, untreated 305 g/m².

2.8 JACKETS

- .1 Polyvinyl Chloride (PVC):
 - .1 One-piece moulded type and sheet to CAN/CGSB-51.53 with pre-formed shapes as required.
 - .2 Colours: to match adjacent finish paint for existing construction and by consultant for new construction.
 - .3 Minimum service temperatures: -20 degrees C.
 - .4 Maximum service temperature: 65 degrees C.
 - .5 Moisture vapour transmission: 0.02 perm.
 - .6 Thickness minimums: 0.5 mm (indoor), 0.76 mm (outdoor).
 - .7 Fastenings:
 - .1 Use solvent weld adhesive compatible with insulation to seal laps and joints.
 - .2 Tacks.
 - .3 Pressure sensitive vinyl tape of matching colour.
 - .8 Special requirements:
 - .1 Outdoor: UV rated material at least 0.5 mm thick.
- .2 ABS Plastic:
 - .1 One-piece moulded type and sheet with pre-formed shapes as required.
 - .2 Colours: to match adjacent finish paint for existing construction and by consultant for new construction.
 - .3 Minimum service temperatures: -40 degrees C.
 - .4 Maximum service temperature: 82 degrees C.
 - .5 Moisture vapour transmission: 0.012 perm.
 - .6 Thickness: 0.75 mm (indoor).
 - .7 Fastenings:
 - .1 Solvent weld adhesive compatible with insulation to seal laps and joints.
 - .2 Tacks.
 - .3 Pressure sensitive vinyl tape of matching colour.
 - .8 Locations:
 - .1 For outdoor use ONLY.

- .3 Canvas:
 - .1 220 gm/m² cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.
 - .2 Lagging adhesive: compatible with insulation.
- .4 Aluminum:
 - .1 To ASTM B209.
 - .2 Thickness: 0.5 mm sheet.
 - .3 Finish: smooth, stucco embossed or corrugated to match existing where applicable.
 - .4 Joining: longitudinal and circumferential slip joints with 50 mm laps.
 - .5 Fittings: 0.5 mm thick die-shaped fitting covers with factory-attached protective liner.
 - .6 Metal jacket banding and mechanical seals: stainless steel, 19 mm wide, 0.5 mm thick at 300 mm spacing.
- .5 Stainless steel:
 - .1 Type: 316.
 - .2 Thickness: 0.25 mm.
 - .3 Finish: smooth, stucco embossed or corrugated to match existing where applicable.
 - .4 Joining: longitudinal and circumferential slip joints with 50 mm laps.
 - .5 Fittings: 0.5 mm thick die-shaped fitting covers with factory-attached protective liner.
 - .6 Metal jacket banding and mechanical seals: stainless steel, 19 mm wide, 0.5 mm thick at 300 mm spacing.

2.9 WEATHERPROOF CAULKING FOR JACKETS INSTALLED OUTDOORS

- .1 Caulking to: Division 07 - Joint Sealants.

3. EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 PRE-INSTALLATION REQUIREMENT

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

3.3 INSTALLATION

- .1 Install in accordance with TIAC National Standards.

- .2 Apply materials in accordance with manufacturers instructions and this specification.
- .3 Use two layers with staggered joints when required nominal wall thickness exceeds 75 mm.
- .4 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
 - .1 Install hangers, supports 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.

3.4 REMOVABLE, PREFABRICATED, INSULATION AND ENCLOSURES

- .1 Application: at expansion joints, valves, primary flow measuring elements flanges and unions at equipment.
- .2 Design: to permit movement of expansion joint and to permit periodic removal and replacement without damage to adjacent insulation.
- .3 Insulation:
 - .1 Insulation, fastenings and finishes: same as system.
 - .2 Jacket: Aluminum.

3.5 INSTALLATION OF ELASTOMERIC INSULATION

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

3.6 PIPING INSULATION SCHEDULES

- .1 Includes valves, valve bonnets, strainers, flanges and fittings unless otherwise specified.
- .2 TIAC Code: A-1.
 - .1 Securements: tape at 300 mm on centre.
 - .2 Seals: lap seal adhesive, lagging adhesive.
 - .3 Installation: TIAC Code 1501-H.
- .3 TIAC Code: A-3.
 - .1 Securements: Tape at 300 mm on centre.
 - .2 Seals: VR lap seal adhesive, VR lagging adhesive.
 - .3 Installation: TIAC Code: 1501-C.
- .4 TIAC Code: A-6.
 - .1 Insulation securements: Tape at 300 mm on centre.
 - .2 Seals: lap seal adhesive, lagging adhesive.

- .3 Installation: TIAC Code: 1601-C.
- .5 TIAC Code: C-2 with vapour retarder jacket.
 - .1 Insulation securements: Tape at 300 mm on centre.
 - .2 Seals: lap seal adhesive, lagging adhesive.
 - .3 Installation: TIAC Code: 1501-C.
- .6 TIAC Code: A-2.
 - .1 Insulation securements: SS bands at 300mm on centre.
 - .2 Seals: lap seal adhesive, lagging adhesive.
 - .3 Installation: TIAC Code: 1501-H.
- .7 Thickness of insulation as listed in following table.
 - .1 Run outs to individual units and equipment not exceeding 4000 mm long.
 - .2 Do not insulate exposed runouts to plumbing fixtures, chrome plated piping, valves, fittings.

Media	Temp °C	TIAC Code	Pipe Size NPS				
			<1	1 to <1.5	1.5 to 4	4 to <8	8+
Steam	up to 120	A-1	65	65	65	75	75
Steam	121-175	A-1	75	100	113	113	113
Steam	176+	A-1	113	125	125	125	125
Condensate Return	60 – 93	A-1	38	38	50	50	50
Pumped Condensate return	up to 93	A-1	38	38	50	50	50
Boiler Feed Water		A-1	25	25	25	25	25
Hot Water Heating	60 - 93	A-1	38	38	50	50	50
Hot Water Heating	up to 59	A-1	25	25	38	38	38
Glycol Heating	60 - 93	A-1	38	38	50	50	50
Glycol Heating	up to 59	A-1	25	25	38	38	38
Domestic HWS	60 - 93	A-1	38	38	50	50	50
Chilled Water	4 - 16	A-3	13	13	25	25	25
Chilled Water or Glycol	below 4	A-3	13	25	25	25	38
Chilled Water Pump Casing		A-3	25	25	25	25	25
Refrigerated Drinking Water		A-3	25	25	25	25	25
Domestic CWS		A-3	25	25	25	25	25
Domestic CWS with vapour retarder		C-2	25	25	25	25	25
Refrigerant	4 - 13	A-6	25	25	25	25	25
Refrigerant	below 4	A-6	25	25	38	38	38
RWL and RWP		C-2	25	25	25	25	25
Cooling Coil cond. drain		C-2	25	25	25	25	25
Diesel generator exhaust system		A-2	38	65	65	75	90

- .8 Finishes:
 - .1 Exposed indoors: PVC jacket.
 - .2 Exposed in mechanical rooms: canvas or PVC jacket.
 - .3 Concealed, indoors: canvas on valves, fittings. No further finish.
 - .4 Use vapour retarder jacket on TIAC code A-3 insulation compatible with insulation.
 - .5 Outdoors: water-proof aluminum or SS jacket.
 - .6 Finish attachments: SS bands, at 150 mm on centre. Seals: closed.
 - .7 Installation: to appropriate TIAC code CRF/1 through CPF/5.

3.7 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

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

1.2 COMMISSIONING AGENT

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

1.3 DESCRIPTION OF WORK

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

1.4 RELATED DOCUMENTS

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

1.5 REFERENCES

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

1.6 SYSTEMS TO BE COMMISSIONED

- .1 Ventilation Systems
 - .1 Fans
 - .2 Variable Air Volume Boxes
 - .3 Silencers
 - .4 Grilles, Registers, and Diffusers
- .2 Domestic Water System
 - .1 Piping
 - .2 Backflow Preventer
- .3 Heating System
 - .1 Piping
 - .2 Control Valves
 - .3 Thermostats
 - .4 Controls
- .4 Hydronic System
 - .1 Radiant Heating
 - .2 Pumps
 - .3 Piping
 - .4 Control Valves
 - .5 Backflow Preventers
- .5 Fire and Smoke Dampers
- .6 Equipment Sound Control
 - .1 Acoustic Plenums
 - .2 Vibration Isolation
- .7 Testing, Adjusting and Balancing Work
- .8 Integrated Automation
- .9 Central Building Automation System,
 - .1 Controllers
 - .2 Field Devices
 - .3 Sequences
 - .4 Network
 - .5 Operator Workstation
 - .6 Operator Interface

2 PRODUCTS

2.1 COMMISSIONING AUTHORITY

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

2.2 SYSTEMS START-UP/VERIFICATION CHECKLISTS

- .1 Ventilation Systems
 - .1 Fans
 - .2 Variable Air Volume Boxes
 - .3 Silencers
 - .4 Grilles, Registers, and Diffusers
- .2 Domestic Water System
 - .1 Piping
 - .2 Backflow Preventer
- .3 Heating System
 - .1 Piping
 - .2 Control Valves
 - .3 Thermostats
 - .4 Controls
- .4 Hydronic System
 - .1 Radiant Heating
 - .2 Pumps
 - .3 Piping
 - .4 Control Valves
 - .5 Backflow Preventers

- .5 Fire and Smoke Dampers
- .6 Equipment Sound Control
 - .1 Acoustic Plenums
 - .2 Vibration Isolation
- .7 Testing, Adjusting and Balancing Work
- .8 Integrated Automation
- .9 Central Building Automation System,
 - .1 Controllers
 - .2 Field Devices
 - .3 Sequences
 - .4 Network
 - .5 Operator Workstation
 - .6 Operator Interface

2.3 FUNCTIONAL PERFORMANCE TEST CHECKLISTS

- .1 Ventilation Systems
 - .1 Fans
 - .2 Variable Air Volume Boxes
 - .3 Silencers
 - .4 Grilles, Registers, and Diffusers
- .2 Domestic Water System
 - .1 Piping
 - .2 Backflow Preventer
- .3 Heating System
 - .1 Piping
 - .2 Control Valves
 - .3 Thermostats
 - .4 Controls
- .4 Hydronic System
 - .1 Radiant Heating
 - .2 Pumps
 - .3 Piping
 - .4 Control Valves
 - .5 Backflow Preventers
- .5 Fire and Smoke Dampers

- .6 Equipment Sound Control
 - .1 Acoustic Plenums
 - .2 Vibration Isolation
- .7 Testing, Adjusting and Balancing Work
- .8 Integrated Automation
- .9 Central Building Automation System,
 - .1 Controllers
 - .2 Field Devices
 - .3 Sequences
 - .4 Network
 - .5 Operator Workstation
 - .6 Operator Interface

3 EXECUTION

3.1 COMMISSIONING CONSULTANT'S RESPONSIBILITIES

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

- .12 ensure all required O&M manuals, instructions and demonstrations are provided to the owner's designated operating staff.

3.2 MECHANICAL ENGINEER'S RESPONSIBILITIES

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

3.3 OWNER'S RESPONSIBILITIES

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

3.4 GENERAL CONTRACTOR'S RESPONSIBILITIES

- .1 The General Contractor has responsibility to ensure the overall completion of the work and shall.
 - .1 participate as required in the HVAC Systems Commissioning process,
 - .2 ensure the HVAC contractor performs all assigned commissioning responsibilities as specified in 3.5,
 - .3 ensure the testing, adjusting and balancing agency performs all assigned commissioning responsibilities as specified in 3.6,
 - .4 ensure the Division 25 sub-contractor performs all assigned commissioning responsibilities as specified in 3.7,
 - .5 ensure the Division 26 sub-contractor performs all assigned commissioning responsibilities as specified in 3.8,
 - .6 ensure the cooperation and participation in the commissioning process of all other sub-contractors as applicable.
- .2 The General Contractor shall assign a representative to the commissioning team, and submit the person's name to the commissioning agency, within one (1) month of the award of the contract. The representative shall have the authority to make decision on behalf of the general contractor as they relate to the organization and scheduling of HVAC commissioning. The representative shall facilitate communications among all contractors and suppliers and other commissioning team members and shall foster the necessary cooperative action. One specific responsibility shall be to attend commissioning meetings and ensure action items arising from them are attended to as required to allow the commissioning process to proceed on schedule.
- .3 In the event that any scheduled equipment or system start-ups or functional performance tests are terminated because the CC or the mechanical engineer

discover deficient or incomplete work, or due to the non-attendance of required contractor or supplier personnel, the contractor or sub-contractor responsible for the termination shall also be responsible for paying reasonable costs of time and travel expenses of any or all of the following representatives who were physically present for the purpose of witnessing the start-up or the FPT: the CC, the mechanical engineer, the electrical engineer, and the owner. The owner may provide a statement to the General Contractor identifying the specific activity that was terminated, the scheduled date, and a list of those in attendance, along with their reasonable time and travel expenses.

3.5 HVAC SUBCONTRACTOR'S RESPONSIBILITIES

- .1 The HVAC sub-contractor, and all the sub-contractors and suppliers within Division 23, shall cooperate with the commissioning consultant (CA), and other commissioning team members, to facilitate the successful completion of the commissioning process.
- .2 The contractor shall assign a representative to the commissioning team, and submit the person's name to the commissioning agency, within one (1) month of the award of the contract. The representative shall have the authority to make decisions on behalf of the mechanical contractor as they relate to the organization and scheduling of HVAC commissioning. The representative shall ensure communications between Division 23 contractors and supplies and all other commissioning team members and shall foster the necessary cooperative action. One specific responsibility shall be to attend commissioning meetings and ensure action items arising from them are attended to as required to allow the commissioning process to proceed on schedule.
- .3 The HVAC sub-contractor, and all mechanical sub-contractors and suppliers, shall cooperate with the Commissioning Agency in carrying out the HVAC commissioning process. In this context, the HVAC sub-contractor shall:
 - .1 include in their quotes the cost of participating in the commissioning process as specified herein.
 - .2 Ensure the Division 25 sub-contractor performs HVAC commissioning responsibilities as listed in 3.7.
 - .3 Provide instruction and demonstrations for the Owner's designated operating staff, in conjunction with the commissioning agency and mechanical engineer, and with the participation of qualified technicians from major equipment suppliers and the controls contractor.
 - .4 Include requirements for submittal data. O&M data, and training information in each purchase order or sub-contract written.
 - .5 Ensure cooperation and participation of specialty sub-contractors such as sheet metal, piping, refrigeration, and water treatment as applicable.
 - .6 Ensure participation of major equipment manufacturing in appropriate start-up, testing and training activities.
 - .7 Attend commissioning meetings scheduled by the CA.
 - .8 Notify the CA a minimum of two weeks in advance of scheduled

equipment and system start-ups, so that the CA may witness system verifications, and equipment and system start-ups.

- .9 Provide sufficient personnel to assist the CA as required during system verification and functional performance testing.
- .10 Prior to set-up, inspect, check and confirm the correct and complete installation of all equipment and systems for which system verification checklists are included in the commissioning plan. Document the results of all inspections and checks on the checklists and sign them. If deficient or incomplete work is discovered, ensure corrective action is taken and re-check until the results are satisfactory, and the system is ready for safe start-up.
- .11 Notify the CA a minimum of two weeks in advance of the time for start of the TAB work. Attend the initial TAB meeting for review of the TAB procedures.
- .12 Provide equipment and systems start-up resources as specified and required. If during an attempted equipment or system start-up, deficient or incomplete work is discovered that would preclude safe operation, the start-up shall be aborted until corrective action has been taken. Ensure such action is taken and verified before re-scheduling a new start-up. Those responsible for deficient or incomplete work will be responsible for costs in accordance with 3.4 in this Section.
- .13 Carry-out performance checks to ensure that all equipment and systems fully functional and ready for the CA to witness formal functional performance tests (FPTs).
- .14 Operate equipment and systems for FPTs in accordance with the commissioning plan and as directed by the commissioning agency. If improper functionality, incomplete work, or other deficiencies affecting system performance are discovered, the FPTs will be stopped by the CC. Those responsible for deficient or incomplete work will be responsible for costs in accordance with 3.4 in this Section. Ensure that all corrections necessary for full and complete system operation as specified are completed; then with the ATC contractor and other applicable sub-contractors, carry out functional performance checks to confirm correct operation before applying to the CA to re-schedule the FPTs for the system in question.
- .15 Prepare preliminary schedule for mechanical system orientation and inspections. O&M Manual submission, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up TAB, and task completion for use by the CA. Update schedule as appropriate throughout the construction period.
- .16 Attend initial O&M staff training session.
- .17 Conduct mechanical system orientation and inspection at the equipment placement completion stage.
- .18 Update drawings to as-built condition and review with the CA.
- .19 Gather O&M data on all equipment and assemble in binders as required

by the commissioning specification. Submit to CA prior to the completion of construction.

- .20 Participate in, and schedule vendors and contractors to participate in the O&M staff training sessions as set up by the CA.
- .21 Provide written notification to the general contractor (or construction manager) and CA that the following work has been completed in accordance with the contract documents and the equipment, systems and sub-systems are operating as required.
 - .1 HVAC equipment including all fans, air handling units, dehumidification units, ductwork, dampers, terminals, and all Division 23 equipment.
 - .2 Refrigeration equipment, pumping systems and heat rejection equipment.
 - .3 Fire-stopping in the fire-rated construction, including fire and smoke damper installation, caulking, gasketing and sealing of smoke barriers.
 - .4 Seismic restraints installed to specification; a certification from the seismic restraint engineer meets this requirement.
 - .5 Dedicated smoke control systems including stairway pressurization and atrium systems.
 - .6 Non-dedicated systems using the air-handling units for smoke control.
 - .7 Fire detection and smoke detection devices furnished under other divisions of this specification as they affect the operation of the smoke control systems.
 - .8 That the building control system is functioning to control HVAC equipment and smoke control systems as specified.
- .22 Provide a complete set of as-built drawings and O&M manuals to the CA.

3.6 TAB AGENCY'S RESPONSIBILITIES

- .1 With respect to HVAC commissioning, the TAB agency shall:
 - .1 Include costs for HVAC commissioning requirements in the quoted price.
 - .2 Attend commissioning meetings scheduled by the CA prior to , and during, on-site TAB work being done.
 - .3 Submit proposed TAB procedures to the CA and mechanical engineer for review and acceptance.
 - .4 Attend the TAB planning meeting scheduled by the CA. Be prepared to discuss the procedures that shall be followed in testing, adjusting and balancing the HVAC system.
 - .5 At the completion of the TAB work, submit the final TAB report to the mechanical contractor, submittal will be to the mechanical contractor, with general contractor, CA, and mechanical engineer notified

- .6 Participate in verification of the TAB report by the CA for verification or diagnostic purposes. This will consist of repeating a sample (normally 10% to 20%) of the measurements contained in the TAB report as directed by the CA.
- .7 Participate in O&M personnel training sessions as scheduled by the CA.

3.7 CONTROLS SUBCONTRACTOR'S RESPONSIBILITIES

- .1 With respect to HVAC commissioning, the controls contractor shall:
 - .1 Include cost for commissioning requirements in the quoted price.
 - .2 Review design for controllability with respect to equipment selected for the project.
 - .1 Review and confirm in writing that a proper hardware specification exists to permit functional performance testing as required by specification and sequence of operation.
 - .2 Review and confirm in writing that proper safeties and interlocks are included in design.
 - .3 Ensure the proper sizing of control valves and actuators, based on design pressure drops. Ensure that control valve authority will result in capacity control as specified. Include valve sizing and authority information in submittal to Consultant.
 - .4 Ensure the proper sizing of control dampers. Ensure damper authority to control air flows as specified. Review and confirm in writing proper damper positioning for mixing to prevent stratification. Ensure correct actuator vs. damper movement for smooth operation. Include damper sizing, control authority and actuator selection data in submittal to mechanical engineer.
 - .5 Ensure the proper selection of sensor ranges and include data with submittal to mechanical engineer.
 - .6 Clarify all questions concerning sequences of operation with the mechanical engineer.
 - .3 Attend commissioning meetings scheduled by the CC.
 - .4 Provide the following submittals to the CC for review:
 - .1 Hardware and software submittals.
 - .2 Control panel construction shop drawings.
 - .3 Diagrams showing all control points, sensor locations, point names, actuators, controllers and where necessary, points of access, all superimposed on diagrams of the physical equipment.
 - .4 Narrative description of all control sequences for each piece of equipment controlled.
 - .5 Logic diagrams showing the logic flow of all control sequences.
 - .6 A list of all control points, including analog inputs, analog outputs,

digital inputs and digital outputs. Include the values of all parameters for each system point. Provide a separate list for each stand-alone control unit.

- .7 A complete control language program listing including all software routines employed in operating the control system. Also, provide a program write-up, organized in the same manner as the control software. This narrative shall describe the logic flow of the software and the functions of each routine and sub-routine. It should also explain individual math or logic operations that are not clear from reading the software listing.
- .8 Hardware operation and maintenance manuals.
- .9 Application software and project applications code manuals.
- .5 Inspect, check, and confirm the proper installation and performance of controls/BAS hardware and software provided by others.
- .6 Integrate installation and programming scheduling with construction and commissioning schedules.
- .7 Inspect, check and confirm the correct installation and operation of input and output field points and devices through documented and signed off point-to-point checkouts.
- .8 Provide thorough training to operating personnel on hardware operations and programming, and the application program for the system, in accordance with the O&M staff training program in the commissioning plan.
- .9 In conjunction with the mechanical contractor, demonstrate system performance to the CC including all modes of system operation (e.g. occupied, unoccupied, emergency) during the functional performance tests (FTP's). If improper functionality, incomplete work, or other deficiencies affecting system performance are discovered, the FTP's will be stopped by the CC. Those responsible for deficient or incomplete work will be responsible for costs in accordance with 3.2 in this Section.
- .10 Provide control system technician to assist during system verification and functional performance testing.
- .11 Provide support and coordination with TAB contractor on all interfaces between controls and TAB scopes of work. Provide, at no additional cost to the TAB and commissioning agencies, all devices, such as portable operator's terminals and all software for the TAB agency to use in completing TAB procedures.

3.8 ELECTRICAL SUBCONTRACTOR'S RESPONSIBILITIES

- .1 With respect to HVAC commissioning, the electrical contractor shall:
 - .1 Include cost for HVAC commissioning requirements in the quoted price.
 - .2 Review design with respect to providing power to the HVAC equipment:
 - .1 Verify that proper hardware specifications exist for functional

performance and sequence of operation required by specification.

- .2 Verify that proper safeties and interlocks are included in the design of electrical connections for HVAC equipment.
- .3 Attend commissioning meetings scheduled by the CC.
- .4 Schedule work so that required electrical installations are completed, and systems verification checks and functional performance tests can be carried out on schedule.
- .5 Inspect, check and confirm in writing the proper installation and performance of all electrical services provided.
- .6 Provide electrical system technicians to assist during system verification and functional performance testing as required by the CC.

END OF SECTION

1. GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Refer to Section 23 01 01.

1.1 REFERENCE STANDARDS

- .1 ASTM International (ASTM)
 - .1 ASTM E202-04, Standard Test Methods for Analysis of Ethylene Glycols and Propylene Glycols.

1.2 CLEANING AND START-UP OF MECHANICAL PIPING SYSTEMS

- .1 In accordance with Section 23 08 16 - Cleaning and Start-Up of HVAC Piping Systems.

1.3 HYDRONIC SYSTEMS - PERFORMANCE VERIFICATION (PV)

- .1 Perform hydronic systems performance verification after cleaning is completed and system is in full operation.
- .2 When systems are operational, perform following tests:
 - .1 Conduct full scale tests at maximum design flow rates, temperatures and pressures for continuous consecutive period of 48 hours to demonstrate compliance with design criteria.
 - .2 Verify performance of hydronic system circulating pumps as specified, recording system pressures, temperatures, fluctuations by simulating maximum design conditions and varying.
 - .1 Pump operation.
 - .2 Boiler and/or chiller operation.
 - .3 Pressure bypass open/closed.
 - .4 Control pressure failure.
 - .5 Maximum heating demand.
 - .6 Maximum cooling demand.
 - .7 Boiler and/or chiller failure.
 - .8 Cooling tower (and/or industrial fluid cooler) fan failure.
 - .9 Outdoor reset. Re-check heat exchanger output supply temperature at 100% and 50% reset, maximum water temperature.

1.4 HYDRONIC SYSTEM CAPACITY TEST

- .1 Perform hydronic system capacity tests after:
 - .1 TAB has been completed

- .2 Verification of operating, limit, safety controls.
- .3 Verification of primary and secondary pump flow rates.
- .4 Verification of accuracy of temperature and pressure sensors and gauges.
- .2 Calculate system capacity at test conditions.
- .3 Using manufacturer's published data and calculated capacity at test conditions, extrapolate system capacity at design conditions.
- .4 When capacity test is completed, return controls and equipment status to normal operating conditions.
- .5 Submit sample of system water to approved testing agency to determine if chemical treatment is correct. Include cost.
- .6 Heating system capacity test:
 - .1 Perform capacity test when ambient temperature is within 10% of design conditions. Simulate design conditions by:
 - .1 Increasing OA flow rates through heating coils (in this case, monitor heating coil discharge temperatures to ensure that coils are not subjected to freezing conditions) or
 - .2 Reducing space temperature by turning of heating system for sufficient period of time before starting testing.
 - .2 Test procedures:
 - .1 Open fully heat exchanger, heating coil and radiation control valves.
 - .2 With boilers on full firing and hot water heating supply temperature stabilized, record flow rates and supply and return temperatures simultaneously.
 - .3 Conduct flue gas analysis test on boilers at full load and at low fire conditions.
- .7 Chilled water system capacity test:
 - .1 Perform capacity test when ambient temperature is within 10% of design conditions. Simulate design conditions by:
 - .1 Adding heat from building heating system or;
 - .2 Raising space temperature by turning off cooling and air systems for sufficient period of time before starting testing and pre-heating building to summer design space temperature (occupied) or above. Set OAD and RAD for minimum outside air if OAT is near outside design temperature or to maximum recirculation if RAT is greater than OAT. RAT to be at least 23 degrees C minimum.
 - .2 Test procedures:
 - .1 Open fully cooling coil control valves.
 - .2 Set thermostats on associated AHU's for maximum cooling.

- .3 Set AHU's for design maximum air flow rates.
- .4 Set load or demand limiters on chillers to 100%.
- .5 After system has stabilized, record chilled water, and condenser water flow rates and supply and return temperatures simultaneously.

1.5 WET AND DRY PIPE SPRINKLER SYSTEM, STANDPIPE AND HOSE SYSTEMS

- .1 Cleaning, testing, start-up, performance verification of equipment, systems, components, and devices is specified elsewhere in Division 23.
- .2 Verification of controls, detection devices, alarm devices is specified Division 26.
- .3 Demonstrate that fire hose will reach to most remote location regardless of partitions, and obstructions.
- .4 Verify operation of interlocks between HVAC systems and fire alarm systems.

1.6 SANITARY AND STORM DRAINAGE SYSTEMS

- .1 Buried systems: perform tests prior to back-filling. Perform hydraulic tests to verify grades and freedom from obstructions.
- .2 Ensure that traps are fully and permanently primed.
- .3 Ensure that fixtures are properly anchored, connected to system.
- .4 Operate flush valves, tank and operate each fixture to verify drainage and no leakage.
- .5 Cleanouts: refer to Section 22 05 15 - Plumbing Specialties and Accessories.
- .6 Roof drains:
 - .1 Refer to Section 22 05 15 - Plumbing Specialties and Accessories.
 - .2 Remove caps as required.

1.7 REPORTS

- .1 In accordance with Division 01 – Commissioning: Reports, supplemented as specified herein.

1.8 TRAINING

- .1 In accordance with Division 01 – Commissioning: Training of O&M Personnel, supplemented as specified herein.

2. PRODUCTS

2.1 NOT USED

- .1 Not Used.

3. EXECUTION

3.1 NOT USED

.1 Not Used.

END OF SECTION

1. GENERAL

1.1 SUMMARY

- .1 Section Includes:
 - .1 Procedures and cleaning solutions for cleaning mechanical piping systems.
- .2 Related Requirements
 - .1 Section 23 08 00.
 - .2 Section 23 08 13.
 - .3 Section 23 25 00.

1.2 REFERENCE STANDARDS

- .1 ASTM International (ASTM)
 - .1 ASTM E202, Standard Test Methods for Analysis of Ethylene Glycols and Propylene Glycols.
- .2 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Safety Data Sheets (SDS).

1.3 SHOP DRAWING SUBMITTALS

- .1 Product Data:
 - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Division 01 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.
- .2 Quality assurance submittals: submit following in accordance with Division 01 - Submittal Procedures.
 - .1 Instructions: submit manufacturer's installation instructions.

1.4 QUALITY ASSURANCE

- .1 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Division 01 - Health and Safety Requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store products off ground, indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

- .2 Store and protect products from nicks, scratches, blemishes, vermin, theft and vandalism.
- .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.

1.6 CLEANING SOLUTIONS

- .1 Tri-sodium phosphate: 0.40 kg per 100 L water in system.
- .2 Sodium carbonate: 0.40 kg per 100 L water in system.
- .3 Low-foaming detergent: 0.01 kg per 100 L water in system.

2. EXECUTION

2.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

2.2 CLEANING HYDRONIC AND STEAM SYSTEMS

- .1 Timing: systems operational, hydrostatically tested and with safety devices functional, before cleaning is carried out.
- .2 Cleaning Agency:
 - .1 Retain qualified water treatment specialist to perform system cleaning.
- .3 Install instrumentation such as flow meters, orifice plates, pitot tubes, flow metering valves only after cleaning is certified as complete.
- .4 Cleaning procedures:
 - .1 Provide detailed report outlining proposed cleaning procedures at least four weeks prior to proposed starting date. Report to include:
 - .1 Cleaning procedures, flow rates, elapsed time.
 - .2 Chemicals and concentrations used.
 - .3 Inhibitors and concentrations.
 - .4 Specific requirements for completion of work.
 - .5 Special precautions for protecting piping system materials and components.
 - .6 Complete analysis of water used to ensure water will not damage systems or equipment.
- .5 Conditions at time of cleaning of systems:
 - .1 Systems: free from construction debris, dirt and other foreign material.

- .2 Control valves: operational, fully open to ensure that terminal units can be cleaned properly.
- .3 Strainers: clean prior to initial fill.
- .4 Install temporary filters on pumps not equipped with permanent filters.
- .5 Install pressure gauges on strainers to detect plugging.
- .6 Report on Completion of Cleaning:
 - .1 When cleaning is completed, submit report, complete with certificate of compliance with specifications of cleaning component supplier.
- .7 Hydronic Systems:
 - .1 Fill system with water, ensure air is vented from system.
 - .2 Fill expansion tanks 1/3 to 1/2 full, charge system with compressed air to at least 35 kPa (does not apply to diaphragm type expansion tanks).
 - .3 Use water metre to record volume of water in system to +/- 0.5%.
 - .4 Add chemicals under direct supervision of chemical treatment supplier.
 - .5 Closed loop systems: circulate system cleaner at 60 degrees C for at least 36 h. Drain as quickly as possible. Refill with water and inhibitors. Test concentrations and adjust to recommended levels.
 - .6 Flush velocity in system mains and branches to ensure removal of debris. System pumps may be used for circulating cleaning solution provided that velocities are adequate.
 - .7 Add chemical solution to system.
 - .8 Establish circulation, raise temperature slowly to maximum design (82 degrees C minimum). Circulate for 12 h, ensuring flow in all circuits. Remove heat, continue to circulate until temperature is below 38 degrees C. Drain as quickly as possible. Refill with clean water. Circulate for 6 hours at design temperature. Drain and repeat procedures specified above. Flush through low point drains in system. Refill with clean water adding to sodium sulphite (test for residual sulphite).
- .8 Glycol Systems:
 - .1 In addition to procedures specified above perform specified procedures.
 - .2 Test to prove concentration will prevent freezing to minus 40 degrees C. Test inhibitor strength and include in procedural report. Refer to ASTM E202.
- .9 Steam Systems: in addition to general requirements as specified above, perform following:
 - .1 Remove internal components of steam traps until flushing and warm-up have been completed.
 - .2 Open drip points to atmosphere. If needed for protection of personnel or environment, install flexible hose and direct discharge to safe location.
 - .3 Starting at drip point closest to source, verify removal of condensate, then re-install steam trap internal parts. Repeat sequence down the line.
 - .4 Water hammer: determine source and eliminate cause.

- .10 Steam boilers:
 - .1 Isolate boilers from piping system.
 - .2 Fill to normal operating level. Add cleaner. Fire to 50% of design operating steam pressure. Maintain for 24 h, during which blow down boiler every 4 hours including water columns, controls, skimmer lines and valves, test cocks, blowdown valves. Add water to return to operating level.
 - .3 Allow boiler to cool, then drain, flush and inspect.
 - .4 Reconnect to piping system.
 - .5 Refill boiler with clean softened water and immediately add chemical inhibitors.
 - .6 Apply heat slowly and raise to normal design operating steam pressure. Maintain for 4 h.
 - .7 Discharge condensate from steam system to sewer for 96 hours after initial operation. During this period continue chemical treatment of boilers with inhibitors to ensure complete removal of oils, grease and millscale from steam and condensate return piping steam.
 - .8 Drain steam condensate until it is clean and free from suspended matter. Ensure proper operation of steam traps.
 - .9 Allow boiler to cool, drain, open inspection ports and wash out with clean water.
 - .10 If boiler is not used immediately, refill with softened water, add sodium sulphite, bring up to pressure. Test for residual sulphite.
 - .11 After cleaning is completed and system is filled, perform relevant start-up procedures as specified for hydronic systems:

2.3 START-UP OF HYDRONIC SYSTEMS

- .1 After cleaning is completed and system is filled:
 - .1 Establish circulation and expansion tank level, set pressure controls.
 - .2 Ensure air is removed.
 - .3 Check pumps to be free from air, debris, possibility of cavitation when system is at design temperature.
 - .4 Dismantle system pumps used for cleaning, inspect, replace worn parts, install new gaskets and new set of seals.
 - .5 Clean out strainers repeatedly until system is clean.
 - .6 Commission water treatment systems as specified in Section 23 25 00 - HVAC Water Treatment.
 - .7 Check water level in expansion tank with cold water with circulating pumps OFF and again with pumps ON.
 - .8 Repeat with water at design temperature.
 - .9 Check pressurization to ensure proper operation and to prevent water hammer, flashing, cavitation. Eliminate water hammer and other noises.
 - .10 Bring system up to design temperature and pressure slowly over a 48 hour period.

- .11 Perform TAB as specified in Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.
- .12 Adjust pipe supports, hangers, springs as necessary.
- .13 Monitor pipe movement, performance of expansion joints, loops, guides, anchors.
- .14 If sliding type expansion joints bind or if bellows type expansion joints flex incorrectly, shut down system, re-align, repeat start-up procedures. Inspect bellows-type expansion joints for squirm and replace squirmed expansion joints with new.
- .15 Re-tighten bolts using torque wrench, to compensate for heat-caused relaxation. Repeat several times during commissioning.
- .16 Check operation of drain valves.
- .17 Adjust valve stem packings as systems settle down.
- .18 Fully open balancing valves (except those that are factory-set).
- .19 Check operation of over-temperature protection devices on circulating pumps.
- .20 Adjust alignment of piping at pumps to ensure flexibility, adequacy of pipe movement, absence of noise or vibration transmission.

2.4 CLEANING

- .1 Clean in accordance with Division 01 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.

END OF SECTION

1. GENERAL

1.1 SUMMARY

- .1 Section Includes:
 - .1 Direct Digital Controls for HVAC Systems.
- .2 Related Requirements
 - .1 College BAS Standards

1.2 REFERENCE STANDARDS

- .1 Comply with the most restrictive of local, Provincial, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with the current editions in effect 30 days prior to the receipt of bids of the following codes:
 - .1 Canadian Electrical Code (CEC)
 - .2 Ontario Building Code (OBC)
 - .3 Underwriters Laboratories (UL/CUL)
 - .4 ANSI/ASHRAE Standard 135, BACnet - A Data Communication Protocol for Building Automation and Control Systems

1.3 ABBREVIATIONS

- .1 AC – Air Conditioning
- .2 ACU – Air Conditioning Unit
- .3 AHU – Air Handling Unit
- .4 AI – Analog Input
- .5 AO – Analog Output
- .6 ATC – Automatic Temperature Control
- .7 AUTO – Automatic
- .8 AUX – Auxiliary
- .9 AV – Analog Value
- .10 BAS – Building Automation System
- .11 BI – Binary Input
- .12 BO – Binary Output
- .13 BV – Binary Value
- .14 C – Common
- .15 CFM – Cubic Feet per Minute
- .16 CHW – Chilled Water

- .17 CHWP – Chilled Water Pump
- .18 CHWR – Chilled Water Return
- .19 CHWS – Chilled Water Supply
- .20 COND – Condenser
- .21 CV – Constant Volume
- .22 CW – Condenser Water
- .23 CWP – Condenser Water Pump
- .24 CWR – Condenser Water Return
- .25 CWS – Condenser Water Supply
- .26 DA – Discharge Air
- .27 DDC – Direct Digital Control
- .28 DI – Digital Input
- .29 DO – Digital Output
- .30 EA – Exhaust Air
- .31 EF – Exhaust Fan
- .32 EVAP – Evaporators
- .33 FAS – Fire Alarm System
- .34 FCU – Fan Coil Unit
- .35 HOA – Hand / Off / Auto
- .36 HP – Heat Pump
- .37 HRU – Heat Recovery Unit
- .38 HVAC – Heating, Ventilating, and Air Conditioning
- .39 HW – Hot Water
- .40 HWP – Hot Water Pump
- .41 HWR – Hot Water Return
- .42 HWS – Hot Water Supply
- .43 HX – Heat Exchanger
- .44 IU – Induction Unit
- .45 LAN – Local Area Network
- .46 MER – Mechanical Equipment Room
- .47 NC – Normally Closed
- .48 NO – Normally Open
- .49 OA – Outdoor Air
- .50 PID – Proportional Integral Derivative

- .51 POT – Portable Operators Terminal
- .52 RA – Return Air
- .53 RF – Return Fan
- .54 RH – Relative Humidity
- .55 RTU – Roof-top Unit
- .56 SA – Supply Air
- .57 SF – Supply Fan
- .58 SP – Static Pressure
- .59 TEMP – Temperature
- .60 UH – Unit Heater
- .61 UV – Unit Ventilator
- .62 VAV – Variable Air Volume
- .63 VFD – Variable Frequency Drive
- .64 VRF – Variable Refrigerant Flow
- .65 VRV – Variable Refrigerant Volume
- .66 WSHP – Water Source Heat Pump

1.4 DEFINITIONS

- .1 Point: may be logical or physical.
 - .1 Logical points: values calculated by system such as setpoints, totals, counts, derived corrections and may include, but not limited to result of and statements in CDL's.
 - .2 Physical points: inputs or outputs which have hardware wired to controllers which are measuring physical properties, or providing status conditions of contacts or relays which provide interaction with related equipment (stop, start) and valve or damper actuators.
- .2 Point Name: composed of two parts, point identifier and point expansion.
 - .1 Point identifier: comprised of three descriptors, "area" descriptor, "system" descriptor and "point" descriptor, for which database to provide 25 character field for each point identifier. "System" is system that point is located on.
 - .1 Area descriptor: building or part of building where point is located.
 - .2 System descriptor: system that point is located on.
 - .3 Point descriptor: physical or logical point description. For point identifier "area", "system" and "point" will be shortforms or acronyms. Database must provide 25 character field for each point identifier.

- .2 Point expansion: comprised of three fields, one for each descriptor. Expanded form of shortform or acronym used in "area", "system" and "point" descriptors is placed into appropriate point expansion field. Database must provide 32 character field for each point expansion.
- .3 Bilingual systems to include additional point identifier expansion fields of equal capacity for each point name for second language.
 - .1 System to support use of numbers and readable characters including blanks, periods or underscores to enhance user readability for each of the above strings.
- .3 Point Object Type: points fall into following object types:
 - .1 AI (analog input).
 - .2 AO (analog output).
 - .3 DI (digital input).
 - .4 DO (digital output).
 - .5 Pulse inputs.
- .4 Symbols and engineering unit abbreviations utilized in displays: to ANSI/ISA S5.5.
 - .1 Printouts: to ANSI/IEEE 260.1.
- .5 Adjustable (adj.):
 - .1 Adjustable by the end user, through the supplied user interface.
- .6 Advanced Application Controller (AAC):
 - .1 A fully programmable control module. This control module may be capable of some of the advanced features found in Building Controllers (storing trends, initiating read and write requests, etc.) but it does not serve as a master controller. Advanced Application Controllers may reside on either the Ethernet/IP backbone or on a subnet.
- .7 Alarm:
 - .1 The control system shall be configured to generate an alarm when this object exceeds user definable limits, as described in the Sequence of Controls.
- .8 Analog Value:
 - .1 An intermediate (software) point that may be editable or read-only. Editable AVs are typically used to allow the user to set a fixed control parameter, such as a setpoint. Read Only AVs are typically used to display the status of a control operation.
- .9 Application Specific Controller (ASC):

- .1 A pre-programmed control module which is intended for use in a specific application. ASCs may be configurable, in that the user can choose between various pre-programmed options, but it does not support full custom programming. ASCs are often used on terminal equipment such as VAV boxes or fan coil units. In many vendors' architectures ASCs do not store trends or schedules but instead rely upon a Building Controller to provide those functions.
- .10 BACnet Interoperability Building Blocks (BIBB):
 - .1 A BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBS are combined to build the BACnet functional requirements for a device in a specification.
- .11 BACnet/BACnet Standard:
 - .1 BACnet communication requirements as defined by the latest version of ASHRAE/ANSI 135 and approved addenda.
- .12 Binary Value:
 - .1 An intermediate (software) point that may be editable or read-only. Editable BVs are typically used to allow the user to set a fixed control parameter, such as a setpoint. Read Only BVs are typically used to display the status of a control operation.
- .13 Building Controller (BC):
 - .1 A fully programmable control module which is capable of storing trends and schedules, serving as a router to devices on a subnet, and initiating read and write requests to other controllers. Typically this controller is located on the Ethernet/IP backbone of the BAS. In many vendors' architectures a Building Controller will serve as a master controller, storing schedules and trends for controllers on a subnet underneath the Building Controller.
- .14 Control Systems Server:
 - .1 A computer(s) that maintain(s) the systems configuration and programming database.
- .15 Controller:
 - .1 Intelligent stand-alone control device. Controller is a generic reference to building controllers, custom application controllers, and application specific controllers.
- .16 Direct Digital Control (DDC):
 - .1 Microprocessor-based control including Analog/Digital conversion and program logic.
- .17 Furnished or Provided:

- .1 The act of supplying a device or piece of equipment as required meeting the scope of work specified and making that device or equipment operational. All costs required to furnish the specified device or equipment and make it operational are borne by the division specified to be responsible for providing the device or equipment.
- .18 Gateway:
 - .1 Bi-directional protocol translator connecting control systems that use different communication protocols.
- .19 Install or Installed:
 - .1 The physical act of mounting, piping or wiring a device or piece of equipment in accordance with the manufacturer's instructions and the scope of work as specified. All costs required to complete the installation are borne by the division specified to include labor and any ancillary materials.
- .20 Integrate:
 - .1 The physical connections from a control system to all specified equipment through an interface as required to allow the specified control and monitoring functions of the equipment to be performed via the control system.
- .21 Interface:
 - .1 The physical device required to provide integration capabilities from an equipment vendor's product to the control system. The equipment vendor most normally furnishes the interface device. An example of an interface is the chilled water temperature reset interface card provided by the chiller manufacturer in order to allow the control system to integrate the chilled water temperature reset function into the control system.
- .22 Local Area Network:
 - .1 Computer or control system communications network limited to local building or campus.
- .23 Loop or control loop:
 - .1 Most commonly a PID control loop. Typically a control loop will include a setpoint, an input which is compared to the setpoint, and an output which controls some action based upon the difference between the input and the setpoint. A PID control loop will also include gains for the proportional, integral, and derivative response as well as an interval which controls how frequently the control loop updates its output. These gains may be adjustable by the end user for control loop "tuning," but in self-tuning control loops or loops which have been optimized for a specific application the gains may not be adjustable.
- .24 Master-Slave/Token Passing (MS/TP):
 - .1 Data link protocol as defined by the BACnet standard.
- .25 Point-to-Point:

- .1 Serial communication as defined in the BACnet standard.
- .26 Primary Controlling LAN:
 - .1 High speed, peer-to-peer controller LAN connecting BCs and optionally AACs and ASCs. Refer to System Architecture below.
- .27 Protocol Implementation Conformance Statement (PICS):
 - .1 A written document that identifies the particular options specified by BACnet that are implemented in a device.
- .28 Router:
 - .1 A device that connects two or more networks at the network layer.
- .29 Schedule:
 - .1 The control algorithm for this equipment shall include a user editable schedule.
- .30 Trend:
 - .1 The control system shall be configured to collect and display a trend log of this object. The trending interval shall be no less than one sample every 5 minutes. (Change of Value trending, where a sample is taken every time the value changes by more than a user-defined minimum, is an acceptable alternative.)
- .31 Web services:
 - .1 Web services are a standard method of exchanging data between computer systems using the XML (extensible markup language) and SOAP (simple object access protocol) standards. Web services can be used at any level within a Building Automation System (BAS), but most commonly they are used to transfer data between BAS using different protocols or between a BAS and a non-BAS system such as a tenant billing system or a utility management system.
- .32 Wiring:
 - .1 Raceway, fittings, wire, boxes and related items.

1.5 SYSTEM DESCRIPTION

- .1 Provide system consisting of a high-speed, peer-to-peer network of DDC controllers, a control system server, and a web-based operator interface.
- .2 Provide system software based on a server/thin client architecture, designed around the open standards of web technology. Ensure the control system server is accessed using a Web browser over the control system network, the owner's local area network, and (at the owner's discretion) over the Internet.
- .3 The intent of the thin-client architecture is to provide operators complete access to the control system via a Web browser. Ensure no special software other than a web browser is required to access graphics, point displays, and trends, configure trends, configure points and controllers, or to download programming into the controllers.

- .4 Ensure system uses the BACnet protocol for communication between the control modules and web server. Communication between the web server and the user's browser shall be HTTP or HTTPS protocol utilizing HTML5. Use of Adobe Flash technology is not acceptable.

1.6 SHOP DRAWING SUBMITTALS

- .1 Make submittals in accordance with Division 01 - Submittal Procedures
- .2 Provide shop drawings and product data on hardware, software, and equipment to be installed or provided. No work may begin on any segment of this project until submittals have been approved for conformity with design intent.
- .3 The submittal data shall be in standard Microsoft (Word, Excel, etc.) or PDF file formats. When manufacturer's cutsheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawing shall clearly reference the specification and/or drawing that the submittal is to cover.
- .4 General catalogs shall not be accepted as cutsheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work. Submittal approval does not relieve Contractor of responsibility to supply sufficient quantities to complete work. Submittals shall be provided within 12 weeks of contract award.
- .5 Include:
 - .1 DDC System Hardware
 - .1 A complete bill of materials to be used indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.
 - .2 Manufacturer's description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below:
 - .1 Direct digital controllers (controller panels)
 - .2 Transducers and transmitters
 - .3 Sensors (including accuracy data)
 - .4 Actuators
 - .5 Valves
 - .6 Relays and switches
 - .7 Control panels
 - .8 Power supplies
 - .9 Batteries
 - .10 Operator interface equipment

- .11 Wiring
- .3 Wiring diagrams and layouts for each control panel. Show termination numbers.
- .4 Schematic diagrams for all field sensors and controllers. Provide floor plans of all sensor locations and control hardware. Riser diagrams showing control network layout, communication protocol, and wire types.
- .2 Central System Hardware and Software
 - .1 A complete bill of material of equipment used indicating quantity, manufacturer, model number, and relevant technical.
 - .2 Manufacturer's description and technical data such as product specifications and installation and maintenance instructions for items listed below and for relevant items furnished under this contract not listed below:
 - .1 Central Processing Unit (CPU) or web server
 - .2 Monitors
 - .3 Keyboards
 - .4 Power supplies
 - .5 Battery backups
 - .6 Interface equipment between CPU or server and control panels
 - .7 Operating System software – web server
 - .8 Color graphic software
 - .9 Third-party software
 - .3 Schematic diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show interface wiring to control system.
 - .4 Network riser diagrams of wiring between central control unit and control panels.
- .3 Controlled Systems
 - .1 Riser diagrams showing control network layout, communication protocol, and wire types.
 - .2 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.

- .3 A schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.
- .4 An instrumentation list (Bill of Materials) for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
- .5 A mounting, wiring, and routing plan-view drawing. The design shall take into account HVAC, electrical, and other systems' design and elevation requirements. The drawing shall show the specific location of all concrete pads and bases and any special wall bracing for panels to accommodate this work.
- .6 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.
- .7 A point list for each control system. List I/O points and software points required to provide specified sequence of operations. Indicate alarmed and trended points.
- .4 Quantities of items submitted shall be reviewed but are the responsibility of the Contractor.
- .5 BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of controller and operator interface.
- .6 Project Documentation.
 - .1 Upon completion of installation, submit three printed copies of record (as-built) documents for approval before final completion. In addition, provide a digital copy of record documents on suitable digital media such as a USB drive. The digital record documents shall be in standard Microsoft (Word, Excel, etc.) or PDF file formats except as noted below. Record documentation shall include the following:
 - .1 Project Record Drawings. As-built versions of submittal shop drawings provided as AutoCAD compatible files on suitable solid state media (file format: .DWG, .DXF, .VSD, or comparable) and as 11" x 17" prints.
 - .2 Testing and Commissioning Reports and Checklists.
 - .3 Operation and Maintenance (O&M) Manual.
 - .4 As-built versions of submittal product data.
 - .5 Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
 - .6 Operator's manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.

- .7 Programming manual or set of manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
- .8 Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
- .9 Documentation of programs operating in the system and object database that can be viewed using technician software tools furnished with system.
- .10 Graphic files, programs, and database to be viewed using technician software tools furnished with system.
- .11 List of recommended spare parts with part numbers and suppliers.
- .12 Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
- .13 Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation or web server software, and graphics software.
- .14 Licenses, guarantees, and warranty documents for equipment and systems.
- .15 Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
- .16 Load into the control system for access by the operator through any operator workstation closeout documentation. There shall be a menu or navigation tab to access the documentation. The documentation can be loaded into the control system in a pdf format. The following documentation shall be included:
 - .1 As-built control diagrams including wiring diagrams and sequences of operations for each controller/piece of equipment.
 - .2 All IOM data as follows:
 - .1 IOM from each equipment manufacturer for each piece of equipment (AHUs, FCUs, Chillers, pumps etc.)
 - .2 IOM for each control module and end device installed in the system.

- .7 Training Materials: Provide course outline and materials for each class at least six weeks before first class. Training shall be furnished via instructor-led sessions, computer-based training, or web-based training. Engineer will modify course outlines and materials if necessary to meet Owner's needs. Engineer will review and approve course outlines and materials at least three weeks before first class.
- .8 Quality Control:
 - .1 Provide equipment and material from manufacturer's regular production, CSA certified, manufactured to standard quoted plus additional specified requirements.
 - .2 Where CSA certified equipment is not available submit such equipment to inspection authorities for special inspection and approval before delivery to site.
 - .3 Submit proof of compliance to specified standards with shop drawings and product data in accordance Division 01 – Submittals. Label or listing of specified organization is acceptable evidence.
 - .4 In lieu of such evidence, submit certificate from testing organization, approved by Consultant, certifying that item was tested in accordance with their test methods and that item conforms to their standard/code.
 - .5 For materials whose compliance with organizational standards/codes/specifications is not regulated by organization using its own listing or label as proof of compliance, furnish certificate stating that material complies with applicable referenced standard or specification.

1.7 QUALITY ASSURANCE

- .1 Installer and Manufacturer Qualifications
 - .1 Installer shall have an established working relationship with the Control System Manufacturer and have, as a minimum, 5 years demonstrated experience with installation and support of the manufacturer's product.
 - .2 Installer shall have successfully completed Control System Manufacturer's control system training. Upon request, Installer shall present record of completed training including course outlines.
- .2 Have local office within 50 km of project staffed by trained personnel capable of providing instruction, routine maintenance and emergency service on systems,
- .3 Provide record of successful previous installations submitting tender showing experience with similar installations utilizing computer-based systems.
- .4 Have access to local supplies of essential parts and provide seven year guarantee of availability of spare parts after obsolescence.
- .5 Ensure qualified supervisory personnel continuously direct and monitor Work and attend site meetings.
- .6 Health and Safety:

1.8 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store products off ground, indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect products from nicks, scratches, blemishes, vermin, theft and vandalism.
 - .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.

1.9 EXISTING- CONTROL COMPONENTS

- .1 Utilize existing control wiring and piping as indicated.
- .2 Re-use field control devices that are usable in their original configuration provided that they conform to applicable codes, standards specifications.
 - .1 Do not modify original design of existing devices without written permission from Consultant.
 - .2 Provide for new, properly designed device where re-usability of components is uncertain.
- .3 Inspect and test existing devices intended for re-use within 30 days of award of contract, and prior to installation of new devices.
 - .1 Furnish test report within 40 days of award of contract listing each component to be re-used and indicating whether it is in good order or requires repair.
 - .2 Failure to produce test report will constitute acceptance of existing devices by contractor.
- .4 Non-functioning items:
 - .1 Provide with report specification sheets or written functional requirements to support findings.
 - .2 Repair or replace existing items judged defective yet deemed necessary for BAS.
- .5 Submit written request for permission to disconnect controls and to obtain equipment downtime before proceeding with Work.

- .6 Assume responsibility for controls to be incorporated into BAS after written receipt of approval from Consultant.
- .1 Be responsible for repair costs due to negligence or abuse of equipment.
- .7 Remove existing controls not re-used or not required. Place in approved storage for disposition as directed.

1.10 SYSTEM PERFORMANCE

- .1 Performance Standards. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for display through the user's web browser.
 - .1 Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 sec.
 - .2 Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.
 - .3 Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.
 - .4 Object Command. Devices shall react to command of a binary object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec.
 - .5 Alarm Response Time. An object that goes into alarm shall be annunciated at the browser within 45 sec.
 - .6 Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec.
 - .7 Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.
 - .8 Multiple Alarm Annunciation. Each user, connected to network accessing the system through their browser (workstation), shall receive alarms within 5 seconds of one another.
 - .9 Reporting Accuracy. System shall report values with minimum end-to-end accuracy listed in Table 1.
 - .10 Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2.

Table-1
Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±0.5°C (±1°F)
Ducted Air	±0.5°C (±1°F)
Outside Air	±1.0°C (±2°F)
Dew Point	±1.5°C (±3°F)
Water Temperature	±0.5°C (±1°F)
Delta-T	±0.15° (±0.25°F)
Relative Humidity	±5% RH
Water Flow	±2% of full scale
Airflow (terminal)	±10% of full scale (see Note 1)
Airflow (measuring stations)	±5% of full scale
Airflow (pressurized spaces)	±3% of full scale
Air Pressure (ducts)	±25 Pa (±0.1 in. w.g.)
Air Pressure (space)	±3 Pa (±0.01 in. w.g.)
Water Pressure	±2% of full scale (see Note 2)
Electrical (A, V, W, Power Factor)	±1% of reading (see Note 3)
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO ₂)	±50 ppm

Note 1: Accuracy applies to 10%–100% of scale

Note 2: For both absolute and differential pressure

Note 3: Not including utility-supplied meters

Table 2
Control Stability and Accuracy

Controlled Variable	Control Accuracy	Range of Medium
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	±1.0°C (±2.0°F)	
Duct Temperature	±1.0°C (±2.0°F)	
Humidity	±5% RH	
Fluid Pressure	±10 kPa (±1.5 psi) ±250 Pa (±1.0 in. w.g.)	MPa (1–150 psi) 0–12.5 kPa (0–50 in. w.g.) differential

1.11 WARRANTY

- .1 Warrant labor and materials for specified control system free from defects for a period of 12 months after final acceptance. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner's warranty service request.

- .2 Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
- .3 If the Consultant determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, the engineer will certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification. Date of acceptance shall begin warranty period.
- .4 Update manufacturer's software/firmware for web server/workstation and controllers to the latest versions that are available from the manufacturer within 30 days from the date of end of the warranty. Install and check out updates before the end of the warranty.
- .5 Provide updates to web server software, project-specific software, graphic software, database software, and firmware that resolve the contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner's written authorization.
- .6 Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired and factory recertified. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Consultant's acceptance.

1.12 OWNERSHIP OF PROPRIETARY MATERIALS

- .1 Project-specific software and documentation shall become Owner's property. This includes, but is not limited to:
 - .1 Graphics
 - .2 Record drawings
 - .3 Database
 - .4 Application programming code
 - .5 Documentation

2. PRODUCTS

2.1 MATERIALS

- .1 Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts shall be available for at least five years after completion of this contract.

2.2 COMMUNICATION

- .1 Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135, BACnet.
- .2 Ensure IP based controllers are capable of providing IPv4 and IPv6 protocol standards as defined by the Internet Data Communications Standard.
- .3 The Owner shall furnish and install all communication media, connectors, repeaters and network switches/routers, and network devices necessary to provide a complete and workable high speed Ethernet communications/LAN network meeting or exceeding recommended control network specifications. The Owner will provide an active IP/Ethernet port/drop within patch distance to each BMS server and BMS controller for connection to owner's LAN.
- .4 BMS contractor will furnish and install all communications media, connectors, repeaters, switches/routers, and network devices necessary to provide a complete and workable serial network. Established network requirements such as labeling, testing, administration, and documentation must be provided to controls vendor prior to start of project.
- .5 Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.
- .6 Internetwork operator interface and value passing shall be transparent to internetwork architecture.
 - .1 An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.
 - .2 Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute specified sequences of operation. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.
- .7 Building Control Panels, and Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated device via the internetwork. The system shall automatically adjust for daylight saving and standard time as applicable.
- .8 System shall be expandable to at least twice the required BACnet objects. No additional licensing/software fees shall be required to add controllers, associated devices, and wiring.

- .9 System shall support Web services data exchange with any other system that complies with XML (extensible markup language) and SOAP (simple object access protocol) standards. Web services support shall as a minimum be provided at the workstation or web server level and shall enable data to be read from or written to the system.
 - .1 System shall support Web services read data requests by retrieving requested trend data or point values (I/O hardware points, analog value software points, or binary value software points) from any system controller or from the trend history database.
 - .2 System shall support Web services write data request to each analog and binary object that can be edited through the system operator interface by downloading a numeric value to the specified object.
 - .3 For read or write requests, the system shall require user name and password authentication and shall support TLS (Transport Layer Security) or equivalent data encryption.
 - .4 System shall support discovery through a Web services connection or shall provide a tool available through the Operator Interface that will reveal the path/identifier needed to allow a third party Web services device to read data from or write data to any object in the system which supports this service.

2.3 OPERATOR INTERFACE

- .1 Operator Interface. The web server shall reside on high-speed network with building controllers. Web pages generated by this server shall be compatible with the latest versions of Microsoft Internet Explorer or Edge, Google Chrome, Mozilla Firefox, and Apple Safari browsers. Any of these supported browsers connected to the server shall be able to access all system information. Mobile devices shall be recognized by the web server and shall supply the appropriate system content as needed. The Operator Interface (web server with client devices) shall conform to the BACnet Operator Workstation (B-OWS) or BACnet Advanced Workstation (B-AWS) device profile as specified in ASHRAE/ANSI 135 BACnet Annex L. This includes the ability to configure and/or reconfigure the system from the client device (change programs, graphics, labels, etc.).
- .2 Communication. Web server and controllers shall communicate using BACnet protocol, including BACnet/SC. Web server and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ANSI/ASHRAE 135, BACnet Annex J. Communication between the web server and client (workstation) shall be HTTP or HTTPS protocol utilizing HTML5 language. Use of Adobe Flash in any part of the communication infrastructure is not acceptable.
- .3 Hardware.

- .1 Web server and/or workstation. Industry-standard hardware shall meet or exceed DDC system manufacturer's recommended specifications and shall meet response times specified elsewhere in this document. The web server may also be configured in client/server fashion to accommodate a "workstation" definition. In "workstation" configuration, the workstation will also perform as a server supplying additional clients as needed. The following hardware requirements apply:
 - .1 System storage shall have sufficient memory to accommodate:
 - .1 All required system software.
 - .2 A DDC database to accommodate, as a minimum, twice the size of the delivered system database.
 - .3 One year of archival trend data based on the points specified to be trended at their specified trend intervals.
 - .2 Provide additional hardware (communication ports, video drivers, network interface cards, cabling, etc.) to facilitate all control functions and software requirements specified for the DDC system.
 - .3 Minimum hardware configuration shall include the following:
 - .1 Quad Core Processor
 - .2 4-24 GB RAM (size dependent on size of system)
 - .3 500 GB hard disk providing data at 3.0 Gb/sec (size dependent on historical data storage requirements)
 - .4 16x DVD+/-RW drive
 - .5 QWERTY Keyboard
 - .6 Optical Mouse
 - .7 24-inch LED Color monitor with 75Hz refresh rate and 1080P resolution to provide a minimum screen resolution of 1920 x 1080 pixels.
 - .8 Serial (USB) and network communication ports, with cables as required for proper DDC system operation.
- .4 System Software.
 - .1 Operating System. Web server shall have an industry-standard professional-grade operating system. Operating system shall meet or exceed the BMS manufacturer's minimum requirements for their software. Acceptable systems include Microsoft Windows 8.1 or 10, Windows Server 2012 R2 or 2016 or 2019 or 2020, Red Hat Enterprise Linux 8.3, or Ubuntu Desktop 18.04 or 20.04 LTS.
 - .2 Security. The web server application shall support Transport Layer Security (TLS) 1.3 capable of encryption of up to 256 bit elliptical curve for transmitting private information over the Internet using HTTPS. Additionally, the web server shall have SHA-2 certificate support capability.

- .3 Database. System shall support any JDBC (Java DataBase Connectivity) compliant engine. This includes: MS SQL, My SQL, Apache Derby, PostgreSQL and Oracle.
- .4 The BMS system shall allow an unlimited number of concurrent users.
- .5 The BMS manufacturer shall provide all software and tools necessary to provide the following capabilities:
 - .1 Create and/or edit any programming used in controllers
 - .2 Create and/or edit any graphics used in the system
 - .3 Software shall not be subscription based and be given to owner at time of turnover. If software is subscription based, manufacturer shall include 10 years of subscription service.
 - .4 The owner shall have the ability to install software on a minimum of five (5) additional owner furnished computers without additional licenses or fees.
- .6 System Graphics. The operator interface software shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint.
 - .1 Minimum graphics resolution shall be 1920 x 1080 for display of detailed system graphics.
 - .2 Floor Plan Graphics. Floor plan graphics shall be capable of allowing the floor plan graphic to dynamically size relative to the end user's monitor resolution.
 - .3 Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.
 - .4 Animation. Graphics shall be able to animate by displaying different image files for changed object status.
 - .5 Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
 - .6 Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, GIF, or SVG. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in or shall only require widely available no-cost plug-ins.

- .7 Custom Graphics. Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system used to create and modify graphics that are saved in the same formats as are used for system graphics.
- .8 Graphics Library. Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library also shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.
- .5 System Applications. System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. If furnished as a stand-alone program, software shall be installable on a standard PC type personal computer with no limit on the number of copies that can be installed under the system license.
 - .1 Automatic System Database Configuration. Each workstation or web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.
 - .2 Manual Controller Memory Download. Operators shall be able to download memory from the system database to each controller.
 - .3 System Configuration. The workstation software shall provide a method of configuring the system. This shall allow for future system changes or additions by users under proper password.
 - .4 On-Line Help. Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.
 - .5 Security. Each operator shall be required to log on to the system with user name and password in order to view, edit, add, or delete data.
 - .1 Operator Access. The user name and password combination shall define accessible viewing, editing, adding, and deleting privileges for that operator. Users with system administrator rights shall be able to create new users and edit the privileges of all existing users. System administrators shall also be able to vary and deny each operator's privileges based on the geographic location, such as the ability to edit operating parameters in Building A, to view but not edit parameters in Building B, and to not even see equipment in Building C.

- .2 Password Policy Rules. System administrator shall invoke policies for minimum password strength, including number of characters, special characters and numbers, upper and lower case, etc.
- .3 Automatic Log Out. Automatically log out each operator if no keyboard or mouse activity is detected. This auto logoff time period shall be user-adjustable.
- .4 Encrypted Security Data. Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.
- .6 System Diagnostics. The system shall automatically monitor the operation of all building management panels and controllers. The failure of any device shall be annunciated to the operator.
- .7 Alarm Processing. System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as required by sequences of operation. Alarms shall be BACnet alarm objects and shall use BACnet alarm services. BMS system shall be capable of assigning alarm sources to categories such as HVAC Critical, or HVAC General. The BMS shall include at a minimum HVAC and FDD categories. BMS system shall allow user to create custom alarm categories.
- .8 Alarm Messages. Alarm messages shall use the English language descriptor for the object in alarm in such a way that the operator will be able to recognize the source, location, and nature of the alarm without relying on acronyms or mnemonics.
- .9 Alarm Reactions. Operator shall be able to configure (by object) what, if any actions are to be taken during an alarm. As a minimum, the workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send SMS text, and audibly annunciate.
- .10 Alarm and Event log. Operators shall be able to view all system alarms and changes of state from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and delete alarms, and archive closed alarms to the workstation or web server hard disk.
- .11 Trend Logs. The operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk. Configure trends as specified by the sequences of operation. Trends shall be BACnet trend objects.

- .12 Object and Property Status and Control. Provide a method for the operator to view, and edit if applicable, the status of any object or property in the system. The status shall be available by menu, on graphics, or through custom programs.
- .13 Reports and Logs. Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.
- .14 Audit and Security Detail. All users accessing the system shall have their actions recorded. Information recorded shall include:
 - .1 Login/logout time and date
 - .2 System modifications - with before and after values
 - .3 Ability to report user activity based on individual and/or date and time.
- .15 Standard Reports. Furnish the following standard system reports:
 - .1 Objects. System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.
 - .2 Alarm Summary. Current alarms and closed alarms. System shall retain closed alarms for an adjustable period.
 - .3 Logs. System shall log the following to a database or text file and shall retain data for an adjustable period:
 - .1 Alarm History.
 - .2 Trend Data. Operator shall be able to select trends to be logged.
- .16 Custom Reports. Operator shall be able to create custom reports that retrieve data, including archived trend data, from the system, that analyze data using common algebraic calculations, and that present results in tabular or graphical format. Reports shall be launched from the operator interface. Operator shall be able to schedule reports to automatically run and be emailed to recipients on a recurring basis from the BMS system.
- .6 Workstation Application Editors. Each PC or browser workstation shall support editing of all system applications. The applications shall be downloaded and executed at one or more of the controller panels.
 - .1 Controller. 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. An editor for the scheduling application shall be provided at each workstation. Provide a method of selecting the desired schedule and schedule type. Exception schedules and holidays shall be shown clearly on the calendar. The start and stop times for each object shall be adjustable from this interface.

- .3 Custom Application Programming. Provide the tools to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:
- .1 Language. Language shall be graphically based or English oriented. If graphically based, language shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks. If English language oriented, language shall be based on the syntax of BASIC, FORTRAN, C, or PASCAL, and shall allow for free-form programming that is not column-oriented or "fill-in-the-blanks."
 - .2 Programming Environment. Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operators shall be able to insert, add, modify, and delete custom programming code, and to copy blocks of code to a file library for reuse in other control programs.
 - .3 Independent Program Modules. Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.
 - .4 Debugging and Simulation. Operator shall be able to step through the program observing intermediate values and results. Operator shall be able to adjust input variables to simulate actual operating conditions. Operator shall be able to adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.
 - .5 Conditional Statements. Operator shall be able to program conditional logic using compound Boolean (AND, OR, and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
 - .6 Mathematical Functions. Language shall support floating-point addition, subtraction, multiplication, division, and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.
 - .7 Variables. Operator shall be able to use variable values in program conditional statements and mathematical functions.

- .1 Time Variables. Operator shall be able to use predefined variables to represent time of day, day of the week, month of the year, and date. Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours, and days. Operator shall be able to start, stop, and reset elapsed time variables using the program language.
- .2 System Variables. Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable, and change setpoints of Controller Software as described in Controller Software section.

2.4 CONTROLLER SOFTWARE

- .1 All controller software applications shall reside and operate in the system controllers.
- .2 All application software in controllers furnished by BMS manufacturer shall be editable through operator workstation, web browser interface, or workstation.
- .3 Each controller furnished by BMS manufacturer shall have all of its local on board software applications backed up and saved to the BMS web server. In the event of a controller failure, the BMS server shall download backed up software applications to replacement controller. Controllers furnished by others and integrated into the BMS are not required to be backed up to BMS server.
- .4 Furnish the following applications for building and energy management:
 - .1 System Security.
 - .2 Scheduling. Provide the capability to execute control functions according to a user created or edited schedule. Each schedule shall provide the following schedule options as a minimum:
 - .1 Weekly Schedule. Provide separate schedules for each day of the week. Each schedule shall be able to include up to 5 occupied periods (5 start-stop pairs or 10 events).
 - .2 Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule has executed, the system shall discard and replace the exception schedule with the standard schedule for that day of the week.
 - .3 Holiday Schedules. Provide the capability for the operator to define up to 24 special or holiday schedules. These schedules will be repeated each year. The operator shall be able to define the length of each holiday period.

- .3 System Coordination. Operator shall be able to group related equipment based on function and location and to use these groups for scheduling and other applications.
- .4 Binary Alarms. Each binary object shall have the capability to be configured to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.
- .5 Analog Alarms. Each analog object shall have both high and low alarm limits. The operator shall be able to enable or disable these alarms.
- .6 Alarm Reporting. The operator shall be able to determine the action to be taken in the event of an alarm. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display on graphics.
- .7 Remote Communication. System shall automatically contact operator workstation or server on receipt of critical alarms. If no network connection is available, system shall use a modem connection.
- .8 Demand Limiting.
 - .1 The demand-limiting program shall monitor building power consumption from a building power meter (provided by others) which generates pulse signals or a BACnet communications interface. An acceptable alternative is for the system to monitor a watt transducer or current transformer attached to the building feeder lines.
 - .2 When power consumption exceeds adjustable levels, system shall automatically adjust setpoints, de-energize low-priority equipment, and take other programmatic actions to reduce demand as specified in in sequences of operation. When demand drops below adjustable levels, system shall restore loads as specified.
- .9 Maintenance Management. The system shall be capable of generating maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits. Configure and enable maintenance alarms as specified in sequences of operation.
- .10 Sequencing. Application software shall sequence chillers, boilers, and pumps as specified in sequences of operation.
- .11 PID Control. System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog value that can be used to position an output or to stage a series of outputs. The calculation interval, PID gains, and other tuning parameters shall be adjustable by a user with the correct security level.
- .12 Staggered Start. System shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts.
- .13 Energy Calculations.

- .1 The system shall accumulate and convert instantaneous power (kW) or flow rates (L/s [gpm]) to energy usage data.
- .2 The system shall calculate a sliding-window average (rolling average). Operator shall be able to adjust window interval to 15 minutes, 30 minutes, or 60 minutes.
- .14 Anti-Short Cycling. All binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.
- .15 On and Off Control with Differential. Provide an algorithm that allows a binary output to be cycled based on a controlled variable and a setpoint. The algorithm shall be direct-acting or reverse-acting.
- .16 Runtime Totalization. Provide software to totalize runtime for each binary input and output. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit. Configure and enable runtime totalization and alarms as required by sequences of operation.

2.5 CONTROLLERS

- .1 General
 - .1 Provide an adequate number of Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), Smart Actuators (SA), and Smart Sensors (SS) as required to achieve performance specified by system performance. Every device in the system which executes control logic and directly controls HVAC equipment must conform to a standard BACnet Device profile as specified in ANSI/ASHRAE 135, BACnet Annex L. Unless otherwise specified, hardwired actuators and sensors may be used in lieu of communicating actuators, communicating sensors, BACnet Smart Actuators and BACnet Smart Sensors.
- .2 BACnet.
 - .1 Building Controllers (BCs). Each BC shall conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-BC in the BACnet Testing Laboratories (BTL) Product Listing.
 - .2 Advanced Application Controllers (AACs). Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.
 - .3 Application Specific Controllers (ASCs). Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.

- .4 Smart Actuators (SAs). An actuator which is controlled by a network connection rather than a binary or analog signal (0-10v, 4-20mA, relay, etc.). Each SA shall conform to BACnet Smart Actuator (B-SA) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-SA in the BACnet Testing Laboratories (BTL) Product Listing.
- .5 Smart Sensors (SSs). A sensor which provides information to the BAS via network connection rather than a binary or analog signal (0-10000 ohm, 4-20mA, dry contact, etc.). Each SS shall conform to BACnet Smart Sensor (B-SS) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-SS in the BACnet Testing Laboratories (BTL) Product Listing.
- .6 BACnet Communication.
 - .1 Each controller residing on the ethernet data link shall be capable of providing BACnet/SC capability as described in the above Communication Section.
 - .2 Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP or BACnet/SC.
 - .3 BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.
 - .4 Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol using BACnet/IP or BACnet/SC, or it shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
 - .5 Each ASC shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
 - .6 Each SA shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
 - .7 Each SS shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using ARCNET or MS/TP Data Link/Physical layer protocol.
- .3 Security.
 - .1 Provide BACnet firewall capability, as defined in the BACnet standard, for controllers that are IP capable.
- .4 Communication.
 - .1 Service Port. Each controller shall provide a service communication port for connection to a Portable Operator's Terminal.

- .2 Signal Management. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.
- .3 Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.
- .4 Stand-Alone Operation. Each piece of equipment shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network such as outdoor air conditions, supply air or water temperature coming from source equipment, etc.
- .5 Environment. Controller hardware shall be suitable for anticipated ambient conditions.
 - .1 Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -29°C to 60°C (-20°F to 140°F).
 - .2 Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).
- .6 Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to a field-removable modular terminal strip or to a termination card connected by a ribbon cable. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.
- .7 Real-time Clock. Controller shall have a real-time clock to keep track of time in the event of a power failure for up to three (3) days.
- .8 Memory.
 - .1 Controller memory shall support operating system, database, and programming requirements.
 - .2 Each controller shall use volatile memory with battery backed up memory or nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.
- .9 Immunity to Power and Noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
- .10 Transformer. Power supply shall be fused or current limiting and shall be rated at a minimum of 125% of controller power consumption.

2.6 INPUT AND OUTPUT INTERFACE

- .1 General. Hard-wire input and output points to BCs, AACs, or ASCs.
- .2 Protection. All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground shall cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no controller damage.
- .3 Binary Inputs. Binary inputs shall allow the monitoring of ON/OFF signals from remote devices. Binary inputs shall sense dry contact closure without application of power external to the controller.
- .4 Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to binary input requirements and shall also accumulate up to 10 pulses per second.
- .5 Analog Inputs. Analog inputs shall monitor low-voltage (0–10 Vdc), current (4–20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.
- .6 Binary Outputs. Binary outputs shall provide for ON/OFF operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on Building Controllers shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.
- .7 Analog Outputs. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0–10 Vdc or a 4–20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.
- .8 Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.
- .9 Universal Inputs and Outputs. Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

2.7 POWER SUPPLIES AND LINE FILTERING

- .1 Power Supplies. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in 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 150% current overload for at least three seconds without trip-out or failure.
 - .1 Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
 - .2 Line voltage units shall be UL recognized and CSA listed.
- .2 Power Line Filtering.
 - .1 Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:
 - .1 Dielectric strength of 1000 V 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 greater at 40–100 Hz

2.8 AUXILIARY CONTROL DEVICES

- .1 Motorized Control Dampers, unless otherwise specified elsewhere, shall be as follows:
 - .1 Type. Control dampers shall be the parallel- or opposed-blade type as specified below or as scheduled on drawings.
 - .1 Outdoor and return air mixing dampers and face-and-bypass dampers shall be parallel-blade and shall direct airstreams toward each other.
 - .2 Other modulating dampers shall be opposed-blade.
 - .3 Two-position shutoff dampers shall be parallel- or opposed-blade with blade and side seals.
 - .2 Frame. Damper frames shall be 2.38 mm (13 gauge) galvanized steel channel or 3.175 mm (1/8 in.) extruded aluminum with reinforced corner bracing.
 - .3 Blades. Damper blades shall not exceed 20 cm (8 in.) in width or 125 cm (48 in.) in length. Blades shall be suitable for medium velocity (10 m/s [2000 fpm]) performance. Blades shall be not less than 1.5875 mm (16 gauge).
 - .4 Shaft Bearings. Damper shaft bearings shall be as recommended by manufacturer for application, oil impregnated sintered bronze, or better.

- .5 Seals. Blade edges and frame top and bottom shall have replaceable seals of butyl rubber or neoprene. Side seals shall be spring-loaded stainless steel. Blade seals shall leak no more than 50 L/s·m² (10 cfm per ft²) at 1000 Pa (4 in. w.g.) differential pressure. Blades shall be airfoil type suitable for wide-open face velocity of 7.5 m/s (1500 fpm).
- .6 Sections. Individual damper sections shall not exceed 125 cm × 150 cm (48 in. × 60 in.). Each section shall have at least one damper actuator.
- .7 Modulating dampers shall provide a linear flow characteristic where possible.
- .8 Linkages. Dampers shall have exposed linkages.
- .2 Electric Damper and Valve Actuators.
 - .1 Stall Protection. Mechanical or electronic stall protection shall prevent actuator damage throughout the actuator's rotation.
 - .2 Spring-return Mechanism. Actuators used for power-failure and safety applications shall have an internal mechanical spring-return mechanism or an uninterruptible power supply (UPS).
 - .3 Signal and Range. Proportional actuators shall accept a 0–10 Vdc or a 0–20 mA control signal and shall have a 2–10 Vdc or 4–20 mA operating range. (Floating motor actuators may be substituted for proportional actuators in terminal unit applications as described in paragraph 2.6H.)
 - .4 Wiring. 24 Vac and 24 Vdc actuators shall operate on Class 2 wiring.
 - .5 Manual Positioning. Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 7 N·m (60 in.-lb) torque capacity shall have a manual crank.
- .3 Control Valves.
 - .1 Control valves shall be two-way or three-way type for two-position or modulating service as shown.
 - .2 Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:
 - .1 Water Valves:
 - .1 Two-way: 150% of total system (pump) head.
 - .2 Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.
 - .2 Steam Valves: 150% of operating (inlet) pressure.
 - .3 Water Valves.
 - .1 Body and trim style and materials shall be in accordance with manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.
 - .2 Sizing Criteria:

- .1 Two-position service: Line size.
 - .2 Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply and return mains, or 5 psi, whichever is greater.
 - .3 Three-way modulating service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), 35 kPa (5 psi) maximum.
- .3 Valves ½ in. through 2 in. shall be bronze body or cast brass ANSI Class 250, spring-loaded, PTFE packing, quick opening for two-position service. Two-way valves to have replaceable composition disc or stainless steel ball.
- .4 Valves 2½ in. and larger shall be cast iron ANSI Class 125 with guided plug and PTFE packing.
- .5 Water valves shall fail normally open or closed, as scheduled on plans, or as follows:
 - .1 Water zone valves—normally open preferred.
 - .2 Heating coils in air handlers—normally open.
 - .3 Chilled water control valves—normally closed.
 - .4 Other applications—as scheduled or as required by sequences of operation.
- .4 Steam Valves.
 - .1 Body and trim materials shall be in accordance with manufacturer's recommendations for design conditions and service with linear ports for modulating service.
 - .2 Sizing Criteria:
 - .1 Two-position service: pressure drop 10% to 20% of inlet psig.
 - .2 Modulating service: 100 kPa (15 psig) or less; pressure drop 80% of inlet psig.
 - .3 Modulating service: 101 to 350 kPa (16 to 50 psig); pressure drop 50% of inlet psig.
 - .4 Modulating service: over 350 kPa (50 psig); pressure drop as scheduled on plans.
- .4 Temperature Sensors.
 - .1 Type. Temperature sensors shall be thermistor (10k Type2).
 - .2 Duct Sensors. Duct sensors shall be single point or averaging as shown. Averaging sensors shall be a minimum of 1.5 m (5 ft) in length per 1 m²(10 ft²) of duct cross-section.

- .3 Immersion Sensors. Provide immersion sensors with a separable stainless steel well. Well pressure rating shall be consistent with system pressure it will be immersed in. Well shall withstand pipe design flow velocities.
- .4 Space Sensors. Space sensors shall have setpoint adjustment, override switch, display, and communication port as shown.
- .5 Differential Sensors. Provide matched sensors for differential temperature measurement.
- .5 Humidity Sensors.
 - .1 Duct and room sensors shall have a sensing range of 20%–80%.
 - .2 Duct sensors shall have a sampling chamber.
 - .3 Outdoor air humidity sensors shall have a sensing range of 20%–95% RH and shall be suitable for ambient conditions of -40°C–75°C (-40°F–170°F).
 - .4 Humidity sensors shall not drift more than 1% of full scale annually.
- .6 Flow Switches. Flow-proving switches shall be paddle (water service only) or differential pressure type (air or water service) as shown. Switches shall be UL listed, SPDT snap-acting, and pilot duty rated (125 VA minimum).
 - .1 Paddle switches shall have adjustable sensitivity and NEMA 1 enclosure unless otherwise specified.
 - .2 Differential pressure switches shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.
- .7 Relays.
 - .1 Control Relays. Control relays shall be plug-in type, UL listed, and shall have dust cover and LED “energized” indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
 - .2 Time Delay Relays. Time delay relays shall be solid-state plug-in type, UL listed and shall have adjustable time delay. Delay shall be adjustable $\pm 100\%$ from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.
- .8 Override Timers.
 - .1 Unless implemented in control software, override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration required by application. Provide 0–6 hour calibrated dial unless otherwise specified. Flush mount timer on local control panel face or where shown.
- .9 Current Transmitters.

- .1 AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4–20 mA two-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be $\pm 1\%$ full-scale 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.
- .10 Current Transformers.
 - .1 AC current transformers shall be UL/CSA recognized and shall be completely encased (except for terminals) in approved plastic material.
 - .2 Transformers shall be available in various current ratios and shall be selected for $\pm 1\%$ accuracy at 5 A full-scale output.
 - .3 Use fixed-core transformers for new wiring installation and split-core transformers for existing wiring installation.
- .11 Voltage Transmitters.
 - .1 AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4–20 mA output with zero and span adjustment.
 - .2 Adjustable full-scale unit ranges shall be 100–130 Vac, 200–250 Vac, 250–330 Vac, and 400–600 Vac. Unit accuracy shall be $\pm 1\%$ full-scale at 500 ohm maximum burden.
 - .3 Transmitters shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized at 600 Vac rating.
- .12 Voltage Transformers.
 - .1 AC voltage transformers shall be UL/CSA recognized, 600 Vac rated, and shall have built-in fuse protection.
 - .2 Transformers shall be suitable for ambient temperatures of 4°C–55°C (40°F–130°F) and shall provide $\pm 0.5\%$ accuracy at 24 Vac and 5 VA load.
 - .3 Windings (except for terminals) shall be completely enclosed with metal or plastic.
- .13 Power Monitors.
 - .1 Selectable rate pulse output for kWh reading, 4–20 mA output for kW reading, N.O. alarm contact, and ability to operate with 5.0 amp current inputs or 0–0.33 volt inputs.
 - .2 1.0% full-scale true RMS power accuracy, +0.5 Hz, voltage input range 120–600 V, and auto range select.
 - .3 Under voltage/phase monitor circuitry.
 - .4 NEMA 1 enclosure.

- .5 Current transformers having a 0.5% FS accuracy, 600 VAC isolation voltage with 0–0.33 V output. If 0–5 A current transformers are provided, a three-phase disconnect/shorting switch assembly is required.
- .14 Hydronic Flowmeters
 - .1 Insertion-Type Turbine Meter
 - .1 Dual counter-rotating axial turbine elements, each with its own rotational sensing system, and an averaging circuit to reduce measurement errors due to swirl and flow profile distortion. Single turbine for piping 2 inches and smaller. Flow sensing turbine rotors shall be non-metallic and not impaired by magnetic drag.
 - .2 Insertion type complete with 'hot-tap' isolation valves to enable sensor removal without water supply system shutdown.
 - .3 Sensing method shall be impedance sensing (non magnetic and non photoelectric)
 - .4 Volumetric accuracy
 - .1 $\pm 0.5\%$ of reading at calibrated velocity
 - .2 $\pm 1\%$ of reading from 3 to 30 ft/s (10:1 range)
 - .3 $\pm 2\%$ of reading from 0.4 to 20 ft/s (50:1 range)
 - .5 Each sensor shall be individually calibrated and tagged accordingly against the manufacturer's primary standards which must be accurate to within 0.1% of flow rate and traceable to the National Institute of Standards and Technology (NIST).
 - .6 Maximum operating pressure of 400 psi and maximum operating temperature of 95°C (200°F) continuous or 105°C (220°F) peak.
 - .7 All wetted metal parts shall be constructed of 316 stainless steel.
 - .8 Analog outputs shall consist of non interactive zero and span adjustments, a DC linearity of 0.1% of span, voltage output of 0-10 Vdc, and current output of 4-20 mA.
 - .2 Magnetic Flow-Tube Type Flowmeter
 - .1 Sensor shall be a magnetic flowmeter, which utilizes Faraday's Law to measure volumetric fluid flow through a pipe. The flowmeter shall consist of two elements, the sensor and the electronics. The sensor shall generate a measuring signal proportional to the flow velocity in the pipe. The electronics shall convert this EMF into a standard current output.
 - .2 Electronic replacement shall not affect meter accuracy (electronic units are not matched with specific sensors).

- .3 Four-wire, externally powered, magnetic type flow transmitter with adjustable span and zero, integrally mounted to flow tube. Output signal shall be a digital pulse proportional to the flow rate (to provide maximum accuracy and to handle abrupt changes in flow). Standard 4-20 mA or 0-10 Vdc outputs may be used provided accuracy is as specified.
- .4 Flow Tube:
 - .1 ANSI class 150 psig steel
 - .2 ANSI flanges
 - .3 Protected with PTFE, PFA, or ETFE liner rated for 102°C (245°F) minimum fluid temperature
- .5 Electrode and grounding material
 - .1 316L Stainless steel or Hastelloy C
 - .2 Electrodes shall be fused to ceramic liner and not require o-rings.
- .6 Electrical Enclosure: NEMA 4, 7
- .7 Approvals:
 - .1 UL or CSA
 - .2 NSF Drinking Water approval for domestic water applications
- .8 Performance
 - .1 Accuracy shall be $\pm 0.5\%$ of actual reading from 3 to 30 ft/s flow velocities, and 0.015 ft/s from 0.04 to 3 ft/s.
 - .2 Stability: 0.1% of rate over six months.
 - .3 Meter repeatability shall be $\pm 0.1\%$ of rate at velocities > 3 ft/s.
- .3 Magnetic Insertion-Type Flowmeter
 - .1 Magnetic Faraday point velocity measuring device.
 - .2 Insertion type complete with "hot-tap" isolation valves to enable sensor removal without water supply system shutdown.
 - .3 4-20 mA transmitter proportional to flow or velocity.
 - .4 Accuracy: larger of 1% of reading and 0.2 ft/s.
 - .5 Flow range: 0.2 to 20 ft/s, bidirectional.
 - .6 Each sensor shall be individually calibrated and tagged accordingly against the manufacturer's primary standards which must be accurate to within 0.1% of flow rate and traceable to the National Institute of Standards and Technology (NIST).
- .4 Vortex Shedding Flowmeter

- .1 Output: 4-20 mA, 0-10 Vdc, 0-5 Vdc.
 - .2 Maximum Fluid Temperature: 427 °C (800°F).
 - .3 Wetted Parts: Stainless Steel.
 - .4 Housing: NEMA 4X.
 - .5 Turndown: 25:1 minimum.
 - .6 Accuracy: 0.5% of calibrated span for liquids, 1% of calibrated span for steam and gases.
 - .7 Body: Wafer style or ANSI flanged to match piping specification.
- .5 Transit-Time Ultrasonic Flowmeter
 - .1 Clamp-On transit-time ultrasonic flowmeter
 - .2 Wide-Beam transducer technology
 - .3 4-20 mA transmitter proportional to flow or velocity.
 - .4 Accuracy: 0.5% of reading in range 1 to 30 ft/s, 0.001 ft/s sensitivity.
- .15 Thermal Energy Meters
 - .1 Matched RTD, solid state, or thermistor temperature sensors with a differential temperature accuracy of $\pm 0.08^{\circ}\text{C}$ ($\pm 0.15^{\circ}\text{F}$).
 - .2 Flow meter: See "Hydronic Flowmeters" section.
 - .3 Unit accuracy of $\pm 1\%$ factory calibrated, traceable to NIST with certification.
 - .4 NEMA 1 enclosure.
 - .5 Panel mounted display.
 - .6 UL listed.
 - .7 Isolated 4–20 ma signals for energy rate and supply and return temperatures and flow.
- .16 Current Switches.
 - .1 Current-operated switches shall be self-powered, solid-state with adjustable trip current. Select switches to match application current and DDC system output requirements.
- .17 Pressure Transducers.
 - .1 Transducers shall have linear output signal and field-adjustable zero and span.
 - .2 Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage.
 - .3 Water pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Transducer shall have 4–20 mA output, suitable mounting provisions, and block and bleed valves.

- .4 Water differential pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Over-range limit (differential pressure) and maximum static pressure shall be 2000 kPa (300psi.) Transducer shall have 4–20 mA output, suitable mounting provisions, and 5-valve manifold.
- .18 Differential Pressure Switches.
 - .1 Differential pressure switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.
- .19 Pressure-Electric (PE) Switches.
 - .1 Shall be metal or neoprene diaphragm actuated, operating pressure rated for 0–175 kPa (0–25 psig), with calibrated scale minimum setpoint range of 14–125 kPa (2–18 psig) minimum, UL listed.
 - .2 Provide one- or two-stage switch action (SPDT, DPST, or DPDT) as required by application. Electrically rated for pilot duty service (125 VA minimum) and/or for motor control.
 - .3 Switches shall be open type (panel-mounted) or enclosed type for remote installation. Enclosed type shall be NEMA 1 unless otherwise specified.
 - .4 Each pneumatic signal line to PE switches shall have permanent indicating gauge.
- .20 Occupancy Sensors.
 - .1 Occupancy sensors shall utilize Passive Infrared (PIR) and/or Microphonic Passive technology to detect the presence of people within a room. Sensors shall be mounted as indicated on the approved drawings. The sensor output shall be accessible by any lighting and/or HVAC controller in the system. Occupancy sensors shall be capable of being powered from the lighting or HVAC control panel, as shown on the drawings. Occupancy sensor delay shall be software adjustable through the user interface and shall not require manual adjustment at the sensor.

2.9 LOCAL CONTROL PANELS

- .1 Provide indoor control cabinets fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable subpanels. A single key shall be common to all field panels and subpanels.
- .2 Interconnections between internal and face-mounted devices shall be prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600 volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
- .3 Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.

2.10 WIRING AND RACEWAYS

- .1 General. Provide copper wiring, plenum cable, and raceways as specified in applicable sections of Division 26.
- .2 Insulated wire shall use copper conductors and shall be UL listed for 90°C (200°F) minimum service.

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 Consultant for resolution before rough-in work is started.
- .2 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 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 PROTECTION

- .1 Protect work and material from damage by his/her work or employees and assume liability for damage thus caused.
- .2 Be responsible for work and equipment until finally inspected, tested, and accepted. Protect any material that is not immediately installed. Close open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.3 COORDINATION

- .1 Site
 - .1 Where the mechanical work will be installed near, or will interfere with, work of other trades, assist in working out space conditions to make a satisfactory adjustment. If work is installed before coordination with other trades, to cause any interference with work of other trades, make the necessary changes in work to correct the condition without extra charge.
 - .2 Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.

- .2 Test and Balance.
 - .1 Furnish a single set of all tools necessary to interface to the control system for test and balance purposes.
 - .2 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, until the first 20 terminal units are balanced.
 - .4 The tools used during the test and balance process will be returned at the completion of the testing and balancing.
- .3 Life Safety.
 - .1 Duct smoke detectors required for air handler shutdown are provided by Others. Interlock smoke detectors to air handlers for shutdown as specified in sequences of operation.
 - .2 Smoke dampers and actuators required for duct smoke isolation are provided by Others. Interlock smoke dampers to air handlers as specified in sequences of operation.
 - .3 Fire and smoke dampers and actuators required for fire-rated walls are provided by Others. Fire and smoke damper control is provided by Others.
- .4 Coordinate 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. Integrate these controls into the system and coordinate as follows:
 - .1 Provide communication media and equipment as specified in above (Communication).
 - .2 Ensure each supplier of a controls product is responsible for the configuration, programming, start up, and testing of that product to meet the sequences of operation described in the Contract Documents.
 - .3 Coordinate and resolve incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.
 - .4 **Be responsible for providing controls described in the contract documents regardless of where within the contract documents these controls are described.**
 - .5 **Be responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.**

3.4 GENERAL WORKMANSHIP

- .1 Install equipment, piping, and wiring/raceway parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.

- .2 Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
- .3 Install equipment in readily accessible locations as defined by Chapter 1 Article 100 Part A of the National Electrical Code (NEC).
- .4 Verify integrity of wiring to ensure continuity and freedom from shorts and grounds.
- .5 Ensure equipment, installation, and wiring complies with industry specifications and standards for performance, reliability, and compatibility and is executed in strict adherence to local codes and standard practices.

3.5 FIELD QUALITY CONTROL

- .1 Ensure work, materials, and equipment complies with rules and regulations of applicable local, province, and federal codes and ordinances as identified in above in this Section.
- .2 Continually monitor the field installation for code compliance and quality of workmanship.
- .3 Facilitate inspection by local and/or provincial authorities having jurisdiction over the work.

3.6 WIRING

- .1 Ensure control and interlock wiring complies with national and local electrical codes, and Division 26 of this specification, Where the requirements of this section differ from Division 26, the requirements of this section shall take precedence.
- .2 Ensure NEC Class 1 (line voltage) wiring is UL listed in approved raceway according to NEC and Division 26 requirements.
- .3 Ensure low-voltage wiring meets NEC Class 2 requirements. Ensure low-voltage power circuits are subfused when required to meet Class 2 current limit.
- .4 Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL listed for the intended application.
- .5 Ensure wiring in mechanical, electrical, or service rooms – or where subject to mechanical damage – is installed in raceway at levels below 3 m (10ft).
- .6 Do not install Class 2 wiring in raceways containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).
- .7 Do not install wiring in raceway containing tubing.
- .8 Where Class 2 wiring is run exposed, run wiring parallel along a surface or perpendicular to it and neatly tied at 3 m (10 ft) intervals.

- .9 Where plenum cables are used without raceway, ensure they are 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 Ensure wire-to-device connections are made at a terminal block or terminal strip. Ensure wire-to-wire connections are at a terminal block.
- .11 Ensure wiring within enclosures is neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
- .12 Maximum allowable voltage for control wiring is 120 V. If only higher voltages are available, provide step-down transformers.
- .13 Ensure wiring is installed as continuous lengths, with no splices permitted between termination points.
- .14 Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at penetrations.
- .15 Ensure size of raceway and size and type of wire type conforms with the manufacturer's recommendations and CEC requirements, except as noted elsewhere.
- .16 Include one pull string in each raceway 2.5 cm (1 in.) or larger.
- .17 Use color-coded conductors throughout with conductors of different colors.
- .18 Locate control and status relays in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.
- .19 Conceal 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).
- .20 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.
- .21 Adhere to this specification's Division 26 requirements where raceway crosses building expansion joints.
- .22 Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of vertical raceways.
- .23 Terminate control and/or interlock wiring and maintain updated (as-built) wiring diagrams with terminations identified at the job site.
- .24 Ensure flexible metal raceways and liquid-tight flexible metal raceways do not exceed 1 m (3 ft) in length and shall be supported at each end. Flexible metal raceway less than ½ in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.

- .25 Ensure raceways are rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Join raceway sections with couplings (according to code). Make terminations with fittings at boxes and install bushings at ends not terminating in boxes.

3.7 COMMUNICATION WIRING

- .1 Adhere to the items listed in the "Wiring" article in Part 3 of the specification.
- .2 Install cabling in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling
- .3 Do not install communication wiring in raceways and enclosures containing Class 1 or other Class 2 wiring.
- .4 Maximum pulling, tension, and bend radius for the cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.
- .5 Verify the integrity of the entire network following cable installation. Use appropriate test measures for each particular cable.
- .6 When a cable enters or exits a building, install a lightning arrestor between the lines and ground. Install the lightning arrestor according to manufacturer's instructions.
- .7 Ensure runs of communication wiring are unspliced length when that length is commercially available.
- .8 Label communication wiring to indicate origination and destination data.
- .9 Ensure grounding of coaxial cable is in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."
- .10 Install BACnet IP, Arcnet, or MS/TP communications wiring in accordance with ASHRAE/ANSI Standard 135. This includes but is not limited to:
 - .1 IP
 - .1 Use Cat5e or greater cabling for connections.
 - .2 Custom made patch cables must use either the T568A or T568 wiring standard and must use the same standard on both ends of the cable.
 - .2 Arcnet
 - .1 Provide shielded, twisted-pair cable with characteristic impedance between 100 nominal. Distributed capacitance between conductors shall be less than 12.5 pF per foot (41 pF per meter.)
 - .2 The maximum length of an Arcnet segment is 610 meters (2000 ft) with AWG 22 cable.
 - .3 The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated by the use of repeaters.
 - .4 An Arcnet network shall have no T connections

.3 MS/TP

- .1 Provide shielded, twisted-pair cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 100 pF per meter (30 pF per foot.)
- .2 The maximum length of an MS/TP segment is 1200 meters (4000 ft) with AWG 18 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.
- .3 The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated by the use of repeaters.
- .4 An MS/TP EIA-485 network shall have no T connections.

3.8 FIBRE OPTIC CABLE

- .1 Do not exceed maximum pulling tensions as specified by the cable manufacturer during installation. Ensure post-installation residual cable tension is within cable manufacturer's specifications.
- .2 Install cabling and associated components in accordance with manufacturers' instructions. Maintain minimum cable andunjacketed fiber bend radii, as specified by cable manufacturer.

3.9 INSTALLATION OF SENSORS

- .1 Install sensors in accordance with the manufacturer's recommendations.
- .2 Mount sensors rigidly and adequately for environment within which the sensor operates.
- .3 Install room temperature sensors on concealed junction boxes properly supported by wall framing.
- .4 Seal wires attached to sensors in their raceways or in the wall to stop air transmitted from other areas from affecting sensor readings.
- .5 Provide sensors used in mixing plenums and hot and cold decks of the averaging type. Install averaging sensors in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
- .6 Install low-limit sensors used in mixing plenums 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 1 m² (1 ft²) of coil area.
- .7 Do not install temperature sensors within the vapor plume of a humidifier. If installing a sensor downstream of a humidifier, install it at least 3 m (10 ft) downstream.
- .8 Install pipe-mounted temperature sensors in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

- .9 Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.
- .10 Differential Air Static Pressure.
 - .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 high-pressure tap to 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 Ensure the piping to the pressure ports on pressure transducers contains a capped test port located adjacent to the transducer.
 - .5 Ensure pressure transducers, other than those controlling VAV boxes, are 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.
 - .6 Ensure air and water differential pressure sensors gauge tees mounted adjacent to the taps. Ensure water gauges have shut-off valves installed before the tee.
- .11 Hard-wire smoke detectors, freezestats, high-pressure cut-offs, and other safety switches to de-energize equipment as described in the sequence of operation. Ensure switches require manual reset. Provide contacts that allow DDC software to monitor safety switch status.
- .12 Install humidity sensors for duct mounted humidifiers at least 3 m (10 ft) downstream of the humidifier. Do not install filters between the humidifier and the sensor.

3.10 FLOW SWITCH INSTALLATION

- .1 Use correct paddle for pipe diameter.
- .2 Adjust flow switch according to manufacturer's instructions.

3.11 ACTUATOR INSTALLATION

- .1 General. Mount and link control damper actuators according to manufacturer's instructions.

- .1 To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
- .2 Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
- .3 Provide mounting hardware and linkages for actuator installation.
- .2 Electric/Electronic
 - .1 Dampers: Direct mount actuators 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° travel available for tightening the damper seal. Mount actuators following manufacturer's recommendations.
 - .2 Valves: Connect actuators to valves with adapters approved by the actuator manufacturer. Mount actuators and adapters following the actuator manufacturer's recommendations.

3.12 WARNING LABELS

- .1 Affix permanent warning labels to equipment that can be automatically started by the control system.
 - .1 Provide labels with white lettering (12-point type or larger) on a red background.
 - .2 Provide label text as follows.
 - .1 **C A U T I O N: This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to "Off" position before servicing.**
- .2 Affix permanent warning labels to motor starters and control panels that are connected to multiple power sources utilizing separate disconnects.
 - .1 Provide labels with white lettering (12-point type or larger) on a red background.
 - .2 Provide label text as follows.
 - .1 **C A U T I O N: This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.**

3.13 IDENTIFICATION OF HARDWARE AND WIRING

- .1 Label wiring and cabling, including that within factory-fabricated panels at each end within 5 cm (2 in.) of termination with control system address or termination number.

- .2 Label pneumatic tubing at each end within 5 cm (2 in.) of termination with a descriptive identifier.
- .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 (½ in.) letters on laminated plastic nameplates.
- .5 Identify other control components with permanent labels. Label plug-in components such that removal of the component does not remove the label.
- .6 Identify room sensors related to terminal boxes or valves with nameplates.
- .7 Ensure manufacturers' nameplates and UL or CSA labels are visible and legible after equipment is installed.
- .8 Ensure identifiers match record documents.

3.14 CONTROLLERS

- .1 Provide a separate controller for each AHU or other HVAC system. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.
- .2 Select building Controllers and Custom Application Controllers to provide the required I/O point capacity required to monitor the hardware points listed in sequences of operation.

3.15 PROGRAMMING

- .1 Provide sufficient internal memory for the specified sequences of operation and trend logging.
- .2 Point Naming. Coordinate with owner for point naming conventions. Name points as shown on the equipment points list provided with each sequence of operation or as directed by owner. If character limitations or space restrictions make it advisable to shorten the name, abbreviations as coordinated with owner may be used. Where multiple points with the same name reside in the same controller, each point name may be customized with its associated Program Object number. For example, "Zone Temp 1" for Zone 1, "Zone Temp 2" for Zone 2.
- .3 Software Programming.
 - .1 Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the contractor. Embed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Use the appropriate technique based on the following programming types:

- .1 Text-based:
 - .1 Must provide actions for all possible situations
 - .2 Must be modular and structured
 - .3 Must be commented
- .2 Graphic-based:
 - .1 Must provide actions for all possible situations
 - .2 Must be documented
- .3 Parameter-based:
 - .1 Must provide actions for all possible situations
 - .2 Must be documented.
- .4 Operator Interface.
 - .1 Standard Graphics. Provide graphics for mechanical systems and floor plans of the building. This includes each chilled water system, hot water system, chiller, boiler, air handler, and all terminal equipment. Point information on the graphic displays shall dynamically update. Show on each graphic all input and output points for the system. Also show relevant calculated points such as setpoints. As a minimum, show on each equipment graphic the input and output points and relevant calculated points as indicated on the applicable Points List or sequence of operation.
 - .2 Provide the labor necessary to install, initialize, start up, and troubleshoot operator interface software and its functions as described in this section. This includes any operating system software, the operator interface database, and any third-party software installation and integration required for successful operation of the operator interface.

3.16 CONTROL SYSTEM CHECKOUT AND TESTING

- .1 Startup Testing. Perform testing listed in this article as part of the necessary verification of an operating control system. Complete this testing before the owner's representative is notified of the system demonstration.
 - .1 Furnish labor and test apparatus required to calibrate and prepare for service of instruments, controls, and accessory equipment furnished under this specification.
 - .2 Verify that 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 input devices individually. Perform calibration procedures according to manufacturers' recommendations.

- .4 Verify that 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 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.
- .7 Alarms and Interlocks:
 - .1 Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
 - .2 Trip interlocks using field contacts to check the logic, as well as to ensure that the fail-safe condition for actuators is in the proper direction.
 - .3 Test interlock actions by simulating alarm conditions to check the initiating value of the variable and interlock action.

3.17 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

- .1 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. Notify the Consultant at least 10 days in advance of the start of the testing procedures.
 - .3 Follow the demonstration process that approved in Part 1, "Submittals." Complete the approved system checklists and forms as part of the demonstration.
 - .4 Provide at least two persons equipped with two-way communication to 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, complete a log 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 each mode of operation.
- .8 Demonstrate complete operation of operator interface.
- .9 Additionally, demonstrate the following items:
 - .1 DDC loop response. 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. 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. 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 Submit operational logs for each system that indicate set points, operating points, valve positions, mode, and equipment status to the 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.
- .10 Repeat tests that fail to demonstrate the operation of the system at a later date. Be responsible for necessary repairs or revisions to the hardware or software to successfully complete all tests.
- .2 Acceptance.
 - .1 Perform tests described in this specification to the satisfaction of both the Consultant and Owner as a pre-condition 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. Perform such tests as part of the warranty.

- .2 The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in Part 1, "Submittals."

3.18 CLEANING

- .1 Clean up debris resulting from his/her activities daily. Remove cartons, containers, crates, etc., as soon as their contents have been removed. Collect waste and place in a designated location.
- .2 At the completion of work in any area, clean work, equipment, etc., keeping it free from dust, dirt, and debris, etc.
- .3 At the completion of work, check equipment furnished under this section for paint damage, and repair any factory-finished paint that has been damaged to match the adjacent areas. Replace cabinets or enclosures that has been deformed with new material and repaint to match the adjacent areas.

3.19 TRAINING

- .1 Provide training for a designated staff of Owner's representatives. Training shall be provided via self-paced training, web-based or computer-based training, classroom training, or a combination of training methods.
- .2 Ensure training enables students to accomplish the following objectives.
 - .1 Day-to-day Operators:
 - .1 Proficiently operate the system
 - .2 Understand control system architecture and configuration
 - .3 Understand DDC system components
 - .4 Understand system operation, including DDC system control and optimizing routines (algorithms)
 - .5 Operate the workstation and peripherals
 - .6 Log on and off the system
 - .7 Access graphics, point reports, and logs
 - .8 Adjust and change system set points, time schedules, and holiday schedules
 - .9 Recognize malfunctions of the system by observation of the printed copy and graphical visual signals
 - .10 Understand system drawings and Operation and Maintenance manual
 - .11 Understand the job layout and location of control components
 - .12 Access data from DDC controllers and ASCs
 - .13 Operate portable operator's terminals

- .2 Advanced Operators:
 - .1 Make and change graphics on the workstation
 - .2 Create, delete, and modify alarms, including annunciation and routing of these
 - .3 Create, delete, and modify point trend logs and graph or print these both on an ad-hoc basis and at user-definable time intervals
 - .4 Create, delete, and modify reports
 - .5 Add, remove, and modify system's physical points
 - .6 Create, modify, and delete programming
 - .7 Add panels when required
 - .8 Add operator interface stations
 - .9 Create, delete, and modify system displays, both graphical and others
 - .10 Perform DDC system field checkout procedures
 - .11 Perform DDC controller unit operation and maintenance procedures
 - .12 Perform workstation and peripheral operation and maintenance procedures
 - .13 Perform DDC system diagnostic procedures
 - .14 Configure hardware including PC boards, switches, communication, and I/O points
 - .15 Maintain, calibrate, troubleshoot, diagnose, and repair hardware
 - .16 Adjust, calibrate, and replace system components
- .3 System Managers/Administrators:
 - .1 Maintain software and prepare backups
 - .2 Interface with job-specific, third-party operator software
 - .3 Add new users and understand password security procedures
- .3 Organize the training into sessions or modules for the three levels of operators listed above. (Day-to-Day Operators, Advanced Operators, System Managers and Administrators). Students will receive one or more of the training packages, depending on knowledge level required.
- .4 Provide course outline and materials according to the "Submittals" article in Part 1 of this specification. Provide one copy of training material per student.
- .5 Ensure the instructor(s) are factory-trained and experienced in presenting this material.
- .6 Ensure classroom training is done using a network of working controllers representative of installed hardware.

3.20 CONTROL VALVE INSTALLATION

- .1 Coordinate valve submittals for type, quantity, size, and piping configuration to ensure compatibility with pipe design.
- .2 Install slip-stem control valves so that the stem position is not more than 60 degrees from the vertical up position. Install ball type control valves with the stem in the horizontal position.
- .3 Install valves in accordance with the manufacturer's recommendations.
- .4 Install control valves 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.
- .5 Install sufficient isolation valves so that the control valve body may be serviced without draining the supply/return side piping system. Provide unions at connections to screw-type control valves.
- .6 Provide tags for all control valves indicating service and number. Provide brass, 1.5 inch in diameter, with ¼ inch high letters. Securely fasten with chain and hook. Match identification numbers as shown on approved controls shop drawings.

3.21 CONTROL DAMPER INSTALLATION

- .1 Coordinate damper submittals for type, quantity, and size to ensure compatibility with sheet metal design.
- .2 Ensure duct openings are free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting. Ensure duct openings measure ¼ in. larger than damper dimensions and are square, straight, and level.
- .3 Ensure individual damper sections, as well as entire multiple section assemblies, are completely square and free from racking, twisting, or bending. Measure diagonally from upper corners to opposite lower corners of each damper section. Ensure both dimensions are within 0.3 cm (1/8 in.) of each other.
- .4 Follow the manufacturer's instructions for field installation of control dampers. Unless specifically designed for vertical blade application, mount dampers 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 Ensure damper blades, axles, and linkage operate without binding. Before system operation, cycle damper after installation to ensure proper operation. On multiple section assemblies, ensure 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.

3.22 SMOKE AND COMBINATION FIRE/SMOKE DAMPER INSTALLATION

- .1 Coordinate smoke and smoke/fire damper installation, wiring, and checkout to ensure that these dampers function properly and that they respond to the proper fire alarm system general, zone, and/or detector trips. Immediately report any discrepancies to the Consultant no less than two weeks prior to inspection by the code authority having jurisdiction.
- .2 Provide complete submittal data to controls system subcontractor for coordination of duct smoke detector interface to HVAC systems.

3.23 DUCT SMOKE DETECTION

- .1 Submit data for coordination of duct smoke detector interface to HVAC systems as required in Part 1, "Submittals."
- .2 Provide a dry-contact alarm output in the same room as the HVAC equipment to be controlled.

3.24 START-UP AND CHECKOUT PROCEDURES

- .1 Start up, check out, and test hardware and software and verify communication between components.
 - .1 Verify that control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
 - .2 Verify that analog and binary input/output points read properly.
 - .3 Verify alarms and interlocks.
 - .4 Verify operation of the integrated system.

3.25 PAINTING

- .1 Painting: in accordance with Division 09 - Interior Painting, supplemented as follows:
 - .1 Clean and touch up marred or scratched surfaces of factory finished equipment to match original finish.
 - .2 Restore to new condition, finished surfaces too extensively damaged to be primed and touched up to make good.
 - .3 Clean and prime exposed hangers, racks, fastenings, and other support components.

- .4 Paint unfinished equipment installed indoors to EEMAC 2Y-1.

END OF SECTION

1. GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Refer to Section 23 01 01.

1.1 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for electric and electronic control system for HVAC and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

1.2 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Section 01 61 00 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials off ground, indoors, in a dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect electric and electronic control systems from nicks, scratches, blemishes, theft, vandalism, and vermin.
 - .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction Waste Management Plan in accordance with Section 01 74 19 - Waste Management and Disposal.

2. PRODUCTS

2.1 THERMOSTAT (LINE VOLTAGE-HEATING AND COOLING)

- .1 Line voltage, wall-mounted thermostat, for heating, cooling, or heating-cooling as applicable with:
 - .1 Full load rating: 16 A at 120 V.
 - .2 Temperature setting range: 5 degrees C to 30 degrees C.
 - .3 Thermometer range: 5 degrees C to 30 degrees C.
 - .4 Markings in 5 degree increments.
 - .5 Differential temperature fixed at 1.1 degrees C.

2.2 THERMOSTAT (HEAVY-DUTY, LINE VOLTAGE, HEATING AND COOLING)

- .1 Heavy-duty line voltage thermostat for heating, cooling, electric heating, heating/cooling with manual changeover, two- stage heating or cooling, or heating/cooling automatic changeover as applicable with:
 - .1 Full load rating: 16 A at 120 V.
 - .2 Temperature setting range: 5 degrees C to 30 degrees C.
 - .3 Thermometer range: 5 degrees C to 30 degrees C.
 - .4 Markings in 5 degree increments.
 - .5 Differential temperature fixed at 1.1 degrees C.

2.3 THERMOSTAT (LINE VOLTAGE, HEATING)

- .1 Line voltage wall mounted electric heating thermostat with:
 - .1 Full load rating: 22 A at 120 V.
 - .2 Temperature setting range: 5 degrees C to 30 degrees C.
 - .3 Double pole.
 - .4 Thermometer range: 5 degrees C to 30 degrees C.
 - .5 Scale markings: off-5-10-15-20-25 degrees C.

2.4 THERMOSTAT (LOW VOLTAGE)

- .1 Low voltage wall thermostat:
 - .1 For use on 24 V circuit at 1.5 A capacity.
 - .2 With heat anticipator adjustable 0.1 to 1.2 A.
 - .3 Temperature setting range: 10 degrees C to 25 degrees C.
 - .4 Sub-base.

2.5 THERMOSTAT (REMOTE BULB)

- .1 Line voltage remote bulb type thermostat with:
 - .1 30 A rating on 120 V.
 - .2 3 m copper capillary tube nylon coated.
 - .3 Moisture and dust-resistant enclosure.

2.6 THERMOSTAT (FAN COIL)

- .1 Line voltage fan coil heating-cooling thermostat with:
 - .1 Full load rating: 6 A at 120 V.
 - .2 Four position fan switches for "Low- Medium-High-Off" fan switch.
 - .3 "Heat-Cool" switch and fan "Off" switch. Fan "Off" switch to break all circuits except heating.
 - .4 Two rocker switches for "Heat-Off-Cool" and "Low-Medium-High" fan switching. Isolate heating and cooling circuits. "Off" switch to break power to fan and thermostat.

2.7 THERMOSTAT GUARDS

- .1 Thermostat guards: lockable, clear plastic. Slots for air circulation to thermostat.

2.8 LOW LIMIT TEMPERATURE ALARM

- .1 Low limit temperature alarm with:
 - .1 Rating: 10.2 A at 120 V.
 - .2 Sensing bulb and 6 m long capillary tube.
 - .3 Switching action: manual.
 - .4 Temperature setting range: 0 degrees C to 15 degrees C.

2.9 HIGH LIMIT TEMPERATURE ALARM

- .1 High limit temperature alarm with:
 - .1 Rating 10 A at 120 V.
 - .2 Positive lock-out.
 - .3 Manual reset only after 14 degrees C drop-in temperature.
 - .4 Cutout setting: 50 degrees C.

2.10 SAIL SWITCH

- .1 Sail switch, [mercury bulb] type with [stainless steel] sail, adjustable range set for m/s air velocity. Full load: 10A at 120 V. Maximum ambient temperature: 82 degrees C.

2.11 FLOW SWITCH

- .1 Flow switch for water, pipe size as indicated, rated at 16 A at 120 V. Maximum liquid temperature: 121 degrees C. Maximum liquid gauge pressure of 1034 kPa ambient temperature range 0 degrees C to 82 degrees C.

2.12 PRESSURE SWITCH

- .1 Pressure switch for air, water or steam as applicable with manual reset, contacts open on rise. Maximum allowable gauge pressure of 1.2 MPa. Full load 16 A at 120 V, ULC rated.

2.13 PNEUMATIC ELECTRIC SWITCH

- .1 Pneumatic electric switch to convert pneumatic signal to two position electric switch action with: maximum safe air gauge pressure 1035 kPa. Setpoint range: 21 to 126 kPa. Fixed differential 14 to 90 kPa. Maximum temperature ambient: 52 degrees C. NEMA 12, full load rating at 8 A at 120 V.

3. EXECUTION

3.1 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for electric and electronic control systems installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Consultant.
 - .2 Inform Consultant of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied [and after receipt of written approval to proceed from Consultant.

3.2 INSTALLATION

- .1 Install control devices.
- .2 On outside wall, mount thermostats on bracket or insulated pad 25 mm from exterior wall.
- .3 Install remote sensing device and capillary tube in metallic conduit. Conduit enclosing capillary tube must not touch heater or heating cable.

3.3 CLEANING

- .1 Progress Cleaning: clean in accordance with Section 01 74 00 - Cleaning.
 - .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.
 - .1 Waste Management: separate waste materials for reuse and recycling in accordance with Section 01 74 19 - Waste Management and Disposal. Remove recycling containers and bins from site and dispose of materials at appropriate facility.

END OF SECTION

1. GENERAL

1.1 RELATED REQUIREMENTS

- .1 Section 23 01 01.

1.2 REFERENCE STANDARDS

- .1 American Society of Mechanical Engineers (ASME)
 - .1 ASME B16.22, Wrought Copper and Copper Alloy Solder - Joint Pressure Fittings.
 - .2 ASME B16.24, Cast Copper Pipe Flanges and Flanged Fittings: Class 150, 300, 600, 900, 1500 and 2500.
 - .3 ASME B16.26, Cast Copper Alloy Fittings for Flared Copper Tubes.
 - .4 ASME B31.5, Refrigeration Piping and Heat Transfer Components.
- .2 ASTM International (ASTM)
 - .1 ASTM A307, Standard Specification for Carbon Steel Bolts and Studs, and Threaded Rod 60,000 PSI Tensile Strength.
 - .2 ASTM B280, Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
- .3 CSA Group (CSA)
 - .1 CSA B52 - Package, Mechanical Refrigeration Code.
- .4 Environment Canada (EC)
 - .1 EPS 1/RA/1, Environmental Code of Practice for the Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems.

1.3 SHOP DRAWING SUBMITTALS

- .1 Submit in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for refrigerant piping, fittings and equipment and include product characteristics, performance criteria, physical size, finish and limitations.
 - .2 Submit WHMIS SDS in accordance with Division 01 - Health and Safety Requirements. Indicate VOC's for adhesive and solvents during application and curing.
- .3 Test Reports: submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.
- .4 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

1.4 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Division 01 - Closeout Submittals.

- .2 Operation and Maintenance Data: submit operation and maintenance data for refrigerant piping for incorporation into manual.
- .3 Submit operation and maintenance manual.

1.5 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials off ground, indoors, in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect refrigerant piping, fittings and equipment from nicks, scratches, blemishes, theft, vermin and vandalism.
 - .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.

2. PRODUCTS

2.1 TUBING

- .1 Processed for refrigeration installations, deoxidized, dehydrated and sealed.
 - .1 Hard copper: to ASTM B280, type ACR.
 - .2 Annealed copper: to ASTM B280, with minimum wall thickness as per CSA B52 and ASME B31.5.

2.2 FITTINGS

- .1 Service: design pressure 2070 kPa and temperature 121 degrees C.
- .2 Brazed:
 - .1 Fittings: wrought copper to ASME B16.22.
 - .2 Joints: silver solder, 15% Ag-80% Cu-5%P or copper-phosphorous, 95% Cu-5%P and non-corrosive flux.
- .3 Flanged:
 - .1 Bronze or brass, to 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 ASME B16.26.

2.3 PIPE SLEEVES

- .1 Hard copper or steel, sized to provide 6 mm clearance around between sleeve and uninsulated pipe or between sleeve and insulation.

2.4 VALVES

- .1 22 mm and under: Class 500, 3.5 Mpa, 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: Class 375, 2.5 Mpa, 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.

3. EXECUTION

3.1 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for refrigerant piping installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Consultant.
 - .2 Inform Consultant of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Consultant.

3.2 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.3 GENERAL

- .1 Install in accordance with CSA B52, EPS1/RA/1 and ASME B31.5 and Section 23 05 05 - Installation of Pipework.

3.4 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.

3.5 PIPING INSTALLATION

- .1 General:
 - .1 Soft annealed copper tubing: bend without crimping or constriction
 - .2 Hard drawn copper tubing: do not bend. Minimize use of fittings.

- .2 Hot gas lines:
 - .1 Pitch at least 1:240 down in direction of flow to prevent oil return to compressor during operation.
 - .2 Provide trap at base of risers greater than 2400 mm high and at each 7600 mm thereafter.
 - .3 Provide inverted deep trap at top of risers.
 - .4 Provide double risers for compressors having capacity modulation.
 - .1 Large riser: install traps as specified.
 - .2 Small riser: size for 5.1 m³/s at minimum load. Connect upstream of traps on large riser.

3.6 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 and 1 MPa on high and low sides respectively.
- .3 Test procedure: build pressure up to 35 kPa 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.

3.7 FIELD QUALITY CONTROL

- .1 Site Tests/Inspection:
 - .1 Close service valves on factory charged equipment.
- .2 Ambient temperatures to be at least 13°C for at least 12 hours before and during dehydration.
- .3 Use copper lines of largest practical size to reduce evacuation time.
- .4 Use two-stage vacuum pump with gas ballast on 2nd stage capable of pulling 5 Pa 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 system components containing gases other than correct refrigerant or having lost holding charge as follows:
 - .1 Twice to 14 Pa absolute and hold for 4 hours.
 - .2 Break vacuum with refrigerant to 14 kPa.
 - .3 Final to 5 Pa absolute and hold for at least 12 hours.
 - .4 Isolate pump from system, record vacuum and time readings until stabilization of vacuum.
 - .5 Submit 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 checks and measurements as per manufacturer's operation and maintenance instructions.
 - .2 Record and report measurements to Consultant.
- .9 Manufacturer's Field Services:
 - .1 Have manufacturer of products, supplied under this Section, review Work involved in the handling, installation/application, protection and cleaning, of its product[s] and submit written reports, in acceptable format, to verify compliance of Work with Contract.
 - .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
 - .3 Schedule site visits, to review Work, at stages listed:
 - .1 After delivery and storage of products, and when preparatory Work, or other Work, on which the Work of this Section depends, is complete but before installation begins.
 - .2 Twice during progress of Work at 25% and 60% complete.
 - .3 Upon completion of the Work, after cleaning is carried out.
 - .4 Obtain reports, within three days of review, and submit, immediately, to Consultant.

3.8 DEMONSTRATION

- .1 Instructions:
 - .1 Post instructions in frame with glass cover in accordance with Division 01 - Closeout Submittals and CSA B52.

3.9 CLEANING

- .1 Progress Cleaning: clean in accordance with Division 01 - Cleaning.
 - .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Division 01 - Cleaning.
- .3 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.
 - .1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

END OF SECTION

1. GENERAL

1.1 RELATED REQUIREMENTS

- .1 Section 23 01 01.

1.2 REFERENCE STANDARDS

- .1 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
- .2 ASTM International (ASTM)
 - .1 ASTM A240/A240M, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip.
 - .2 ASTM A635/A635M, Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Alloy, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, General Requirements for.
 - .3 ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.
 - .4 ASTM B209/B209M, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
- .3 National Fire Protection Association (NFPA)
 - .1 NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
 - .2 NFPA 90B, Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
 - .3 NFPA 91, Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particular Solids.
 - .4 NFPA 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
- .4 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
 - .1 SMACNA HVAC Duct Construction Standards - Metal and Flexible.
 - .2 SMACNA HVAC Air Duct Leakage Test Manual.
- .5 South Coast Air Quality Management District (SCAQMD), California State, Regulation XI. Source Specific Standards

- .1 SCAQMD Rule 1168, Adhesives and Sealants Applications.
- .6 American Welding Society (AWS)
 - .1 AWS B2.2, Brazing Procedures and Performance Qualifications
 - .2 AWS D9.1, Sheet Metal Welding Code

1.3 SHOP DRAWING SUBMITTALS

- .1 Submit in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for metal ducts and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:
 - .1 Submit specifically for the following:
 - .1 Plenum and plenum-related items showing physical dimensions, joints, sealants, door construction, and hardware.
 - .2 Factory fabricated ducts, fittings, and joining systems.
 - .2 Submit changes or alterations in ductwork layout with supporting calculations for pressure drop.
- .4 Test and Evaluation Reports:
 - .1 Certification of Ratings:
 - .1 Catalogue or published ratings to be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.

1.4 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials off ground, indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect ducts from nicks, scratches, blemishes, theft, vandalism and vermin.
 - .3 Replace defective or damaged materials with new.

- .4 Handle and install ductwork in accordance with the advanced level described in SMACNA Duct Cleanliness for New Construction Guidelines.
 - .5 Seal ductwork either by blanking or capping duct ends, bagging small fittings, surface wrapping or shrink wrapping.
 - .6 Wipe internal surfaces of the uninsulated ductwork to remove excess dust immediately prior to installation.
 - .7 Seal open ends on completed ductwork and overnight work-in-progress.
 - .8 Firmly fit access covers position on completion of each section of the work.
 - .9 Keep protective coverings in place until immediately before installation.
 - .10 Close open ends of ductwork with temporary metal or polyethylene seals to prevent entry of dust and debris during construction.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.

1.5 QUALITY ASSURANCE

- .1 Perform Work to SMACNA - HVAC Duct Construction Standards - Metal and Flexible and ASHRAE standards.
- .2 Perform Duct Leakage Testing to SMACNA "HVAC Air Duct Leakage Testing Manual"
- .3 Brazing: Certify brazing procedures, brazers, and operators in accordance with AWS B2.2 Brazing Procedures and Performance Qualifications
- .4 Welding: Certify welding procedures, welding equipment and welders in accordance with AWS D9.1 Sheet Metal Welding Code.
- .5 No variation of duct configuration or sizes permitted except by written permission.
- .6 Size round ducts installed in place of rectangular ducts to ASHRAE table of equivalent rectangular and round ducts.
- .7 Sizes indicated on drawings are clear inside dimensions and do not include for duct linings.

2. PRODUCTS

2.1 DUCT CONSTRUCTION

- .1 Duct Construction Schedule

Duct Application	Duct Pressure	Pressure Class (Pa)	Seal Class	Leakage Class
Rectangular HVAC Supply from AHU to terminal unit or reheat coil	Positive	1000	A	6
Round HVAC Supply from AHU to terminal unit or reheat coil	Positive	1000	A	3
Rectangular HVAC Supply from terminal unit or reheat coil to air outlet	Positive	500	A	6
Round HVAC Supply from terminal unit or reheat coil to air outlet	Positive	500	A	3
Rectangular HVAC Single zone supply from AC Unit to air outlet	Positive	500	A	6
Round HVAC Single zone supply from AC Unit to air outlet	Positive	500	A	3
Rectangular HVAC Return from air outlet to AHU	Negative	500	A	6
Round HVAC Return from air outlet to AHU	Negative	500	A	3
Rectangular Sanitary exhaust ductwork	Negative	500	A	6
Round Sanitary exhaust ductwork	Negative	500	A	3
Rectangular General HVAC exhaust ductwork	Negative	500	A	6
Round General HVAC exhaust ductwork	Negative	500	A	3
Exhaust fan discharge ductwork	Positive	500	A	0
Kitchen exhaust duct	Negative	1000	A	0
<u>Notes:</u> 1. Pressure class shall be the lower of exhaust fan shut-off pressure or value shown				

2.2 SEAL CLASSIFICATION

- .1 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 airtight with gaskets and/or sealant. Longitudinal seams unsealed.

2.3 SEALANT

- .1 Sustainability Characteristics:
 - .1 Adhesives and sealants: in accordance with Division 07 - Joint Sealants.
 - .2 Adhesives and sealants: VOC limit to SCAQMD Rule 1168.
- .2 Sealant: oil resistant, water borne, polymer type flame resistant duct sealant. Temperature range of minus 30° C to plus 93° C.

2.4 TAPE

- .1 Tape: polyvinyl treated, open weave fiberglass tape, 50 mm wide.

2.5 DUCT LEAKAGE

- .1 Leakage Class is defined as

$$CL = F / (P)^{0.65}$$

where: CL = Leakage Class

F = Leakage Factor (cfm/100-ft² of duct surface)

P = Static pressure in the duct (in.wg.)

- .2 Table

LEAKAGE FACTOR (F) CFM/100 –sq.ft. of DUCT SURFACE					
LEAK CLASS	PRESSURE CLASS (in.wg.) (+ve or –ve)				
C _L	1	2	4	6	10

48	48	75	118	154	214
24	24	38	59	77	107
12	12	19	30	38	54
6	6	9	15	19	27
3	3	5	7	10	13
0	0	0	0	0	0

2.6 FITTINGS

- .1 Fabrication: to SMACNA and ASHRAE
- .2 Radiused elbows:
 - .1 Rectangular: standard radius or short radius with single thickness turning vanes, centreline radius: 1.5 times width of duct for standard, 1.0 times for short radius.
 - .2 Round: smooth radius or five piece, centreline radius: 1.5 times diameter.
- .3 Mitred elbows, rectangular:
 - .1 To 400 mm width: with single thickness turning vanes.
 - .2 Over 400 mm: with double thickness turning vanes.
- .4 Branches:
 - .1 Rectangular main and branch: with radius on branch 1.5 times width of duct.
 - .2 Round main and branch: enter main duct at 45 degrees with conical connection.
 - .3 Provide volume control damper in branch duct near connection to main duct.
 - .4 Main duct branches: with splitter damper.
- .5 Transitions:
 - .1 Diverging: 20 degrees maximum included angle.
 - .2 Converging: 30 degrees maximum included angle.
- .6 Offsets:
 - .1 Full or short radiused elbows as indicated.
- .7 Obstruction deflectors: maintain full cross-sectional area.
 - .1 Maximum included angles: as for transitions.

2.7 FIRE STOPPING

- .1 Retaining angles around duct, on both sides of fire separation in accordance with Division 07 - Fire Stopping.
- .2 Coordinate with Division 07 - Fire Stopping to ensure fire stopping materials and installation does not distort duct.

2.8 GALVANIZED STEEL

- .1 Lock forming quality: to ASTM A653/A653M, Z90 zinc coating.

- .2 Thickness, fabrication and reinforcement: to ASHRAE and SMACNA.
- .3 Joints: to ASHRAE and SMACNA. Provide proprietary manufactured duct joint where shown. Proprietary manufactured flanged duct joint to be considered to be a class A seal.

2.9 STAINLESS STEEL

- .1 To ASTM A240/A240M, T304L or T316L.
- .2 Finish: number 2B
- .3 Thickness, fabrication and reinforcement: to ASHRAE and SMACNA or as indicated.
- .4 Joints: to ASHRAE and SMACNA, continuous inert gas welded.

2.10 ALUMINUM

- .1 To ASHRAE and SMACNA. Aluminum type: ASTM B209, alloy 3003-H-14.
- .2 Thickness, fabrication and reinforcement: to ASHRAE and SMACNA.
- .3 Joints: to ASHRAE and SMACNA. Provide continuous weld where indicated.

2.11 BLACK STEEL

- .1 To ASTM A635/A635M.
- .2 Thickness: 1.2 mm or as indicated.
- .3 Fabrication: ducts and fittings to ASHRAE and SMACNA.
- .4 Reinforcement: as indicated.
- .5 Joints: continuous weld.

2.12 HANGERS AND SUPPORTS

- .1 Hangers and Supports: in accordance with Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.
 - .1 Strap hangers: of same material as duct but next sheet metal thickness heavier than duct.
 - .1 Maximum size duct supported by strap hanger: 500mm.
 - .2 Hanger configuration: to ASHRAE and SMACNA.
 - .3 Hangers: galvanized steel angle with galvanized steel rods to ASHRAE, SMACNA and following table:

Duct Size	Angle Size	Rod Size
(mm)	(mm)	(mm)
up to 750	25 x 25 x 3	6
751 to 1050	40 x 40 x 3	6
1051 to 1500	40 x 40 x 3	10
1501 to 2100	50 x 50 x 3	10
2101 to 2400	50 x 50 x 5	10
2401 and over	50 x 50 x 6	10

- .4 Provide stainless steel supports for stainless steel ductwork.
- .5 Upper hanger attachments:
 - .1 For concrete: manufactured concrete inserts.
 - .2 For steel joist: manufactured joist clamp or steel plate washer to suit structure.
 - .3 For steel beams: manufactured beam clamps:

3. EXECUTION

3.1 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for metal duct installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence Consultant.
 - .2 Inform Consultant of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Consultant.

3.2 DUCT CLEANLINESS

- .1 Handle and install ductwork in accordance with the advanced level described in SMACNA Duct Cleanliness for New Construction Guidelines.
- .2 Ductwork leaving the premises of the manufacturer may include:

- .1 self-adhesive labels or marking for part(s) identification shall be applied to external surfaces only;
 - .2 exposed mastic sealant;
 - .3 light zinc oxide coating on the metal surface;
 - .4 a light coating of oil on machine formed ductwork;
 - .5 minor protrusions into the airway of rivets, screws, bolts and other jointing devices;
 - .6 internal insulation and associated fasteners;
 - .7 discoloration marks from plasma cutting process.
 - .8 to maintain cleanliness during transportation, ensure ductwork is sealed either by blanking or capping duct ends, bagging small fittings, surface wrapping or shrink wrapping. Take care to prevent damage during transportation and off loading.
- .3 Provide a clean and dry environment where the ductwork is protected from dust for the storage of ductwork prior to installation. Visually examine sealed ends for damage and reseal with an appropriate material as needed.
 - .4 During installation, ensure the working area is clean, dry and the ductwork is protected from dust.
 - .5 Wipe the internal surfaces of the uninsulated ductwork to remove excess dust immediately prior to installation.
 - .6 Seal open ends on completed ductwork and overnight work-in-progress.
 - .7 Ensure access covers are firmly fitted in position on completion of each section of the work.
 - .8 Ensure protective coverings are only removed immediately before installation. Inspect to determine if additional wipe down is necessary.

3.3 GENERAL

- .1 Do work in accordance with ASHRAE and SMACNA.
- .2 Do not break continuity of insulation vapour barrier with hangers or rods.
 - .1 Insulate strap hangers 100 mm beyond insulated duct.
- .3 Support risers in accordance with ASHRAE and SMACNA.
- .4 Install breakaway joints in ductwork on sides of fire separation.
- .5 Install proprietary manufactured flanged duct joints in accordance with manufacturer's instructions.
- .6 Manufacture duct in lengths and diameter to accommodate installation of acoustic duct lining.

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

3.4 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	3000
1501 and over	2500

3.5 WATERTIGHT DUCT

- .1 Provide watertight duct for:

- .1 Dishwasher exhaust.
- .2 Plenums behind intake and exhaust louvres.
- .3 Fresh air intake ductwork.
- .4 Minimum 3000 mm from duct mounted humidifier in all directions.
- .5 As indicated.
- .2 Do not use spiral ducts or elbows for watertight exhaust systems.
- .3 Form bottom of horizontal duct without longitudinal seams.
 - .1 Weld joints of bottom and side sheets.
 - .2 Seal other joints with duct sealer.
- .4 Slope horizontal branch ductwork down towards fume hoods or equipment served.
 - .1 Slope header ducts down toward risers.
- .5 Fit base of riser with 150 mm deep drain sump and 32 mm drain connected, with deep seal trap and valve and discharging to open funnel drain.
- .6 Provide drains in fresh air intakes and exhaust plenums complete with trap and piped to drain.
 - .1 material.

3.6 SEALING AND TAPING

- .1 Apply sealant in accordance with SMACNA and to manufacturer's recommendations.
- .2 Bed tape in sealant and recoat with minimum of 1 coat of sealant to manufacturers recommendations.

3.7 HVAC SYSTEM CLEANING

- .1 Qualifications of HVAC Systems Cleaning Contractor
 - .1 Member of National Air Duct Cleaners Association (NADCA)
 - .2 Supervisor: Air System Cleaning Specialist certified by NADCA
 - .3 Firm: regularly engaged in HVAC system cleaning with minimum 3-years experience
 - .4 Employees: trained in safe use of equipment and individual health protection measures

- .2 Maintain a copy of all current SDS documentation and safety certifications for products employed in the cleaning operations at the site at all times. Submit a copy of SDS sheets to Owner.
- .3 Standards: Conform to NADCA Standard ACR 2006, Assessment, Cleaning and Restoration of HVAC Systems and NADCA Guidelines.
- .4 Scope of HVAC System Cleaning Work:
 - .1 Clean each HVAC System and component as follows:
 - .1 Interior surfaces of new ductwork and accessories installed as part of this project
 - .2 Interior surfaces of existing ductwork and accessories that are to remain in service on completion of this project,
 - .3 Interior surfaces of new and existing HVAC System components that are to remain in service on completion of this project, including: air handling units, fans, fan housings, air coils, drain pans, humidifiers, filters, filter frames, intake and exhaust and mixing plenums, air blenders, air outlets and inlets, air terminal units, power ventilators, sound attenuators, reheat coils, turning vanes, dampers, and sensors
 - .2 Verify the cleanliness of each HVAC System and component through visual inspection, video recording and testing indicated hereinafter.
- .5 Cleaning & Disinfection Requirements
 - .1 Conduct visual/video inspections of HVAC Systems and components without disruption of settled dust or debris and without microbial amplification. Record and submit video inspections before and after cleaning as follows:
 - .1 ducts serving Class 2 areas (laboratory): 25%
 - .2 ducts serving Class 3 areas (classrooms):10%
 - .2 Mark and record position of adjustable devices and ensure that they are re-set to their original position on completion of cleaning and verification work,
 - .3 Document and report damage to HVAC Systems and components discovered during inspections to Consultant and to Owner,
 - .4 Cleaning: remove visible surface contaminants and deposits from each HVAC System and component
 - .5 Disinfection: disinfect internal surfaces of ductwork, equipment and accessories that serve one or more Class 1 areas.

- .6 Containment: ensure that dust and debris collected during the cleaning process is contained within the HVAC System and not otherwise dispersed outside of the system.
- .7 Particulate Collection: use high power vacuums with HEPA filtration to 99.97% efficiency on particles greater than 0.3-micron size
- .8 Odours and Mist control: ensure that odours and mist vapours arising from cleaning operations are contained within the HVAC System and are prevented from escaping to and dispersing outside of the system.
- .9 Provide adequate access into ductwork for cleaning purposes. Provide access doors conforming to project specifications.
- .10 Disconnect flexible ducts to provide access for cleaning.
- .11 Protect components which may be harmed by excessive dirt with filters, or bypass during cleaning.
- .12 Where mechanical brushing and vacuuming is not appropriate or is not sufficient to clean a component of the system, dismantle and remove the component and clean or replace as appropriate.
- .13 Ensure that appropriate liquid collection and drainage measures are in place prior to undertaking any washdown procedures.
- .14 Anti-microbial Agents and Coatings: apply anti-microbial agents where active fungal growth is suspected or where unacceptable levels of fungal contamination exist. Apply anti-microbial treatments and coatings in strict adherence to the manufacturer's written recommendations and registration listings. Application of anti-microbial agents and coatings may be performed only after removal of surface deposits and debris.
- .6 Cleanliness Verification:
 - .1 Visual Inspection: no visible contaminants present when examined under a bright light (equivalent to 100w incandescent bulb). Maximum 0.75mg/100cm² with no significant local accumulations.
 - .2 Air Coils and reheat coils: restored to within 10% of original design pressure drop
 - .3 In Class 1 areas (critical care) test supply ducts for each room as follows:
 - .1 Microbial Samples: rose bengal agar Hycon contact plates, incubated for 3 days at 37°C with number of micro-organisms counted and reported in both per plate and per cm² concentration levels. Maximum 1 cfu per cm².

- .2 Bacterial Samples: tryptic soy agar contact plates, incubated for 3 days at 37°C with number of micro-organisms counted and reported in both per plate and per cm² concentration levels. Maximum 1 cfu per cm².
- .4 Particle Profiling Procedures: In the event of a dispute between Contractor and Owner regarding cleanliness, Contractor shall perform NADCA PP procedures in accordance with Chapter 2 of NADCA Guideline to ACR 2006; Particle Measurement, Air Sampling and Surface Sampling for each supply air system at representative locations selected by Owner and in the discharge plenum of each air handling unit.
- .7 Report:
 - .1 Provide certificate of cleanliness from third party inspection service with following minimum qualifications:
 - .1 Environmental Engineer licensed in the province of Ontario or
 - .2 Certified Industrial Hygienist, and
 - .3 minimum 3 years experience in duct cleaning
 - .2 Provide photographic/video record of cleaned surfaces and components
 - .3 Provide comparative record of damage discovered on initial inspection and of remedial measures implemented by others

3.8 CLEANING

- .1 Progress Cleaning: clean in accordance with Division 01 - Cleaning.
 - .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Division 01 - Cleaning.
- .3 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.
 - .1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

END OF SECTION

1. GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Refer to Section 23 01 01.

1.1 REFERENCE STANDARDS

- .1 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
 - .1 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

1.2 SHOP DRAWING SUBMITTALS

- .1 Submit in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for air duct accessories and include product characteristics, performance criteria, physical size, finish and limitations.
 - .2 Indicate:
 - .1 Flexible connections.
 - .2 Duct access doors.
 - .3 Volume control dampers
 - .4 Automatic balancing dampers
 - .5 Balancing dampers – manual and remote.
 - .6 Turning vanes.
 - .7 Instrument test ports.
 - .8 Spin-in collars

1.3 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials off ground, indoors, in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect air duct accessories from nicks, scratches, and blemishes, vermin, theft and vandalism.
 - .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.

2. PRODUCTS

2.1 GENERAL

- .1 Manufacture in accordance with SMACNA - HVAC Duct Construction Standards.

2.2 FLEXIBLE CONNECTIONS

- .1 Frame: galvanized sheet metal frame 2.3mm thick with fabric clenched by means of double locked seams.
- .2 Material:
 - .1 Fire resistant, self extinguishing, neoprene coated glass fabric, temperature rated at minus 40 degrees C to plus 90 degrees C, density of 1.3 kg/m².
 - .2 MIL-C-20696B Para. 4.4.3, 4.4.4 (Oil and Hydrocarbon resistance)
 - .3 UL Certified NFPA 701 Tests for Flame Propagation of fabrics and film.
 - .4 10/120 ASTM E84 Flame/Smoke rating.
 - .5 -40F to 250F Continuous temperature range.
 - .6 White woven fiberglass colour
 - .7 Galvanized steel conforming to ASTM-A-525 G 60 or better
- .3 Acceptable Manufacturers" Duro-Dyne DDFDC.

2.3 DUCT ACCESS DOORS – ROUND DUCT

- .1 Manufacturer: Greenheck
 - .1 Model: RAD
- .2 Differential pressure rating: maximum differential pressure rating of 20 in. w.g.
- .3 Construction
 - .1 Frame/Door Panel: Constructed of galvanized steel for the outer top plate and uninsulated lower inside plate. Provide insulated lower inside plate for insulated ducts.
 - .2 Door Springs: Conical springs between the two plates provides for easy installation.
 - .3 Gasket: Closed cell neogasket
 - .4 Handle: High impact plastic knobs
 - .5 Finish: Mill finish is standard.

2.4 DUCT ACCESS DOORS – RECTANGULAR DUCT

- .1 Non-Insulated Ducts: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm 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 thick complete with sheet metal angle frame and 25 mm thick rigid glass fibre insulation.
- .3 Gaskets: 1/8" thick by 1/2" wide closed cell neoprene gasketing between door and frame and also between frame and duct
- .4 Hardware:
 - .1 Up to 300 x 300 mm: two sash locks complete with safety chain.
 - .2 301 to 450 mm: four sash locks complete with safety chain.
 - .3 451 to 1000 mm: piano hinge and minimum two sash locks.
 - .4 Doors over 1000 mm: piano hinge and two handles operable from both sides.
 - .1 Hold open devices.
 - .2 300 x 300 mm glass viewing panels.
- .5 Acceptable Manufacturer: Acudor Acorn CD-5080 (unhinged), HD-5070 (hinged). WD-8000 (for doors over 1000mm).

2.5 DUCT ACCESS DOORS – GREASE DUCTS

- .1 Provide UL- and ULC-listed access doors for installation into grease ducts
- .2 Construction:
 - .1 Door panel 1.6mm galvanized steel
 - .2 Back mounting frame 1.6mm mild steel
 - .3 Door panel secured with wing nuts on studs connected to back frame
 - .4 Gasket rated to 1260°C for fire tight seal. Gasket if high temperature bonded to the front panel.
 - .5 Access panels larger than 178 x 178 have a 13mm turn-down to add rigidity.
 - .6 Complete with e-clips holding back frame to duct for each stud.
- .3 Features:
 - .1 Bolt-in unit easily installed into existing ductwork.
 - .2 Complete with duct cutout template.
 - .3 No bolts penetrate duct interior.
 - .4 Two handles for easy removal
 - .5 Complete with label showing UL/ULC listing and "ACCESS PANEL – DO NOT OBSTRUCT"
- .4 Acceptable Manufacturer: Acudor GDD

2.6 TURNING VANES

- .1 Factory or shop fabricated single thickness or double thickness with trailing edge, to recommendations of SMACNA and as indicated. Manufacturer: Duro-Dyne, Hart & Cooley.
- .2 Volume extractors: gang operated curved blades, adjustable from full open to full closed positions. Units shall be factory assembled, fabricated from 14 ga. and 22 ga. (2 and .9 mm) steel, with blades on 1" (25 mm) centres, and No. 2 or No. 3 operators to suit application. Manufacturer: E.H. Price.

2.7 INSTRUMENT TEST PORTS

- .1 1.6 mm thick steel zinc plated after manufacture.
- .2 Cam lock handles with neoprene expansion plug and handle chain.
- .3 28 mm minimum inside diameter. Length to suit insulation thickness.
- .4 Neoprene mounting gasket.

2.8 SPIN-IN COLLARS

- .1 Conical galvanized sheet metal spin-in collars with lockable butterfly damper.
- .2 Sheet metal thickness to co-responding round duct standards.

3. EXECUTION

3.1 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for air duct accessories installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Consultant.
 - .2 Inform Consultant of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Consultant.

3.2 INSTALLATION

- .1 Flexible Connections:
 - .1 Install in following locations:
 - .1 Inlets and outlets to supply air units and fans.
 - .2 Inlets and outlets of exhaust and return air fans.
 - .3 As indicated.
 - .2 Length of connection: 100 mm.
 - .3 Minimum distance between metal parts when system in operation: 75 mm.

- .4 Install in accordance with recommendations of SMACNA.
- .5 When fan is running:
 - .1 Ducting on sides of flexible connection to be in alignment.
 - .2 Ensure slack material in flexible connection.
- .2 Access Doors and Viewing Panels:
 - .1 Size:
 - .1 1200 x 1200 mm for person size entry.
 - .2 600 x 600 mm for servicing entry.
 - .3 300 x 300 mm for viewing.
 - .4 As indicated.
 - .2 Locations:
 - .1 Fire and smoke dampers.
 - .2 Control dampers.
 - .3 Devices requiring maintenance.
 - .4 Required by code.
 - .5 Reheat coils.
 - .6 Elsewhere as indicated.
- .3 Instrument Test Ports:
 - .1 General:
 - .1 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's instructions.
 - .2 Provide test ports as required by Balancing Agency to completely test and balance the system. No temporary holes will be permitted in ductwork or flexible connections.
 - .2 Locate to permit easy manipulation of instruments.
 - .3 Install insulation port extensions as required.
 - .4 Locations:
 - .1 For traverse readings:
 - .2 For temperature readings:
- .4 Turning Vanes:
 - .1 Install in accordance with recommendations of SMACNA and as indicated.
 - .2 Provide turning vanes where space restrictions prohibit the use of elbows having a minimum inside radius equal to the duct width for horizontal elbows or the duct depth for vertical elbows.

3.3 CLEANING

- .1 Progress Cleaning: clean in accordance with Division 01 - Cleaning.
 - .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Division 01 - Cleaning.
- .3 Waste Management: separate waste materials for recycling in accordance with Division 01 - Waste Management and Disposal.
 - .1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

END OF SECTION

1. GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Refer to Section 23 01 01.
- .2 Refer to Section 23 07 13 for minimum insulation values.

1.1 REFERENCE STANDARDS

- .1 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)
 - .1 ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings.
- .2 National Fire Protection Association (NFPA)
 - .1 NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
 - .2 NFPA 90B, Standard for Installation of Warm Air Heating and Air-Conditioning Systems.
- .3 Sheet Metal and Air-Conditioning Contractors' National Association (SMACNA)
 - .1 SMACNA HVAC Duct Construction Standards - Metal and Flexible.
 - .2 SMACNA IAQ Guideline for Occupied Buildings under Construction.
- .4 Underwriters' Laboratories (UL)
 - .1 UL 181, Standard for Factory-Made Air Ducts and Air Connectors.
- .5 Underwriters' Laboratories of Canada (ULC)
 - .1 CAN/ULC-S110, Standard Methods of Tests for Air Ducts.

1.2 SHOP DRAWING SUBMITTALS

- .1 Submit in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for flexible ducts and include product characteristics, performance criteria, physical size, finish and limitations.
 - .2 Indicate:
 - .1 Thermal properties.
 - .2 Friction loss.
 - .3 Acoustical loss.
 - .4 Leakage.
 - .5 Fire rating.
 - .6 Bend radius.
- .3 Test and Evaluation Reports:

- .1 Catalogue or published ratings to be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.

1.3 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials off ground, indoors, in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect flexible ducts from nicks, scratches, blemishes, vandalism, theft and vermin.
 - .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction Waste Management Plan Waste Reduction Workplan in accordance with Division 01 - Waste Management and Disposal.

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 Type 1: spiral wound flexible aluminum, as indicated.
- .2 Performance:
 - .1 Factory tested to 2.5 kPa without leakage.
 - .2 Maximum relative pressure drop coefficient: 3.

2.3 METALLIC - INSULATED

- .1 Type 2: spiral wound flexible aluminum with factory applied, flexible glass fibre thermal insulation with vapour barrier and reinforced mylar/neoprene laminate aluminum jacket, as indicated.
- .2 Performance:
 - .1 Factory tested to 2.5 kPa without leakage.
 - .2 Maximum relative pressure drop coefficient: 3.

2.4 NON-METALLIC - INSULATED

- .1 Type 4: non-collapsible, coated mineral base fabric aluminum foil/mylar type mechanically bonded to, and helically supported by, external steel wire with factory applied, flexible mineral fibre thermal insulation with vapour barrier and reinforced mylar/neoprene laminate jacket, as indicated.
- .2 Performance:
 - .1 Factory tested to 2.5 kPa without leakage.
 - .2 Maximum relative pressure drop coefficient: 3.

2.5 METALLIC ACOUSTIC INSULATED - MEDIUM PRESSURE

- .1 Type 5: spiral wound, flexible perforated aluminum with factory applied flexible mineral fibre thermal insulation and sleeved by aluminum foil/mylar laminate Type M vapour barrier, as indicated.
- .2 Performance:
 - .1 Factory tested to 2.5 kPa without leakage.
 - .2 Maximum relative pressure drop coefficient: 3.
 - .3 Acoustical performance: Minimum attenuation (dB/m) to following table:

	Frequency (Hz)				
Duct Diam:	125	250	500	1000	2000
[100]	[0.6]	[3]	[12]	[27]	[0]
[150]	[1.2]	[3]	[12]	[22]	[27]
[200]	[2.0]	[5]	[12]	[19]	[20]
[300]	[2.4]	[5]	[12]	[16]	[15]

2.6 METALLIC - ACOUSTIC INSULATED - HIGH PRESSURE

- .1 Type 6: spiral wound, flexible perforated aluminum with factory applied flexible mineral fibre thermal insulation and encased in spiral wound flexible aluminum jacket, as indicated.
- .2 Performance:
 - .1 Factory tested to 2.5 kPa without leakage.
 - .2 Maximum relative pressure drop coefficient: 3.
 - .3 Acoustical performance: minimum attenuation (dB/m) to following table:

	Frequency (Hz)				
Duct Diam:	125	250	500	1000	2000
[100]	[0.6]	[3]	[12]	[27]	[0]
[150]	[1.2]	[3]	[12]	[22]	[27]
[200]	[2.0]	[5]	[12]	[19]	[20]
[300]	[2.4]	[5]	[12]	[16]	[15]

2.7 NON-METALLIC - ACOUSTIC INSULATED

- .1 Type 7: non-collapsible, coated mineral base perforated fabric type helically supported by and mechanically bonded to steel wire with factory applied flexible mineral fibre acoustic insulation and encased in aluminum foil/mylar laminate Type M vapour barrier.
- .2 Performance:
 - .1 Factory tested to 2.5 kPa without leakage.
 - .2 Maximum relative pressure drop coefficient: 3.
 - .3 Acoustical performance: Minimum attenuation (dB/m) to following table:

	Frequency (Hz)				
Duct Diam:	125	250	500	1000	2000
[100]	[0.6]	[3]	[12]	[27]	[0]
[150]	[1.2]	[3]	[12]	[22]	[27]
[200]	[2.0]	[5]	[12]	[19]	[20]
[300]	[2.4]	[5]	[12]	[16]	[15]

3. EXECUTION

3.1 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for flexible ducts installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Consultant.
 - .2 Inform Consultant of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Consultant

3.2 DUCT INSTALLATION

- .1 Install in accordance with:
 - .1 CAN/ULC-S110
 - .2 UL 181
 - .3 NFPA 90A
 - .4 NFPA 90B
 - .5 SMACNA.

3.3 CLEANING

- .1 Progress Cleaning: clean in accordance with Division 01 - Cleaning.
 - .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Division 01 - Cleaning.
- .3 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.

- .1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

END OF SECTION

1. GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Refer to Section 23 01 01.

1.1 REFERENCE STANDARDS

- .1 ASTM International (ASTM)
 - .1 ASTM C423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
 - .2 ASTM C916, Standard Specification for Adhesives for Duct Thermal Insulation.
 - .3 ASTM C1071, Standard specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
 - .4 ASTM C1338, Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.
 - .5 ASTM G21, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
- .2 National Fire Protection Association (NFPA)
 - .1 NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
 - .2 NFPA 90B, Standard for the Installation of Warm Air Heating and Air Conditioning Systems.
- .3 North American Insulation Manufacturers Association (NAIMA)
 - .1 NAIMA AH116, Fibrous Glass Duct Construction Standards.
- .4 Sheet Metal and Air Conditioning Contractor's National Association (SMACNA)
 - .1 SMACNA, HVAC Duct Construction Standards, Metal and Flexible.
 - .2 SMACNA IAQ Guideline for Occupied Buildings Under Construction.
- .5 Underwriter's Laboratories of Canada (ULC)
 - .1 CAN/ULC-S102, Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submit in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for duct liners and include product characteristics, performance criteria, physical size, finish and limitations.

1.3 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Division 01 - Closeout Submittals.

- .2 Operation and Maintenance Data: submit operation and maintenance data for duct liners for incorporation into manual.

1.4 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials off ground, indoors, in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect duct liners from nicks, scratches, blemishes, theft, vandalism, and vermin.
 - .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction Waste Management Plan Waste Reduction Workplan in accordance with Division 01 - Waste Management and Disposal.

2. PRODUCTS

2.1 DUCT LINER

- .1 General:
 - .1 Mineral Fibre duct liner: air surface coated mat facing.
 - .2 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50 when tested in accordance with CAN/ULC-S102.
 - .3 Fungi resistance: to ASTM C1338.
- .2 Rigid:
 - .1 Use on flat surfaces and where indicated.
 - .2 25 mm thick, to ASTM C1071 Type 2, fibrous glass rigid board duct liner.
 - .3 Density: 48 kg/m³ minimum.
 - .4 Thermal resistance to be minimum 0.76 (m². degrees C)/W for 25 mm thickness when tested in accordance with ASTM C177, at 24 degrees C mean temperature.
 - .5 Maximum velocity on faced air side: 20.3 m/s.
 - .6 Minimum NRC of 0.70 at 25 mm thickness based on Type A mounting to ASTM C423.
- .3 Flexible:
 - .1 Use on round or oval surfaces and surfaces indicated.
 - .2 25 mm thick, to ASTM C1071 Type 1, fibrous glass blanket duct liner.
 - .3 Density: 24 kg/m³ minimum.

- .4 Thermal resistance to be minimum $0.74 \text{ (m}^2 \cdot \text{degrees C)/W}$ for 25 mm thickness when tested in accordance with ASTM C177, at 24 degrees C mean temperature.
- .5 Maximum velocity on coated air side: 25.4 m/s.
- .6 Minimum NRC of 0.65 at 25 mm thickness based on Type A mounting to ASTM C423.

2.2 ADHESIVE

- .1 Adhesive: to NFPA 90A, NFPA 90B, and ASTM C916.
- .2 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50. Temperature range minus 29 degrees C to plus 93 degrees C.
- .3 Water-based fire retardant type.

2.3 FASTENERS

- .1 Weld pins 2.0 mm diameter, length to suit thickness of insulation. Metal retaining clips, 32 mm square.

2.4 JOINT TAPE

- .1 Poly-Vinyl treated open weave fiberglass membrane 50 mm wide.

2.5 SEALER

- .1 Meet requirements of CAN/ULC-S102.
- .2 Meet requirements of NFPA 90A and NFPA 90B as applicable.
- .3 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50. Temperature range minus 68 degrees C to plus 93 degrees C.

3. EXECUTION

3.1 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for duct liner installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Consultant.
 - .2 Inform Consultant of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Consultant.

3.2 GENERAL

- .1 Do work in accordance with SMACNA HVAC Duct Construction Standard NAIMA AH116 except as specified otherwise.

- .2 Line inside of ducts where indicated.
- .3 Duct dimensions, as indicated, are clear inside duct lining.

3.3 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 to ASTM C916.
 - .1 Exposed leading edges and transverse joints to be factory coated or coated with adhesive during fabrication.
 - .2 In addition to adhesive, install weld pins not less than 2 rows per surface and not more than 425 mm on centres to compress duct liner sufficiently to hold it firmly in place.
 - .1 Spacing of mechanical fasteners in accordance with SMAC HVAC Duct Construction Standard and NAIMA AH116.
- .2 In systems, where air velocities exceeds 20 m/s, install galvanized sheet metal nosing to leading edges of duct liner.

3.4 JOINTS

- .1 Seal butt joints, exposed edges, weld pin and clip penetrations and damaged areas of liner with joint tape and sealer. Install joint tape in accordance with manufacturer's written recommendations, and as follows:
 - .1 Bed tape in sealer.
 - .2 Apply 2 coats of sealer over tape.
- .2 Replace damaged areas of liner at discretion of Consultant.
- .3 Protect leading and trailing edges of duct sections with sheet metal nosing having 15 mm overlap and fastened to duct.

3.5 CLEANING

- .1 Progress Cleaning: clean in accordance with Division 01 - Cleaning.
 - .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Division 01 - Cleaning.
- .3 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.
 - .1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

END OF SECTION

1. GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Refer to Section 23 01 01.

1.2 REFERENCE STANDARDS

- .1 American National Standards Institute/Air Movement and Control Association (ANSI/AMCA)
 - .1 ANSI/AMCA Standard 99, Standards Handbook.
 - .2 ANSI/AMCA Standard 204, Balance Quality and Vibration Levels for Fans.
 - .3 ANSI/AMCA 210, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
 - .4 ANSI/AMCA Standard 211, Certified Ratings Program – Product Rating Manual for Fan Air Performance.
 - .5 ANSI/AMCA Standard 300, Reverberant Room Method for Sound Testing of Fans.
 - .6 ANSI/AMCA Standard 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
 - .7 ANSI/AMCA Standard 311, Certified Ratings Program – Product Rating Manual for Fan Air Performance.
 - .8 ANSI/AMCA Standard 500, Laboratory Methods of Testing Dampers for Rating.
- .2 National Fire Protection Agency (NFPA):
 - .1 NFPA 70, National Electrical Code
 - .2 NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems
 - .3 NFPA 92A, Recommend Practice for Smoke-Control System
 - .4 NFPA 92B, Standard for Smoke Management System in Malls, Atria, and Large Areas
 - .5 NFPA 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
- .3 Occupational Health and Safety Association (OSHA)
 - .1 OSHA Guideline 1910.212 – General Requirements for Machine Guarding.
 - .2 OSHA Guideline 1910.219 - General Requirements for Guarding Safe Use of Mechanical Power Transmission Apparatus.
 - .3 OSHA Guideline 1926.300 - General Requirements for Safe Operation and Maintenance of Hand and Power Tools.
- .4 Underwriters Laboratories (UL/cUL)

- .1 UL/cUL 507 - Electric Fans
- .2 UL/cUL 555 - Fire Dampers
- .3 UL/cUL 555S - Smoke Dampers
- .4 UL/cUL 705, Power Ventilators
- .5 UL/cUL 705, Supplement SC, Power Ventilators for Restaurant Exhaust Appliances.
- .6 UL/cUL 705, Supplement SD, Power Ventilator for Smoke Control Systems.
- .5 The Master Painters Institute (MPI)
 - .1 Architectural Painting Specification Manual.
 - .1 MPI #18, Primer, Zinc Rich, Organic.

1.3 SHOP DRAWING SUBMITTALS

- .1 Submit in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for HVAC fans and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:
 - .1 Provide:
 - .1 Fan performance curves showing point of operation, bhp and efficiency.
 - .2 Sound rating data at point of operation.
 - .2 Indicate:
 - .1 Motors, sheaves, bearings, shaft details.
 - .2 Minimum performance achievable with variable speed controllers.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- .1 Extra Materials:
 - .1 Submit in accordance with Division 01 - Closeout Submittals.
 - .1 Provide:

1.5 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:

- .1 Store materials off ground, indoors, in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
- .2 Store and protect HVAC fans from nicks, scratches, blemishes, vermin, theft and vandalism.
- .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for return by manufacturer of packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.

2. PRODUCTS

2.1 SYSTEM DESCRIPTION

- .1 Performance Requirements:
 - .1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards in force.
 - .2 Capacity: flow rate, total static pressure, bhp, efficiency, revolutions per minute, power, model, size, sound power data and as indicated on schedule.
 - .3 Fans: statically and dynamically balanced, constructed in conformity with ANSI/AMCA Standard 99.
 - .4 Sound ratings: comply with ANSI/AMCA Standard 301, tested to ANSI/AMCA Standard 300. Supply unit with ANSI/AMCA certified sound rating seal.
 - .5 Performance ratings: based on tests performed in accordance with ANSI/AMCA Standard 210. Supply unit with ANSI/AMCA certified rating seal, except for propeller fans smaller than 300 mm diameter.

2.2 FANS GENERAL

- .1 Motors:
 - .1 In accordance with Section 23 05 13 - Common Motors Requirements for HVAC Equipment supplemented as specified herein.
 - .2 For use with variable speed controllers.
 - .3 Sizes as indicated. Two speed with two windings and speeds approximately as indicated.
 - .4 Two speed with split winding, constant or variable torque and speeds as indicated.
- .2 Accessories and hardware: matched sets of V-belt drives, adjustable slide rail motor bases, belt guards, coupling guards fan inlet and outlet safety screens as indicated and as specified in Section 23 05 13 - Common Motor Requirements for HVAC Equipment, inlet and outlet dampers and vanes and as indicated.

- .3 Factory primed before assembly in colour standard to manufacturer.
- .4 Scroll casing drains: as indicated.
- .5 Finish on fume hood exhaust fans: as indicated.
- .6 Bearing lubrication systems plus extension lubrication tubes where bearings are not easily accessible.
- .7 Vibration isolation: to Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment.
- .8 Flexible connections: to Section 23 33 00 - Air Duct Accessories.

2.3 CENTRIFUGAL FANS – DIRECT DRIVE, SINGLE WIDTH

- .1 General:
 - .1 Base fan performance at standard conditions (density 0.075 Lb/ft³).
 - .2 Fans capable of accommodating static pressure and flow variations of +/- 15% of scheduled values.
 - .3 Normal operating temperature up to 180°F
 - .4 Permanently affixed manufacture's engraved metal nameplate containing the model and individual serial number.
 - .5 Equipped with lifting lugs.
 - .6 Constructed of heavy gauge steel
 - .7 After fabrication, untreated steel components go through a multi-stage cleaning and pre-treatment process before being finished with a high-performance powder coating having a minimum thickness of 2-4 mils, electrostatically applied and baked.
 - .8 Coating must exceed 1,000-hour salt spray under ASTM B117 test method. No uncoated metal fan parts will be allowed.
- .2 Fan Housing and Outlet:
 - .1 Fan housing aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.
 - .2 Construct fan of airtight PermaLock™ construction with the scroll panel material formed and embedded into the side panels continuously welded heavy gauge scroll construction. All interior and exterior surface untreated steel shall be coated with a high-performance powder coating.
 - .3 Provide housing and bearing support of bolted framework welded formed steel members to prevent vibration and rigidly support the shaft and bearings.
 - .4 Provide OSHA compliant shaft guard to cover motor pulley and belt(s).
- .3 Fan wheels:
 - .1 Welded steel or aluminum construction.

- .2 Maximum operating speed of centrifugal fans not more than 40% of first critical speed.
- .3 Fan Wheel statically and dynamically balanced to balance grade G6.3 per ANSI S2.19.
- .4 Air foil, forward curved, or backward inclined blades, as indicated.
- .5 The wheel and fan inlet carefully matched and shall have precise running tolerances for maximum performance and operating efficiency.
- .4 Fan Motors and Drive:
 - .1 AC Induction Motor
 - .1 Meet or exceed EISA (Energy Independence and Security Act) efficiencies.
 - .2 NEMA T-frame, 690, 870, 1170, 1770 or 3500 RPM in 60 Hz, (720, 950, 1425 or 2900 in 50 Hz) Open Drip Proof (ODP) or Totally Enclosed Fan Cooled (TEFC).
 - .3 Drive belts and sheaves shall be sized for 150% of the fan operating brake horsepower, and shall be readily and easily accessible for service, if required.
 - .4 Movable motor plate with adjustment screws to make belt tensioning operations.
 - .5 Fan shaft to be turned and polished steel that is sized so the first critical speed is at least 25% over the maximum operating speed for each pressure class.
 - .2 EC Motor
 - .1 Open type enclosure and electronic commutation type motor (ECM) specifically designed for fan applications.
 - .2 Permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase.
 - .3 Internal motor circuitry to convert AC power supplied to the fan to DC power to operate the motor. Speed controllable down to 20% of full speed (80% turndown).
 - .4 Speed controlled by either a potentiometer dial mounted at the motor or by a 0-10 VDC signal.
 - .5 Motor minimum 85% efficient at all speeds.
- .5 Bearings:
 - .1 Fan shaft: turned and polished steel that is sized so the first critical speed is at least 25% over the maximum operating speed for each pressure class.
 - .2 Air Handling Quality, heavy-duty grease lubricated, self-aligning or roller pillow block type.

- .3 Air Handling Quality bearings designed with low swivel torque to allow the outer race of the bearing to pivot or swivel within the cast pillow block.
- .4 100% tested for noise and vibration by the manufacturer.
- .5 100% tested to ensure the inner race diameter is within tolerance to prevent vibration.
- .6 Selected for a basic rating fatigue life (L-10) of 200,000 hours at maximum operating speed for each pressure class.
- .7 Fixed to the fan shaft using concentric mounting locking collars, which reduce vibration, increase service life, and improve serviceability. Bearings that use set screws shall not be allowed.
- .8 Provide Zerk fittings to allow for lubrication.
- .6 AMCA Air and Sound
 - .1 Fans shall be licensed to bear the AMCA ratings seal for air performance (AMCA 210) and sound performance (AMCA 300).
- .7 Factory Vibration Test
 - .1 Provide fans with electronic vibration analysis in accordance with ANSI/AMCA Standard 204, while operating at the specified fan RPM.
 - .2 Ensure vibration signatures are taken on the motor mounting plate in the horizontal, vertical and axial direction. Maximum allowable fan vibration shall be 0.08 in. /sec peak velocity – arrangement 4, 0.15 in. /sec peak velocity – arrangement 8, filter-in as measured at the fan RPM. Provide report at no charge to the customer upon request.

2.4 CABINET FANS - GENERAL PURPOSE

- .1 General Description
 - .1 Base fan performance at standard conditions (density 0.075 Lb/ft³)
 - .2 Provide cabinet fan designed for supply, exhaust or ducted return applications as shown.
 - .3 UL-705 certified for indoor (standard) and outdoor applications (must configure fan for outdoor use to allow outdoor installation)
 - .4 Maximum continuous operating temperature is 130° F (54.4° C)
 - .5 Provide fans bearing permanently affixed manufacture's engraved metal nameplate containing the model number and individual serial number
- .2 Fan Wheel
 - .1 Forward curved centrifugal wheel
 - .2 Constructed of galvanized steel
 - .3 Statically and dynamically balanced in accordance to AMCA Standard 204-05

- .3 Motors
 - .1 Motor enclosures: Open Drip-Proof or Totally Enclosed Fan Cooled as shown.
 - .2 Permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase
 - .3 Mounted on vibration isolators located in airstream
 - .4 Accessible for maintenance
- .4 Shafts and Bearings
 - .1 Ground and polished solid steel shaft with an anti corrosive coating
 - .2 Permanently sealed bearings or pillow block ball bearings
 - .3 Bearing minimum L10 life 100,000 hours (equivalent to L50 average life of 500,000 hours), at maximum cataloged operating speed
 - .4 Provide 100 percent factory tested bearings
 - .5 Ensure fan shaft first critical speed is at least 25 percent over maximum operating speed
- .5 Housing
 - .1 Constructed of heavy gauge galvanized steel.
 - .2 Rectangular design construction and shall include rectangular duct mounting collars.
 - .3 Includes pre-punched mounting brackets.
- .6 Housing Supports and Drive Frame
 - .1 Drive frame assemblies constructed of heavy gauge steel and mounted on vibration isolators
 - .2 Designed with belt adjustment to eliminate scroll damage
- .7 Duct Collars
 - .1 Provided for easy duct connections for outlet and inlet collars
- .8 Drive Assembly
 - .1 Belts, pulleys, and keys oversized for a minimum of 150 percent of driven horsepower
 - .2 Belts: Static free and oil resistant
 - .3 Fully machined cast iron pulleys, keyed and securely attached to the wheel and motor shafts
 - .4 Motor pulleys adjustable for final system balancing
 - .5 Readily accessible for maintenance

- .9 Access Panel
 - .1 Hinged or removable panel allowing full access to internal components.
- .10 Mounting Brackets
 - .1 Fully adjustable for multiple installation conditions.
- .11 Options/Accessories
 - .1 Disconnect switches NEMA 1 providing positive electrical shut-off and wired from fan motor to junction box.
 - .2 Finishes: Industrial Epoxy
 - .3 Insulated Housing
 - .1 Thickness: 0.5 inches
 - .2 Fiberglass duct liner located in the interior of fan housing, mixing box, and filter box to provide noise reduction and condensation control
 - .4 Side Access Door
 - .1 Location of door: Both Sides
 - .2 Removable to provide access to internal components
 - .5 Vibration Isolators
 - .1 Types: Neoprene/Rubber Mount
 - .2 Isolators are sized to match the weight of each fan
 - .6 Wiring Pigtail
 - .1 Direct hook-up to the power supply which eliminates field wiring at the fan
 - .2 Nine foot wiring extension

2.5 IN-LINE CENTRIFUGAL FANS

- .1 General Description
 - .1 Base fan performance at standard conditions (density 0.075 Lb/ft³)
 - .2 Provide cabinet fan designed for supply, exhaust or ducted return applications as shown.
 - .3 UL-705 certified for indoor (standard) and outdoor applications (must configure fan for outdoor use to allow outdoor installation)
 - .4 Maximum continuous operating temperature is 130° F (54.4° C)
 - .5 Provide fans bearing permanently affixed manufacture's engraved metal nameplate containing the model number and individual serial number
- .2 Fan Wheel

- .1 Constructed of aluminum
- .2 Wheel type to be non-overloading, backward inclined centrifugal wheel
- .3 Statically and dynamically balanced to AMCA Standard 204-05
- .4 The wheel cone and fan inlet will be matched and shall have precise running tolerances for maximum performance and operating efficiency.
- .5 Single thickness blades are securely riveted or welded to a heavy gauge back plate and wheel cone.
- .3 AC Induction Motor
 - .1 Motor enclosures: Open Drip-Proof, Totally Enclosed Fan Cooled, Totally Enclosed Air Over, Explosion Resistant Enclosure as shown.
- .4 Electronically Commutated Motor
 - .1 Motor enclosures: Open Drip Proof, Totally Enclosed Fan Cooled, Totally Enclosed Air Over, Totally Enclosed Non-Vented as shown.
 - .2 Electronic commutation type motor (ECM) specifically designed for fan applications. AC induction type motors are not acceptable. Examples of unacceptable motors are: Shaded Pole, Permanent Split Capacitor (PSC), Split Phase, Capacitor Start and 3 phase induction type motors.
 - .3 Permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase.
 - .4 Internal motor circuitry to convert AC power supplied to the fan to DC power to operate the motor or integrated variable frequency drive.
 - .5 Speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted at the motor or by a 0-10 VDC signal.
 - .6 Up to 95% efficiency, model and horsepower dependent.
- .5 Housing/Cabinet Construction
 - .1 Square design constructed of heavy gauge galvanized steel, aluminum or painted steel
 - .2 Inlet cone constructed of heavy gauge galvanized steel, aluminum, painted steel, or composite.
 - .3 Drive frame construction: structural steel with formed flanges.
- .6 Disconnect Switch
 - .1 NEMA 1 providing positive electrical shut-off and wired from fan motor to junction box.
- .7 Duct Collar
 - .1 Provide square inlet and discharge collars to provide easy slip fit duct connection.
- .8 Access Panel

- .1 Two sided access panels, permit easy access to all internal components
- .2 Located perpendicular to the motor mounting panel
- .9 Options/Accessories
 - .1 Damper:
 - .1 Type: Gravity
 - .2 Galvanized frames with pre-punched mounting holes
 - .3 Balanced for minimal resistance to flow
 - .2 Finishes: Coating: None
 - .3 Inlet and Outlet Guards:
 - .1 Metal construction to provide protection for non-ducted installations
 - .4 Insulated Housing:
 - .1 Thickness: 1 inch
 - .2 For noise reduction and condensation control
 - .3 Constructed of fiberglass liner
 - .5 Vibration Isolation
 - .1 Type: Neoprene/Rubber Mount
 - .2 Sized to match the weight of each fan
 - .6 Motor Cover
 - .1 Constructed of galvanized steel
 - .2 Covers motor and drives for safety
 - .3 Standard on unit specified with UL and ODP motor enclosures
 - .7 Pressure Probe:
 - .1 1/4 inch diameter tube in fan venturi that allows hook up to manometer
 - .8 Wiring Pigtail
 - .1 Direct hook-up to the power supply

3. Execution

3.1 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for HVAC fans installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Consultant.
 - .2 Inform Consultant of unacceptable conditions immediately upon discovery.

- .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Consultant.

3.2 FAN INSTALLATION

- .1 Install fans as indicated, complete with resilient mountings specified in Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment, flexible electrical leads and flexible connections in accordance with Section 23 33 00 - Air Duct Accessories.
- .2 Provide sheaves and belts required for final air balance.
- .3 Bearings and extension tubes to be easily accessible.
- .4 Access doors and access panels to be easily accessible.

3.3 ANCHOR BOLTS AND TEMPLATES

- .1 Size anchor bolts to withstand seismic acceleration and velocity forces as specified.

3.4 CLEANING

- .1 Progress Cleaning: clean in accordance with Division 01 - Cleaning.
 - .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Division 01 - Cleaning.
- .3 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.
 - .1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

END OF SECTION

Part 1 General

1.1 RELATED REQUIREMENTS

- .1 Section 23 01 01

1.2 REFERENCE STANDARDS

- .1 American National Standards Institute/Air Movement and Control Association (ANSI/AMCA)
- .1 ANSI/ASHRAE 51 (ANSI/AMCA 210), Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
- .2 International Organization of Standardization (ISO)
- .1 ISO 3741, Acoustics-Determination of Sound Power Levels of Noise Sources Using Sound Pressure - Precision Methods for Reverberation Rooms.
- .3 National Fire Protection Association (NFPA)
- .1 NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
- .4 Underwriter's Laboratories (UL)
- .1 UL 181, Factory-Made Air Ducts and Air Connectors.

1.3 SHOP DRAWING SUBMITTALS

- .1 Submit in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for air terminal units and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:
 - .1 Submit drawings stamped and signed by professional engineer registered or licensed in Ontario.
 - .2 Indicate the following:
 - .1 Capacity.
 - .2 Pressure drop.
 - .3 Noise rating.
 - .4 Leakage.

- .4 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .5 Test and Evaluation Reports:
 - .1 Test data: to ANSI/AMCA Standard 210.
 - .1 Submit published test data on DIN (Direct Internal Noise), in accordance with ISO 3741 made by independent testing agency for 0, 2.5 and 6 m/s branch velocity or inlet velocity.
 - .2 Sound power level in accordance with ISO 3741 for 2nd through 7th octave band, also made by [independent] testing agency.
 - .3 Pressure loss through silencer shall not exceed 60% of inlet velocity pressure maximum.

1.4 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Division 01 - Closeout Submittals.
- .2 Operation and Maintenance Data: submit operation and maintenance data for air terminal units for incorporation into manual.

1.5 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials off ground, indoors, in dry location, and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect air terminal units from nicks, scratches, blemishes, .
 - .3 Replace defective or damaged materials with new.

1.6 CONSTRUCTION

- .1 Single Duct Terminal Units shall be METALAIR Air Terminal Units. The units shall be the size and capacity as outlined in the plans and specifications. Casing dimensions shall be checked to ensure the terminals fit the available space.

- .2 Casing. The air terminals shall be constructed of galvanized steel. The casing shall be a minimum of 22-gauge. The terminal primary air inlet valve shall have a round (oval or rectangular for larger sizes) inlet for field duct connection. The terminal unit discharge shall allow for a slip and drive duct connection. Units shall have a universal control-mounting panel constructed of minimum 22-gauge steel. Control panel shall include stand-offs to allow controls to be mounted without penetrating the terminal casing. Control panels without stand-offs are not acceptable.

1.6 PRIMARY INLET AIR VALVE

- .1 Inlet Tube. Primary inlet air valve assembly shall have multiple rivets on the round inlet tube to minimize leakage and prevent the damper from binding on overlapping seam welds. Inlet tubes with overlapping welds or non- continuous, skipped welds are not acceptable. Inlet air valve shall have three structural beads machine formed into the tube. One external bead shall be provided for the attachment of flexible duct. Inlet air valves without three structural beads are not acceptable.
- .2 Flow Sensor. Primary inlet air valve flow sensor shall be a center averaging sensor with flow sampling of both velocity pressure and flow differential pressure from four quadrants.
- .3 Damper Assembly. Air terminals with inlet flow sensing devices shall be provided with a gasketed access door to permit removal, inspection and cleaning of the air flow sensor.
- .4 Damper Assembly. Damper shaft shall rotate in a self-lubricating, long life, low friction thermo- plastic bearing. Damper shaft construction shall be one piece, continuous extruded aluminum. Damper shaft end shall include a permanent cast damper position indicator. A damper stop shall be required to prevent over rotation of the damper blade. A flexible gasket-mounted damper blade without adhesives shall provide damper seal. Mechanically fastened damper assembly shall be double layer, 18 gauge equivalent, galvanized steel with integral blade seal. Leakage through the damper assembly shall be less than 1% of maximum CFM at 3" static pressure.

1.7 INSULATION

- .1 Standard Fiberglass Insulation. Air Terminals shall be internally insulated with 1" thick, 1.5 lb. /ft³, dual density fiberglass. Insulation and edges shall be coated to prevent air erosion to 6000FPM surface velocity. Insulation shall comply with UL 181 and NFPA 90A.

1.8 ACCESS PANELS AND MOUNTING

Access Panels. An optional separate bottom primary inlet access panel is available. Mounting. Terminal shall include 3" wide bottom-mounting surfaces on opposite ends designed to accept bottom-mounting hardware including trapeze type. Bottom-mounting surfaces shall allow mounting hardware to be installed without interfering with access or removal of the bottom access panels.

1.9 SOUND

Sound Ratings. The terminal manufacturer shall provide AHRI certified sound power data for radiated and discharge sound. All NC values shall be calculated per AHRI standard 885-98. Verify sound ratings for the terminal do not exceed specified value at scheduled static pressure. Sound performance shall be AHRI certified. Each individual terminal unit shall bear an AHRI label.

Attenuators. Sound attenuator shall be provided where scheduled to meet acoustical performance requirements. The attenuator and terminal unit shall be single piece construction. Attenuator insulation shall be the same as the unit casing insulation.

2.0 CONTROLS

Controls shall be field supplied, installed and wired by the controls contractor.

Part 2 Execution

2.1 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for air terminal units installation in accordance with manufacturer's written instructions.
- .1 Visually inspect substrate in presence of Consultant.
- .2 Inform Consultant of unacceptable conditions immediately upon discovery.
- .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Consultant.

2.2 INSTALLATION

- .1 Install in accordance with manufacturers recommendations.
- .2 Support independently of ductwork.
- .3 Install with at least 1000 mm of flexible inlet ducting and minimum of four duct diameters of straight inlet duct, same size as inlet.
- .4 Locate controls, dampers and access panels for easy access.

2.3 CLEANING

- .1 Progress Cleaning: clean in accordance with Division 01 - Cleaning.
- .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Division 01 - Cleaning.
- .1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

END OF SECTION

1. GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Refer to Section 23 01 01.

1.2 REFERENCE STANDARDS

- .1 American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE)
 - .1 ASHRAE 70 - Method of Testing the Performance of Air Outlets and Air Inlets
- .2 American Society of Testing and Materials (ASTM)
 - .1 ASTM 610 – Standard Practice for Evaluating Degree of Rusting on Painted Steel Surfaces
 - .2 ASTM 714 – Test Method for Evaluating Degree of Blistering of Paints
 - .3 ASTM D1308 – Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes
 - .4 ASTM D1654 – Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
 - .5 ASTM D4752 – Standard Practice for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub
- .3 National Fire Protection Association (NFPA)
 - .1 NFPA 90A – Standard for the Installation of Air-Conditioning and Ventilating Systems
- .4 Underwriters Laboratories (UL/ULC)
 - .1 UL/ULC – Underwriters Laboratories Fire Resistance Directory/Underwriters Laboratories of Canada Equipment and Materials Directory, if applicable.

1.3 SHOP DRAWING SUBMITTALS

- .1 Submit in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for diffusers, registers and grilles and include product characteristics, performance criteria, physical size, finish and limitations.
 - .2 Indicate following:
 - .1 Capacity.
 - .2 Throw and terminal velocity.
 - .3 Noise criteria.
 - .4 Air pressure drop, static and dynamic.

.5 Neck velocity.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- .1 Extra Materials:
 - .1 Provide maintenance materials in accordance with Division 01 - Closeout Submittals.
 - .2 Include:
 - .1 Keys for volume control adjustment.
 - .2 Keys for air flow pattern adjustment.

1.5 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials off ground, indoors, in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect diffuser, registers and grilles from nicks, scratches, and blemishes.
 - .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.

2. PRODUCTS

2.1 SYSTEM DESCRIPTION

- .1 Performance Requirements:
 - .1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards.

2.2 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 manual volume control damper operators.
- .4 Colour: standard or as shown.

2.3 MANUFACTURED UNITS

- .1 Grilles, registers and diffusers of same generic type, products of one manufacturer.

2.4 STEEL LOUVRED GRILLE

- .1 Basis of Design: Price Industries, Inc.
 - .1 Steel Louvered Supply Grille: Model 510, 510Z, 520
 - .2 Steel Louvered Return Grille: Model 530, 535
- .2 Steel Louvered Supply Grille
 - .1 Description:
 - .1 Furnish and install Price Model 510, 510Z, or 520 steel louvered supply grilles and registers of sizes and mounting types designated by the plans and air distribution schedule.
 - .2 Construction:
 - .1 The grille blades and border shall be steel construction.
 - .2 Grilles shall be single deflection or double deflection louver type, and shall have:
 - .1 One set of fully adjustable blades, with 3/4 inch on center blade spacing (Model 510).
 - .2 One set of fixed blades with 0 degree deflection and 3/4 inch on center blade spacing (Model 510Z).
 - .3 Two sets of fully adjustable blades with 3/4 inch on center blade spacing (Model 520).
 - .3 The grilles front blade orientation shall be (select one), as indicated on the outlet schedule.
 - .1 Front blades parallel to the long dimension.
 - .2 Front blades parallel to the short dimension.
 - .3 Paint Specification:
 - .1 Paint finish B12 White:
 - .1 Baked-on powder coat finish.
 - .2 The paint film thickness shall be a minimum of 2 mils.

- .3 The finish shall have a hardness of 2H as tested in accordance with ASTM D3363.
- .4 The finish shall pass an ASTM B117 Corrosive Environment Salt Spray Test for 1000 hours with no measurable creep, rusting or blistering as per ASTM D1654, D610 and D714.
- .5 The finish shall pass an ASTM D870 Water Immersion test of a minimum of 500 hours with no measurable with no rusting or blistering as per ASTM D610 and D714.
- .6 The finish shall have an impact resistance of 100 inch-pounds in accordance with ASTM D2794.
- .4 Options:
 - .1 Opposed Blade Damper:
 - .1 The register shall be supplied with a coated steel opposed blade damper. The damper shall be operable from the register face.
 - .2 Border Style:
 - .1 The grille shall be suitable for surface mounting, T-bar lay-in mounting, panel mounting, or spiral duct frame mount, as applicable (refer to Architectural drawings for ceiling details) complete with a border in the following style:
 - .1 1-1/4 inch flat frame (required for spiral duct mount).
 - .2 1 inch narrow frame.
 - .3 Panel mount border. The maximum grille size shall equal the module size minus four inches. The panel module shall be the following size (select one):
 - .1 48 x 24 inches.
 - .3 Mounting Frames:
 - .1 The grille shall be supplied with (as applicable):
 - .1 3/8 inch flat border mounting frame.
 - .2 Spiral duct mounting frame.
 - .4 Fastening:
 - .1 The grille shall be supplied with the following fastening method (as applicable):
 - .1 Countersunk screw holes complete with screws.
 - .2 No screw holes.
 - .3 Concealed mounting brackets.
- .3 Steel Louvred Return Grille

- .1 Description:
 - .1 Furnish and install Price Model 530 and 535 steel louvered return grilles and registers of sizes and mounting types designated by the plans and air distribution schedule.
- .2 Construction:
 - .1 The grille blades and border shall be steel construction.
 - .2 Grilles shall be 45 degree deflection fixed louver type to minimize see-through, and shall have:
 - .1 One set of fixed blades with 3/4 inch on center blade spacing (Model 530)
 - .2 One set of fixed blades with 1/2 inch on center blade spacing (Model 535).
 - .3 The grilles blade orientation shall be, as indicated on the outlet schedule.
 - .1 Blades parallel to the long dimension.
 - .2 Blades parallel to the short dimension.
- .3 Paint Specification:
 - .1 Paint finish B12 White:
 - .1 Baked-on powder coat finish.
 - .2 The paint film thickness shall be a minimum of 2 mils.
 - .3 The finish shall have a hardness of 2H as tested in accordance with ASTM D3363.
 - .4 The finish shall pass an ASTM B117 Corrosive Environment Salt Spray Test for 1000 hours with no measurable creep, rusting or blistering as per ASTM D1654, D610 and D714.
 - .5 The finish shall pass an ASTM D870 Water Immersion test of a minimum of 500 hours with no measurable with no rusting or blistering as per ASTM D610 and D714.
 - .6 The finish shall have an impact resistance of 100 inch-pounds in accordance with ASTM D2794.
- .4 Options:
 - .1 Opposed Blade Damper:
 - .1 The register shall be supplied with a coated steel (D) opposed blade damper. The damper shall be operable from the register face.
 - .2 Border Style:

- .1 The grille shall be suitable for surface mounting, T-bar lay-in mounting, panel mounting, or spiral duct frame mount (refer to Architectural drawings for details), complete with a border in the following style:
 - .1 Surface Mount with 1-1/4 inch flat border. (required for spiral duct mount)
 - .2 Surface Mount with 1 inch narrow border.
 - .3 Panel mount border. The maximum grille size shall equal the module size minus four inches. The panel module shall be the following size (select one):
 - .1 12 x 12 inches.
 - .2 24 x 12 inches.
 - .3 24 x 24 inches.
 - .4 48 x 24 inches.
- .3 Mounting Frames:
 - .1 The grille shall be supplied with (select one):
 - .1 3/8 inch flat border mounting frame.
 - .2 5/8 inch narrow border mounting frame.
- .4 Fastening:
 - .1 The grille shall be supplied with the following fastening method (select one):
 - .1 Countersunk screw holes complete with screws.
 - .2 Concealed bracket (applies to Model 530 and surface mount only).
 - .3 No screw holes (default for T-bar frames).
- .5 Light Shield:
 - .1 The grille shall be supplied with a light shield to minimize the direct line of sight through the grille into the ceiling plenum and block reflected light from ceiling fixtures.

2.5 SQUARE CONE DIFFUSER

- .1 Description:
 - .1 Furnish and install Price model SCD – steel, SCDAS – Aluminized Steel or ASCD – aluminum square cone ceiling diffusers of sizes and mounting types designated by the plans and air distribution schedule.
- .2 Construction:

- .1 Diffusers shall be steel, aluminized steel, or aluminum construction, and shall consist of a seamless, one-piece, precision formed backpan that incorporates a round inlet collar of sufficient length for connecting rigid or flexible duct.
- .2 The diffuser shall integrate with all duct sizes shown on the plans without affecting the face size and appearance of the unit.
- .3 An inner cone assembly shall consist of 3 cones or 4 cones on 24 x 24 size which drop below the ceiling plane to assure optimal VAV air diffusion performance. The inner cone assembly shall be completely removable from the diffuser face to allow for full access to any dampers or other ductwork components located near the diffuser neck.
- .4 The diffuser ceiling module size shall be as per drawing schedule:
 - .1 24 x 24 inches (600 x 600 millimeters)
 - .2 20 x 20 inches (500 x 500 millimeters)
 - .3 12 x 12 inches (300 x 300 millimeters)
- .3 Paint Specification:
 - .1 Paint finish shall be B12 White:
 - .1 All components shall have a baked-on powder coat finish.
 - .2 The paint finish must demonstrate no degradation when tested in accordance with ASTM D1308 (covered and spot immersion) and ASTM D4752 (MEK double rub) paint durability tests.
 - .3 The paint film thickness shall be a minimum of 2.0 mils.
 - .4 The finish shall have a hardness of 2H.
 - .5 The finish shall withstand a minimum salt spray exposure of 500 hours with no measurable creep in accordance with ASTM D1654, and 1000 hours of exposure with no rusting or blistering as per ASTM D610 and ASTM D714.
 - .6 The finish shall have an impact resistance of 80 inch-pounds.
- .4 Mounting Frame:
 - .1 The diffuser mounting frame shall be suitable for lay-in or surface mount applications with the following frame style as applicable (refer to Architectural drawings for ceiling details):
 - .1 9/16 inch wide T-bar with drop frame
 - .2 Concealed spline
 - .3 15/16 inch wide flat T-bar
 - .4 Snap-in T-bar
 - .5 9/16 wide tegular T-bar
 - .6 Clip-on Recessed Spline
 - .7 Surface mount

- .5 Options:
 - .1 Steel Panel:
 - .1 The diffuser shall be mounted in a steel panel for lay-in applications.
 - .2 The panel size shall be based on the diffuser size selected.
 - .1 For 24 x 24 diffusers, the panel shall be (select one):
 - .1 24 x 48
 - .2 30 x 30
 - .2 For 12 x 12 diffusers, the panel shall be (select one):
 - .1 12 x 24
 - .2 12 x 48
 - .3 16 x 16
 - .4 20 x 20
 - .5 24 x 24

2.6 SQUARE PLAQUE DIFFUSER

- .1 Description:
 - .1 Furnish and install Price model SPD – steel, SPDAS – aluminized steel or ASPD – aluminum as shown square plaque ceiling diffusers of sizes and mounting types designated by the plans and air distribution schedule.
- .2 Construction:
 - .1 Diffusers shall be steel construction, and shall consist of a seamless, one-piece, precision formed backpan that incorporates a round inlet collar of sufficient length for connecting rigid or flexible duct.
 - .2 An inner plaque assembly shall be incorporated and shall drop no more than ¼ inch below the ceiling plane to assure proper air distribution performance.
 - .3 The inner plaque assembly shall be completely removable from the room side to allow for full access to any dampers or other ductwork components located near the diffuser neck.
 - .4 The diffuser shall integrate with all duct sizes shown on the plans without affecting the face size and appearance of the unit.
 - .5 The face panel shall have smooth edges and rounded corners to blend with the back cone.
 - .6 The diffuser ceiling module size shall be:
 - .1 24 x 24 inches (600 x 600 millimeters)
 - .2 12 x 12 inches (300 x 300 millimeters)

- .3 Paint Specification:
 - .1 Paint finish:
 - .1 All components shall have a baked-on powder coat finish (B12 White).
 - .1 The paint finish must demonstrate no degradation when tested in accordance with ASTM D1308 (covered and spot immersion) and ASTM D4752 (MEK double rub) paint durability tests.
 - .2 The paint film thickness shall be a minimum of 2.0 mils.
 - .3 The finish shall have a hardness of 2H.
 - .4 The finish shall withstand a minimum salt spray exposure of 500 hours with no measurable creep in accordance with ASTM D1654, and 1000 hours of exposure with no rusting or blistering as per ASTM D610 and ASTM D714.
 - .5 The finish shall have an impact resistance of 80 inch-pounds.
 - .4 Mounting Frame:
 - .1 The diffuser mounting frame shall be suitable for lay-in or surface mount applications with the following frame style (refer to Architectural drawings for ceiling details):
 - .1 15/16 inch wide flat T-bar
 - .2 9/16 inch wide T-bar with drop frame
 - .3 9/16 wide tegular T-bar
 - .4 Snap-in T-bar
 - .5 Options:

2.7 EGG CRATE GRILLES

- .1 Basis of Design: Price Industries, Inc.
 - .1 Egg Crate Grille: Model 80, 81, 82
- .2 General:
 - .1 The egg crate grille shall be supplied with a cubical grid core, used as a high capacity return or exhaust outlet with high free area and low sound and pressure drop.
- .3 Description:
 - .1 Furnish and install Price Model [80], [81], [82] egg crate grilles and registers of sizes and mounting types designated by the plans and air distribution schedule.
- .4 Construction:

- .1 Grilles shall be aluminum construction, consisting of an extruded aluminum border:
 - .1 An aluminum $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}$ inch grid egg crate core. [Model 80]
 - .2 Two aluminum $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}$ inch grids stacked to make a $\frac{1}{2} \times \frac{1}{2} \times 1$ inch grid egg crate core. [Model 81]
 - .3 An aluminum $\frac{1}{2} \times \frac{1}{2} \times 1$ inch grid egg crate core, single piece option. [Model 81]
 - .4 An aluminum $1 \times 1 \times 1$ inch grid egg crate core. [Model 82]
- .2 The minimum grille size shall be six inches by four inches. The maximum one-piece grille size without a mullion shall be 48 inches x 24 inches. The maximum size grille size with a mullion is 96 x 48 inches.
- .5 Paint Specification:
 - .1 Paint finish shall be B12 White:
 - .1 Baked-on powder coat finish.
 - .1 The paint film thickness shall be a minimum of 2 mils.
 - .2 The finish shall have a hardness of 2H as tested in accordance with ASTM D3363.
 - .3 The finish shall pass an ASTM B117 Corrosive Environment Salt Spray Test for 1000 hours with no measurable creep, rusting or blistering as per ASTM D1654, D610 and D714.
 - .4 The finish shall pass an ASTM D870 Water Immersion test of a minimum of 500 hours with no measurable with no rusting or blistering as per ASTM D610 and D714.
 - .5 The finish shall have an impact resistance of 100 inch-pounds in accordance with ASTM D2794.
- .6 Options:
 - .1 Opposed Blade Damper:
 - .1 The grille shall be supplied with a coated steel opposed blade damper.
 - .2 Border Style:
 - .1 The grille shall be suitable for sidewall, exposed duct, or T-bar lay-in mounting, complete with a border in the following style to suit installation specifics and as indicated:
 - .1 1-1/4 inch flat face border for surface mount applications.
 - .2 One inch narrow face border for surface mount applications.
 - .3 1-1/4 inch curved face border for surface mount applications.
 - .4 9/16 inch bolt slot or flat T-bar border.

- .5 Narrow flat face border for 15/16 inch T-bar lay-in.
- .6 Channel border (no flange) for 15/16 inch T-bar applications to maximize free area.
- .7 Exposed duct border for mounting directly to exposed ducts.
- .8 Core only (no border) for 15/16 inch T-bar applications.
- .9 Panel mount border (15/16 or 9/16 inch T-bar mounting only). The maximum grille size shall equal the module size minus four inches. The panel module size shall be the following size (**select one**):
 - .1 12 x 12 inches.
 - .2 24 x 12 inches.
 - .3 24 x 24 inches.
 - .4 48 x 24 inches.
- .3 Mounting Frames:
 - .1 The grille shall be supplied with a 3/8 inch flat border mounting frame.
- .4 Fastening:
 - .1 The grille shall be supplied with the following fastening method:
 - .1 Countersunk screw holes complete with oval-head screws.
 - .2 Concealed mounting bracket.
 - .3 Straight screw holes.
 - .4 No screw holes (default for T-Bar frames).
- .5 Thin Line Return Dissipater (Nominal 22 x 22 inch size and Flat Face Border T-bar frame only):
 - .1 The grille shall be supplied with a Thin Line Return Dissipater (TLRD) to provide sound power insertion loss across the full range of frequencies and shall be suitable for ceiling and wall applications.
 - .2 The manufacturer shall provide catalogued performance for insertion loss and transmission loss.
 - .3 The TLRD shall be a high-quality welded galvanized steel construction. Satin Coat paint shall be available as an option.
 - .4 The TLRD shall be factory-mounted to the grille and shipped as a one-piece construction to simplify field installation.

2.8 SIGHT-PROOF TRANSFER/DOOR GRILLES

- .1 Basis of Design: Price Industries, Inc.
 - .1 Sight-proof Transfer/Door Grilles – Steel Construction: Model STG1

- .2 Sight-proof Transfer/Door Grilles – Aluminum Construction: Model ATG1/ATGH
- .3 Sight-proof or Light-proof Transfer/Door Grilles – Aluminum Construction: Model ATG2
- .2 General:
 - .1 The transfer/door grille shall be supplied with a sight-proof core to allow airflow to a space that is not directly served by a ducted source of supply air or a ducted outlet for return or exhaust.
- .3 Sight-Proof Transfer/Door Grilles – Steel Construction [Price Model STG1]:
 - .1 Construction
 - .1 Core and frame material shall be steel.
 - .2 Paint finish:
 - .1 Baked-on powder coat finish.
 - .1 The paint film thickness shall be a minimum of 2 mils.
 - .2 The finish shall have a hardness of 2H as tested in accordance with ASTM D3363.
 - .3 The finish shall pass an ASTM B117 Corrosive Environment Salt Spray Test for 1000 hours with no measurable creep, rusting or blistering as per ASTM D1654, D610 and D714.
 - .4 The finish shall pass an ASTM D870 Water Immersion test of a minimum of 500 hours with no measurable with no rusting or blistering as per ASTM D610 and D714.
 - .5 The finish shall have an impact resistance of 100 inch-pounds in accordance with ASTM D2794.
 - .2 All components shall have a custom finish in a color to match a customer supplied sample.
- .4 Sight-Proof Transfer/Door Grilles – Aluminum Construction
 - .1 Construction
 - .1 Core and frame material shall be aluminum.
 - .2 Finish:
 - .1 All aluminum components shall have a B15 Aluminum baked-on powder coat finish.
 - .1 The paint finish must demonstrate no degradation when tested in accordance with ASTM D1308 (covered and spot immersion) and ASTM D4752 (MEK double rub) paint durability tests.

- .2 The paint film thickness shall be a minimum of 2.0 mils.
- .3 The finish shall have a hardness of 2H.
- .4 The finish shall withstand a minimum salt spray exposure of 500 hours with no measurable creep in accordance with ASTM D1654, and 1000 hours of exposure with no rusting or blistering as per ASTM D610 and ASTM D714.
- .2 The finish shall have an impact resistance of 80 in/lb.
- .3 All aluminum components shall have a custom finish in a color to match a customer supplied sample.
- .5 Sight-Proof or Light Proof Transfer/Door Grilles – Aluminum Construction
 - .1 Construction
 - .1 Core and frame material shall be aluminum.
 - .2 Finish shall be:
 - .1 All aluminum components shall have a B17 Black baked-on powder coat finish.
 - .1 The paint finish must demonstrate no degradation when tested in accordance with ASTM D1308 (covered and spot immersion) and ASTM D4752 (MEK double rub) paint durability tests.
 - .2 The paint film thickness shall be a minimum of 2.0 mils.
 - .3 The finish shall have a hardness of 2H.
 - .4 The finish shall withstand a minimum salt spray exposure of 500 hours with no measurable creep in accordance with ASTM D1654, and 1000 hours of exposure with no rusting or blistering as per ASTM D610 and ASTM D714.
 - .5 The finish shall have an impact resistance of 80 in/lb.
- .6 Border Styles:
 - .1 Channel Border:
 - .1 The grille shall be supplied with a channel border for on-site wood trim framing by others.
 - .2 Flat border, one side:
 - .1 The grille shall be supplied with a 1-1/4" wide flat border on one side.
 - .2 The grille shall include countersunk screw hole fastening.
 - .3 Flat border, both sides:
 - .1 The grille shall be supplied with a 1-1/4" wide flat border on both sides.

- .2 The grille shall include countersunk screw hole fastening.

2.9 RETURN AND EXHAUST GRILLES AND REGISTERS

- .1 General: with opposed blade dampers.
- .2 Type RA: aluminum, 19 mm border, single 45 degrees deflection, face bars parallel to long dimension. Finish standard or as shown. Model as shown.

2.10 DIFFUSERS

- .1 General: volume control dampers with flow straightening devices and blank-off quadrants as shown and gaskets.
- .2 Type DA: aluminum, square type, having fixed pattern, lay-in or surface mounted. Finish standard or as shown. Model as shown.
- .3 Type DB: aluminum, round type, having fixed pattern, lay-in or surface mounted. Finish standard or as shown. Model as shown.

3. EXECUTION

3.1 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for diffuser, register and grille installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Consultant.
 - .2 Inform Consultant of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Consultant.

3.2 INSTALLATION

- .1 Install in accordance with manufacturers instructions.
- .2 Install with flat head stainless steel screws in countersunk holes where fastenings are visible.
- .3 Bolt grilles, registers and diffusers, in place, in gymnasium and similar game rooms.
- .4 Provide concealed safety chain on each grille, register and diffuser in gymnasium and similar game rooms and elsewhere as indicated.

3.3 CLEANING

- .1 Progress Cleaning: clean in accordance with Division 01 - Cleaning.

- .1 Leave Work area clean at end of each day.
 - .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Division 01 - Cleaning.
 - .3 Waste Management: separate waste materials for recycling in accordance with Division 01 - Waste Management and Disposal.
-
- .1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

END OF SECTION

1. GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Refer to Section 23 01 01.

1.2 REFERENCE STANDARDS

- .1 American Architectural Manufacturers Association (AAMA)
 - .1 AAMA 605.2 - Voluntary Specification for High Performance Organic Coatings on Architectural Extrusions and Panels.
 - .2 AAMA 606.1 - Voluntary Guide Specification and Inspection Methods for Integral Color Anodic Finishes for Architectural Aluminum.
 - .3 AAMA 607.1 - Voluntary Guide Specification and Inspection Methods for Clear Anodic Finishes for Architectural Aluminum.
 - .4 AAMA 611 – Voluntary Specification for Anodized Architectural Aluminum
 - .5 AAMA 2603 – Voluntary Specification, Performance Requirements and Test Procedures For Pigmented Organic Coatings on Aluminum Extrusions and Panels
 - .6 AAMA 2605 – Voluntary Specification, Performance Requirements and Test Procedures For Superior Performing Pigmented Organic Coatings on Aluminum Extrusions and Panels
- .2 Air Movement and Control Association (AMCA)
 - .1 AMCA 99 - Standards Handbook
 - .2 AMCA 200 - Publication, Air Systems
 - .3 AMCA 201-90 - Publication, Fans and Systems
 - .4 AMCA 202-88 - Publication, Troubleshooting
 - .5 AMCA 203-90 - Publication, Field Performance Measurement of Fan Systems
 - .6 AMCA 204-05 - Standard Balance Quality and Vibration Levels for Fans
 - .7 AMCA 210-99 - Standard Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
 - .8 AMCA 211-05 - Publication, Certified Ratings Program – Product Rating Manual for Fan Air Performance
 - .9 AMCA 300-96 - Standard Reverberant Room Method for Sound Testing of Fans
 - .10 AMCA 311-05 - Publication Certified Ratings Program – Product Rating Manual for Fan Sound Performance
 - .11 AMCA 500L – Laboratory Methods for Testing Louvers for Rating
 - .12 AMCA 99-0401-86 - Classification for Spark Resistant Construction
 - .13 AMCA 99-2408-69 - Operating Limits for Centrifugal Fans

- .3 ASTM International (ASTM)
 - .1 ASTM E90, Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
 - .2 ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
 - .3 ASTM B221 - Aluminum-Alloy Extruded Bar, Rod, Wire, Shape, and Tube.
 - .4 ASTM D7091 (formerly ASTM D1400) – Standard Practice for Non-destructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals
 - .5 ASTM E330-02 - Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylight and Curtain Walls by Uniform Static Air Pressure Difference
- .4 National Fire Protection Association (NFPA)
 - .1 NFPA 70 - National Electrical Code
 - .2 NFPA 90A-02 - Standard for the Installation of Air-Conditioning and Ventilating Systems
 - .3 NFPA 92A-06 - Recommend Practice for Smoke-Control System
 - .4 NFPA 92B-05 - Standard for Smoke Management System in Malls, Atria, and Large Areas
 - .5 NFPA 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
- .5 National Research Council Canada (NRC)
 - .1 National Building Code of Canada (NBC).
- .6 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
- .7 Society of Automotive Engineers (SAE)
- .8 Underwriters Laboratories (UL)
 - .1 UL 507 - Electric Fans
 - .2 UL 555 - Fire Dampers
 - .3 UL 555S - Smoke Dampers
 - .4 UL 705 - Standard Power Ventilators
 - .5 UL 762 - Standard Power Roof Ventilators for Restaurant Exhaust Appliances
 - .6 UL 793 - Snow Load

1.3 SHOP DRAWING SUBMITTALS

- .1 Submit in accordance with Division 01 - Submittal Procedures.
- .2 Product Data:

- .1 Submit manufacturer's instructions, printed product literature and data sheets for louvers, intakes and vents and include product characteristics, performance criteria, physical size, finish and limitations.
- .2 Indicate following:
 - .1 Pressure drop.
 - .2 Face area.
 - .3 Free area.
 - .4 Moisture entrainment.
- .3 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .4 Test Reports: submit certified data from independent laboratory substantiating acoustic and aerodynamic performance to ASTM E90.

1.4 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials off ground, indoors, in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect louvers, intakes and vents from nicks, scratches, blemishes, theft, vandalism, and damage by vermin.
 - .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.

2. PRODUCTS

2.1 SYSTEM DESCRIPTION

- .1 Performance Requirements:
 - .1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards.

2.2 WALL VENTS

- .1 Manufacturer: Sunvent Industries, a division of Sylro Sales Corporation, 1 Industrial Drive, No. 26, Pelham, New Hampshire 03076; 800-325-4115; www.sunventindustries.com .
- .2 Model: EX Series Extruded Aluminum Wall Vent.

	Vent Height (inches)						
Vent Width (inches)		2-3/8	4-3/4	7-3/4	11-3/4	15-3/4	2-3/8
	8-1/8	0.029 SF	0.080 SF	0.136 SF	0.207 SF	0.279 SF	0.029 SF
	12-5/8	0.044 SF	0.120 SF	0.204 SF	0.310 SF	0.418 SF	0.044 SF
	15-5/8	0.056 SF	0.156 SF	0.263 SF	0.400 SF	0.540 SF	0.056 SF
	16-1/2	0.060 SF	0.196 SF	0.280 SF	0.426 SF	0.575 SF	0.060 SF
	24	0.088 SF	0.271 SF	0.408 SF	0.620 SF	0.836 SF	0.088 SF
	32	0.117 SF	0.321 SF	0.543 SF	0.826 SF	1.115 SF	0.117 SF

- .3 Materials:
 - .1 Extruded aluminum: 0.125 inch minimum thickness extruded aluminum complying with ASTM B221, Alloy 6063, Temper T-5.
 - .2 Sheet aluminum: 0.040 inch minimum thickness complying with ASTM B209.
 - .3 Fasteners: Type, size, and spacing as recommended by vent manufacturer for project conditions.
 - .4 Sealant and backer rod: Type as recommended by vent manufacturer.
- .4 Construction: Extruded aluminum framed vent without flanges and with overlapping horizontal louver blades fabricated from extruded aluminum sections.
- .5 Louver blades: Fixed, horizontal blades 1 inch deep at 1 inch centers. Blade shall be set at 45 degrees. Top of blade formed with storm drip.
- .6 Frame:
 - .1 Material: Extruded member with mortar ribs.
 - .2 Top of frame shall have an integral drip edge at front of frame.
 - .3 Bottom of frame shall have an integral water stop at back of frame and integral drip edge at front of frame.
- .7 Fabricate vents with mechanical connections such that all fasteners are concealed when vent is installed.
- .8 Insect screen: Aluminum 18 by 14 mesh screen set behind louvers in extruded stop on frame.

2.3 STATIONARY LOUVRES - ALUMINUM

- .1 Basis of Design: Price Industries, Inc.
 - .1 Drainable Louver
- .2 Description:
 - .1 Furnish and install Price Model DE439 Drainable Louver of size and shape indicated on the plans and/or as described in schedules.
 - .2 Louver performance shall be based on tests and procedures in accordance with AMCA publication 500-L.
- .3 Construction:
 - .1 Louvers shall be constructed of 6063-T5 alloy extruded aluminum.
 - .2 Louver blades and frames shall be minimum 0.081 inch wall thickness. Louver assemblies shall be 4 inches deep with 39-degree stationary drainable blades. Louvers shall be welded construction.
 - .3 Louvers shall be designed to withstand a 25 pound per square foot wind load.
 - .4 Louvers shall be fitted with 1/2 inch x 0.051 inch flattened expanded aluminum bird screen. Bird screen shall be mounted on interior louver face.
 - .5 Louvers shall be supplied with a standard mill finish.

3. EXECUTION

3.1 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for louvres, intakes and vents installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Consultant.
 - .2 Inform Consultant of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Consultant.

3.2 INSTALLATION

- .1 In accordance with manufacturer's and SMACNA recommendations.
- .2 Reinforce and brace as indicated.
- .3 Anchor securely into opening. Seal with caulking to ensure weather tightness.

3.3 CLEANING

- .1 Progress Cleaning: clean in accordance with Division 01 - Cleaning.
 - .1 Leave Work area clean at end of each day.

- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Division 01 - Cleaning.
- .3 Waste Management: separate waste materials for reuse and recycling in accordance with Division 01 - Waste Management and Disposal.
 - .1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Read and conform to:
 - .1 The Contract CCDC 2, Stipulated Price Contract as amended,
 - .2 Division 1 requirements and documents referred to therein.
- .2 Section 25 01 01 applies to and governs the work of all Sections of Division 25.
- .3 The technical Sections of this Division are generally divided into units of work for the purpose of ready reference.
- .4 The division of the work among subcontractors is not the Consultant's responsibility and the Consultant assumes no responsibility to act as an arbiter and/or to establish subcontract limits between any Sections of the work.
- .5 The specifications are integral with the drawings which accompany them. Neither is to be used alone. Any item or subject omitted from one but implied in the other is fully and properly required.
- .6 Wherever differences occur in the tender documents, the most onerous condition governs. Base the bid on the costliest arrangement.

1.2 DEFINITIONS

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

1.3 WORK INCLUDED

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

with incidentals necessary for a complete operating installation. Provide all tools, equipment and services required to do the work.

- .2 Cutting and patching of new or existing work
- .3 Identification of equipment, valves, dampers and controllers
- .4 Motors required for equipment supplied under this Division.
- .5 Take such measures and include in Bid Price for the proper protection of the existing building and its finishes at all times during alterations and construction of the new addition. Coordinate this protective work with all trades.
- .6 Refer to Mechanical/Electrical Equipment Schedule for extent of wiring and electrical characteristics.
- .7 Verify the correct operation of each equipment item provided and/or altered and each system in total and obtain the Owner's approval prior to starting and/or returning to operation.

1.4 SUBMITTALS

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

"This review by the Consultant is for the sole purpose of ascertaining conformance with general design concept. This review shall not mean that the Consultant approves the detail design inherent in the shop drawings, responsibility for which shall remain with the Contractor submitting same, and such review shall not relieve the Contractor of his responsibility for errors or omissions in the shop drawings or of his responsibility for meeting all requirements of the Contract Documents. The Contractor is responsible for dimensions to be confirmed and

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

- .3 Composite Wiring Diagrams: Prepare and submit three (3) copies of complete composite wiring diagrams of each specific control system. Indicate all electrical equipment and wiring, both internal and external, for review and coordination of trades.
- .4 Contractor's Material and Test Certificates: Prepare and submit certificates for each system installed. Where certificates are prescribed by regulations, codes or standards ensure they conform to the requirements of those documents (eg. NFPA-standards). Include a copy of each certificate in the Operation and Maintenance manual. Certificates shall include the following:
 - .1 description of the system (description and type),
 - .2 description of the tests conducted and results observed, including re-testing, where necessary,
 - .3 description of any corrective measures undertaken,
 - .4 description of materials used (pipe and fittings),
 - .5 list of witnesses for each test conducted,
 - .6 date system left ready for service,
 - .7 signature of installing Contractor.
- .5 Directories & Schematics
 - .1 Submit five (5) copies of a neat typewritten directory indicating the valve number, related service, and location of each valve under this Division.
 - .2 Submit five (5) copies of system control schematics for each mechanical system indicating relative locations of equipment and control devices.
 - .3 Enclose one (1) copy of each directory/schematic under glass in a neat polished 18" x24" (460 mm x 610 mm) metal frame, complete with mounting clips.
- .6 Maintenance Data and Operating Instructions
 - .1 Submit three (3) copies of Operation and Maintenance Manual individually bound in hard backed three-ring binders.
 - .2 Ensure the binder spines have typewritten lettering as follows:

OPERATION & MAINTENANCE MANUAL

for

[Insert Project Name]

[Insert date of submission]

[Insert Division Title]
 - .3 Provide a list of names, addresses and telephone numbers of equipment suppliers, installing contractors, general contractors, architect and

- Consultant. Include special telephone numbers for service departments on normal and emergency call basis.
- .4 Provide descriptive literature (shop drawings) of each manufactured item. Include a bill of material with purchase order numbers and vendor's identification of equipment orders for each item.
 - .5 Include copies of start-up reports and checklists and all certificates issued with respect to this contract.
 - .6 Ensure operating instructions include the following:
 - .1 General description of each mechanical system.
 - .2 Step by step procedure to follow in putting each piece of equipment into service.
 - .3 Schematic control diagrams for each separate mechanical system, control thermometers, freezestats, firestats, pressure gauges, automatic valves, and refrigeration accessories. Mark correct operating settings for each control device on these diagrams.
 - .4 Diagram of the electrical control system indicating the wiring of all related electrical components such as PE and EP switches, firestats, freezestats, fuses, interlocks, electrical switches and relays.
 - .5 Drawings of each control panel including temperature control and electrical panels, completely identifying all components on the panels and their function.
 - .7 Ensure maintenance instructions include the following:
 - .1 Manufacturer's maintenance instructions for each item of mechanical equipment installed under this Division. Instructions shall include installation instructions, parts numbers and lists, name of supplier and maintenance and lubrication instructions.
 - .2 Summary list of each item of mechanical equipment requiring lubrication, indicating the name of the equipment item, location of all points of lubrication, type of lubricant recommended, and frequency of lubrication.
 - .3 Equipment directory indicating name, model, serial number and nameplate data of each item of equipment supplied, and system with which it is associated.
 - .4 Balancing and testing reports.
 - .5 Copy of valve directory.
 - .8 As-Built Records: Prepare and submit complete as-built records prior to Substantial Performance of the Contract. Refer to paragraph 3.2.5 and to Division 1 for requirements.
 - .9 Requests for Shut-Down: Obtain permission for systems shut-down and/or service interruption from the Owner prior to disruption of any system or service in use by the Owner. Employ the Owner's standard form of request where available.

Refer to Division 1 for additional requirements.

- .10 Requests for Start-up: Obtain permission from the Owner to start-up or to return to service any item of equipment, system or service installed new or previously shut-down. Refer to Division 1 for additional requirements.

1.5 QUALITY ASSURANCE

- .1 Conform to minimum requirements or better of provincial and local codes, where existing, and to requirements of local inspection authorities for execution of work under this Division.
- .2 Ensure materials supplied under this Division conform to minimum requirements and recommendations or better of applicable standards of the following:
- | | | |
|-----|-----------------|--|
| .1 | ANSI | American National Standards Institute |
| .2 | ASA | American Standards Association |
| .3 | ASHRAE | American Society of Heating, Refrigerating, and Air Conditioning Engineers |
| .4 | ASME | American Society of Mechanical Engineers |
| .5 | ASTM | American Society of Testing and Materials |
| .6 | CAN2 | National Standard of Canada (Published by CGSB) |
| .7 | CAN3 | National Standard of Canada (Published by CSA) |
| .8 | CGSB | Canadian General Standards Board |
| .9 | CSA | Canadian Standards Association |
| .10 | EEMAC of Canada | Electrical & Electronic Manufacturer's Association |
| .11 | NBC | National Building Code of Canada |
| .12 | NEBB | National Environmental Balancing Bureau |
| .13 | NFPA | National Fire Protection Association |
| .14 | NEMA | National Electrical Manufacturers Association |
| .15 | OBC | Ontario Building Code |
| .16 | OFC | Ontario Fire Code |
| .17 | OFM | Ontario Fire Marshall |
| .18 | ULC | Underwriter's Laboratories of Canada Ltd |
| .19 | UL | Underwriter's Laboratories (including cUL) |
- .3 Use latest editions and amendments in effect on date of Bid call subject to requirements of OBC.
- .4 Arrange and pay for permits and inspections by authorities having jurisdiction, required in the undertaking of this Division. Make modifications required by authorities.
- .5 All tradesmen employed on the project shall hold valid trade certificates/licenses

and shall make a copy available for review by the Consultant and/or Owner when requested.

1.6 PRODUCT DELIVERY, HANDLING AND STORAGE

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

1.7 JOB CONDITIONS

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

1.8 INTERRUPTIONS

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

1.9 WARRANTY

- .1 Refer to Division 1 and to Section 21 01 01 General Requirements.
- .2 Arrange with each manufacturer/supplier to extend warranties as necessary to coincide with warranty period or those periods specified.
- .3 Make submissions necessary to register product warranties to the benefit of the Owner.
- .4 Submit to Consultant, prior to Substantial Performance of the Contract,

manufacturer's written warranties covering periods longer than one year or offering greater benefits than required in specifications and in the Owner's name.

1.10 EXTRAS AND CREDITS

- .1 Accompany price submissions requested by Consultant for extra work, or work to be deleted, with a complete cost breakdown as follows:
 - .1 Materials, quantities, and unit costs including any applicable contractors trade discount clearly identified. Provide supplier quotations.
 - .2 Labour hours and unit costs.
 - .3 Total materials and labour costs.
 - .4 Overhead and profit mark-ups in accordance with the General Conditions of the Contract.
- .2 Quotations from software such as Allpriser will not be accepted. Provide actual material costs.

2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

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

2.2 ACCEPTABLE PRODUCTS

- .1 First item named or specified by catalogue number meets specifications regarding performance, quality of material and workmanship, and is acceptable to the Consultant.
- .2 Items, other than first named, meeting specifications regarding quality of materials and workmanship are acceptable to the Consultant, only, if they also meet performance and/or capacities specified and can be accommodated within

the space allotted.

- .3 General approval indicated by inclusion of other manufacturers named is subject to final review of shop drawings, performance data and test reports.

2.3 EQUIVALENTS AND ALTERNATIVES

- .1 Suppliers wishing approval for additional equipment items as equivalent to those specified must submit complete description, technical and performance data to Consultant at least ten (10) working days prior to Bid closing date. Such equivalent equipment, if accepted, to conform to specifications with regard to all details, accessories, modifications, features and performance. Deviations from specifications must be stated in writing at time of submission for approval.
- .2 Bid Prices shall include only products specified or approved equivalents. Contractors may propose unsolicited alternatives to the products specified. Alternative proposals shall be submitted in sealed envelope at time of general contract Bid submission and shall include full description and technical data, and a statement of the related increase or decrease in Bid Price should alternatives be accepted. All additional costs associated with unsolicited alternative proposals such as larger motor starters, larger power feeders, space revisions to associated equipment, controls, etc. shall be included in alternative price. Prior approval by Consultant is not required for unsolicited alternative proposals.
- .3 Where the Contractor uses equipment other than that first named, on which the design is based, he shall be responsible for all details of installation including equipment size, arrangement, fit, and maintenance of all required clearances. Contractor shall prepare and submit revised layouts to indicate arrangement of all affected piping, ductwork, conduit, lighting, equipment, etc. Failure by Contractor to provide such drawings will be considered indication that original arrangements and space allocations are adequate. All additional costs associated with equivalent equipment such as larger motor starters, larger power feeders, space revisions to associated equipment, controls, etc. shall be included in Bid Price.

2.4 SUBSTITUTIONS DURING PROGRESS OF WORK

- .1 If during the progress of work, specified products are not obtainable, equivalent or similar products by other manufacturers may be permitted by Consultant.
- .2 Apply, in writing, to Consultant for substitution of any products, indicating the following:
 - .1 Manufacturer's name, model number, details of construction, accurate dimensions, capacities and performance of proposed products.
 - .2 Reason for substitution.
 - .3 Any revisions to the contract price made necessary by substitution.
 - .4 Any revisions to the contract time made necessary by substitution.
 - .5 Any revisions to layout, arrangement or services made necessary by substitution.
- .3 No substitutions will be permitted without written authorization from the Consultant.

2.5 CONSULTANT'S REVIEW

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

3 EXECUTION

3.1 RELATIONSHIP WITH OTHER TRADES

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

3.2 INSTALLATION REQUIREMENTS

- .1 The Consultant's drawings and instructions govern the location of all items. Prepare fully coordinated installation drawings prior to installation.
- .2 Install equipment neatly to the satisfaction of the Consultant. Unless noted otherwise install products and services to follow building planes. Ensure installation permits free use of space and maximum headroom.
- .3 Confirm the exact location of outlets, fixtures and connections. Confirm location of outlets for equipment supplied under other Divisions.
- .4 Install equipment and apparatus to allow free access for maintenance, adjustment and eventual replacement.
- .5 Install metering and/or sensing devices to provide proper and reliable sampling of quantities being measured. Install instruments to permit easy observation.
- .6 Provide suitable shielding and physical protection for devices.
- .7 Install products and services in accordance with the manufacturer's requirements and/or recommendations.
- .8 Provide bases, supports, hangers and fasteners. Secure products and services so as not to impose undue stresses on the structure and systems.
- .9 Do not use powder activated tools except as permitted by the Prime Consultant and the Owner's workplace health and safety policies.
- .10 Ensure that the load onto structures does not exceed the maximum loading per square metre indicated on the structural drawings or as directed by the Consultant.

3.3 CONTRACT DRAWINGS

- .1 The drawings of this Division are performance drawings and indicate general

arrangement of the work. They are diagrammatic except where specific details are given.

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

3.4 RECORD DRAWINGS

- .1 Maintain project "as-built" record drawings. Obtain white prints from the Consultant for this purpose and pay printing costs. Identify each set as "Project Record Copy".
- .2 Record deviations from contract documents caused by site conditions or by changes ordered by the Consultant. Record deviations in red ink clearly and accurately, using industry standard drafting procedures consistent with quality and standards of Consultants documents.
- .3 Record deviations as work progresses throughout the execution of this contract. Maintain record drawings on site in clean, dry, legible condition, making them available for periodic review by the Consultant.
- .4 Record location of concealed services, particularly underground services. Before commencing any backfilling, obtain accurate measurements and information concerning correct location and depth of services.
- .5 Transfer records from the "Project Record Copy" to a DVD in Autocad format matching the Consultant's documents. Arrange computer file in layers to exactly match the layering system of the Consultant.
- .6 Submit the "Project Record Copy" on one or more DVD with white prints of each drawing to the Consultant at the time of Substantial Performance.

3.5 INSTRUCTION

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

3.6 COMMISSIONING

- .1 Refer to Section 25 08 00 Commissioning.
- .2 The Contractor shall start-up and completely commission all equipment and systems installed and/or modified under this contract. Commissioning work shall be completed to the satisfaction of the Consultant prior to acceptance of the Work or any part thereof.
- .3 Commissioning shall conform to CAN/CSA Z318.0 Commissioning of Health Care Facilities
- .4 The Commissioning Team shall be comprised of;
 - .1 Representatives of the Commissioning Coordinator (Commissioning Agent)
 - .2 The individual, company or agency undertaking the work of each Section,
 - .3 Representatives of the Contractor and his sub-contractors as required,
 - .4 Representatives of equipment manufacturers,
 - .5 Representatives of the Consultants,
 - .6 Representatives of the Owner.

- .5 The Contractor and his sub-contractors shall each assign an individual representing each of the relevant trades to the commissioning team and shall ensure that representatives of the equipment manufacturers are present during the relevant commissioning tasks.
- .6 The Contractor shall provide all necessary labour, materials, equipment, testing apparatus and incidentals necessary to completely start-up, verify, test and commission each system provided as part of the Work.
- .7 Each Section shall prepare Check Sheets in accordance with the standards listed above and shall issue them to the commissioning team for use during the commissioning process.
- .8 Three (3) copies of commissioning manuals shall be provided, bound in hard cover D-ring binders with transparent cover on front and spine personalized to indicate;
 - .1 name and logo of Health Care Facility,
 - .2 name of the project,
 - .3 the Owner's project number,
 - .4 identification of the system commissioned,
 - .5 the date that the system was commissioned.
- .9 Commissioning manuals shall include machine printable index dividers to organize each manual by system and by commissioning stage.

END OF SECTION

1. GENERAL

1.1 SUMMARY

- .1 Section Includes.
 - .1 Methods and procedures for start-up, verification and commissioning, for Building Automation System (BAS) and includes:
 - .1 Start-up testing and verification of systems.
 - .2 Check out demonstration or proper operation of components.
 - .3 On-site operational tests.
- .2 Related Requirements
 - .1 Section 25 05 01.

1.2 DEFINITIONS

- .1 For additional acronyms and definitions refer to Section 25 05 01 - BAS: General Requirements.
- .2 AEL: ratio between total test period less any system downtime accumulated within that period and test period.
- .3 Downtime: results whenever BAS is unable to fulfill required functions due to malfunction of equipment defined under responsibility of BAS contractor. Downtime is measured by duration, in time, between time that Contractor is notified of failure and time system is restored to proper operating condition. Downtime not to include following:
 - .1 Outage of main power supply in excess of back-up power sources, provided that:
 - .1 Automatic initiation of back-up was accomplished.
 - .2 Automatic shut-down and re-start of components was as specified.
 - .2 Failure of communications link, provided that:
 - .1 Controller automatically and correctly operated in stand-alone mode.
 - .2 Failure was not due to failure of any specified BAS equipment.
 - .3 Functional failure resulting from individual sensor inputs or output devices, provided that:
 - .1 System recorded said fault.
 - .2 Equipment defaulted to fail-safe mode.
 - .3 AEL of total of all input sensors and output devices is at least 99% during test period.

1.3 DESIGN REQUIREMENTS

- .1 Confirm with Consultant that Design Criteria and Design Intent are still applicable.

- .2 Commissioning personnel to be fully aware of and qualified to interpret Design Criteria and Design Intent.

1.4 SHOP DRAWING SUBMITTALS

- .1 Submittals in accordance with Division 01 - Submittal Procedures.
- .2 Final Report: submit report to Consultant.
 - .1 Include measurements, final settings and certified test results.
 - .2 Bear signature of commissioning technician and supervisor
 - .3 Report format to be approved by Consultant before commissioning is started.
 - .4 Revise "as-built" documentation, commissioning reports to reflect changes, adjustments and modifications to BAS as set during commissioning and submit to Consultant in accordance with Division 01 - Closeout Submittals.
 - .5 Recommend additional changes and/or modifications deemed advisable in order to improve performance, environmental conditions or energy consumption.

1.5 CLOSEOUT SUBMITTALS

- .1 Provide documentation, O&M Manuals, and training of O&M personnel for review of Consultant before interim acceptance in accordance with Division 01 - Closeout Submittals.

1.6 COMMISSIONING

- .1 Do commissioning in accordance with Division 01 - General Commissioning Requirements.
- .2 Carry out commissioning in presence of Consultant.
- .3 Inform, and obtain approval from, Consultant in writing at least 14 days prior to commissioning or each test. Indicate:
 - .1 Location and part of system to be tested or commissioned.
 - .2 Testing/commissioning procedures, anticipated results.
 - .3 Names of testing/commissioning personnel.
- .4 Correct deficiencies, re-test in presence of Consultant until satisfactory performance is obtained.
- .5 Acceptance of tests will not relieve Contractor from responsibility for ensuring that complete systems meet every requirement of Contract.
- .6 Load system with project software.
- .7 Perform tests as required.

1.7 COMPLETION OF COMMISSIONING

- .1 Commissioning to be considered as satisfactorily completed when objectives of commissioning have been achieved and reviewed by Consultant.

1.8 ISSUANCE OF FINAL CERTIFICATE OF COMPLETION

- .1 Final Certificate of Completion will not be issued until receipt of written approval indicating successful completion of specified commissioning activities including receipt of commissioning documentation.

2. PRODUCTS

2.1 EQUIPMENT

- .1 Provide sufficient instrumentation to verify and commission the installed system. Provide two-way radios.
- .2 Instrumentation accuracy tolerances: higher order of magnitude than equipment or system being tested.
- .3 Independent testing laboratory to certify test equipment as accurate to within approved tolerances no more than two(2) months prior to tests.
- .4 Locations to be approved, readily accessible and readable.
- .5 Application: to conform to normal industry standards.

3. EXECUTION

3.1 PROCEDURES

- .1 Test each system independently and then in unison with other related systems.
- .2 Commission each system using procedures prescribed by the Commissioning Agent.
- .3 Commission integrated systems using procedures prescribed by Commissioning Agent.
- .4 Debug system software.
- .5 Optimize operation and performance of systems by fine-tuning PID values and modifying CDLs as required.
- .6 Test full scale emergency evacuation and life safety procedures including operation and integrity of smoke management systems under normal and emergency power conditions as applicable.

3.2 FIELD QUALITY CONTROL

- .1 Pre-Installation Testing.
 - .1 General: consists of field tests of equipment just prior to installation.
 - .2 Testing may be on site or at Contractor's premises as approved by Consultant.
 - .3 Configure major components to be tested in same architecture as designed system. Include BECC equipment and 2 sets of Building Controller's including MCU's, LCU's, and TCU's.

- .4 Equip each Building Controller with sensor and controlled device of each type (AI, AO, DI, DO).
- .5 Additional instruments to include:
 - .1 DP transmitters.
 - .2 VAV supply duct SP transmitters.
 - .3 DP switches used for dirty filter indication and fan status.
- .6 In addition to test equipment, provide inclined manometer, digital micro-manometer, milli-amp meter, source of air pressure infinitely adjustable between 0 and 500 Pa, to hold steady at any setting and with direct output to milli-amp metre at source.
- .7 After setting, test zero and span in 10 % increments through entire range while both increasing and decreasing pressure.
- .8 Consultant to mark instruments tracking within 0.5 % in both directions as "approved for installation".
- .9 Transmitters above 0.5% error will be rejected.
- .10 DP switches to open and close within 2% of setpoint.
- .2 Completion Testing.
 - .1 General: test after installation of each part of system and after completion of mechanical and electrical hook-ups, to verify correct installation and functioning.
 - .2 Include following activities:
 - .1 Test and calibrate field hardware including stand-alone capability of each controller.
 - .2 Verify each A-to-D convertor.
 - .3 Test and calibrate each AI using calibrated digital instruments.
 - .4 Test each DI to ensure proper settings and switching contacts.
 - .5 Test each DO to ensure proper operation and lag time.
 - .6 Test each AO to ensure proper operation of controlled devices. Verify tight closure and signals.
 - .7 Test operating software.
 - .8 Test application software and provide samples of logs and commands.
 - .9 Verify each CDL including energy optimization programs.
 - .10 Debug software.
 - .11 Blow out flow measuring and static pressure stations with high pressure air at 700 kPa.
 - .12 Provide point verification list in table format including point identifier, point identifier expansion, point type and address, low and high limits and engineering units. Include space on commissioning technician and Consultant. This document will be used in final startup testing.

- .3 Final Startup Testing: Upon satisfactory completion of tests, perform point-by-point test of entire system under direction of Commissioning Agent and provide:
 - .1 Two technical personnel capable of re-calibrating field hardware and modifying software.
 - .2 Detailed daily schedule showing items to be tested and personnel available.
 - .3 Consultants acceptance signature to be on executive and applications programs.
 - .4 Commissioning to commence during final startup testing.
 - .5 O&M personnel to assist in commissioning procedures as part of training.
 - .6 Commissioning to be supervised by qualified supervisory personnel and Consultant.
 - .7 Commission systems considered as life safety systems before affected parts of the facility are occupied.
 - .8 Operate systems as long as necessary to commission entire project.
 - .9 Monitor progress and keep detailed records of activities and results.
- .4 Final Operational Testing: to demonstrate that BAS functions in accordance with contract requirements.
 - .1 Prior to beginning of 30 day test demonstrate that operating parameters (setpoints, alarm limits, operating control software, sequences of operation, trends, graphics and CDL's) have been implemented to ensure proper operation and operator notification in event of off-normal operation.
 - .2 Test to last at least 30 consecutive 24 hour days.
 - .3 Tests to include:
 - .4 System will be accepted when:
 - .5 In event of failure to attain specified AEL during test period, extend test period on day-to-day basis until specified AEL is attained for test period.
 - .6 Correct defects when they occur and before resuming tests.
- .5 Consultant to verify reported results.

3.3 ADJUSTING

- .1 Final adjusting: upon completion of commissioning as reviewed by Consultant, set and lock devices in final position and permanently mark settings.

3.4 DEMONSTRATION

- .1 Demonstrate to Commissioning Agent operation of systems including sequence of operations in regular and emergency modes, under normal and emergency conditions, start-up, shut-down interlocks and lock-outs in accordance with Division 01 - Demonstration and Training.

END OF SECTION

1. GENERAL

1.1 SUMMARY

- .1 Section Includes.
 - .1 Requirements and procedures for training program, instructors and training materials, for Building Automation System (BAS) Work.
- .2 Related Requirements
 - .1 Section 25 05 01.

1.2 DEFINITIONS

- .1 CDL - Control Description Logic.
- .2 For additional acronyms and definitions refer to Section 25 05 01 - BAS: General Requirements.

1.3 SHOP DRAWING SUBMITTALS

- .1 Submittals in accordance with Division 01 - Submittal Procedures, supplemented and modified by requirements of this Section.
- .2 Submit training proposal complete with hour-by-hour schedule including brief overview of content of each segment to Consultant 30 days prior to anticipated date of beginning of training.
 - .1 List name of trainer, and type of visual and audio aids to be used.
 - .2 Show co-ordinated interface with other BAS mechanical and electrical training programs.
- .3 Submit reports within one week after completion of each phase of training program that training has been satisfactorily completed.

1.4 QUALITY ASSURANCE

- .1 Provide competent instructors thoroughly familiar with aspects of BAS installed in facility.
- .2 Consultant reserves right to approve instructors.

1.5 INSTRUCTIONS

- .1 Provide instruction to designated personnel in adjustment, operation, maintenance and pertinent safety requirements of BAS installed.
- .2 Training to be project specific.

1.6 TIME FOR TRAINING

- .1 Number of days of instruction to be as specified in this section (1 day = 8 hours including two 15 minute breaks and excluding lunch time).

1.7 TRAINING MATERIALS

- .1 Provide equipment, visual and audio aids, and materials for classroom training.

- .2 Supply manual for each trainee, describing in detail data included in each training program.
 - .1 Review contents of manual in detail to explain aspects of operation and maintenance (O&M).

1.8 TRAINING PROGRAM

- .1 To be in 2 phases over six month period.
- .2 Phase 1: two day program to begin before 30 day test period at time mutually agreeable to Contractor, Owner, Commissioning Agent and Consultant.
 - .1 Train O&M personnel in functional operations and procedures to be employed for system operation.
 - .2 Supplement with on-the-job training during 30 day test period.
 - .3 Include overview of system architecture, communications, operation of computer and peripherals, report generation.
 - .4 Include detailed training on operator interface functions for control of mechanical systems, CDL's for each system, and elementary preventive maintenance.
- .3 Phase 2: Five day program to begin 8 weeks after acceptance for operators, equipment maintenance personnel and programmers.
 - .1 Provide multiple instructors on pre-arranged schedule. Include at least following:
 - .1 Operator training: provide operating personnel, maintenance personnel and programmers with condensed version of Phase 1 training.
 - .2 Equipment maintenance training: provide personnel with 2 days training within 5 day period in maintenance of BAS equipment, including general equipment layout, trouble shooting and preventive maintenance of BAS components, maintenance and calibration of sensors and controls.
 - .3 Programmers: provide personnel with 2 days training within 5 day period in following subjects in approximate percentages of total course shown:

Software and architecture: 10%
Application programs: 15%
Controller programming: 50%
Trouble shooting and debugging: 10%
Colour graphic generation: 15%

1.9 ADDITIONAL TRAINING

- .1 List courses offered by name, duration and approximate cost per person per week. Note courses recommended for training supervisory personnel.

1.10 MONITORING OF TRAINING

- .1 Consultant to monitor training program and may modify schedule and content.

2. PRODUCTS

2.1 NOT USED

.1 Not Used.

3. EXECUTION

3.1 NOT USED

.1 Not Used.

END OF SECTION

1. GENERAL

1.1 SUMMARY

- .1 Section Includes:
 - .1 General requirements for building Energy Monitoring and Control System (BAS) that are common to NMS BAS Sections.
 - .2 Sustainable requirements for construction and verification.
 - .1 [REDACTED].
- .2 Related Requirements
 - .1 Section [REDACTED].

1.2 REFERENCE STANDARDS

- .1 American National Standards Institute (ANSI)/The Instrumentation, Systems and Automation Society (ISA).
 - .1 ANSI/ISA 5.5-1985, Graphic Symbols for Process Displays.
- .2 American National Standards Institute (ANSI)/ Institute of Electrical and Electronics Engineers (IEEE).
 - .1 ANSI/IEEE 260.1-1993, American National Standard Letter Symbols Units of Measurement (SI Units, Customary Inch-Pound Units, and Certain Other Units).
- .3 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE).
 - .1 ASHRAE STD 135-R2001, BACNET - Data Communication Protocol for Building Automation and Control Network.
- .4 CSA Group (CSA).
 - .1 CAN/CSA-Z234.1-89(R1995), Canadian Metric Practice Guide.
- .5 Consumer Electronics Association (CEA).
 - .1 CEA-709.1-B-2002, Control Network Protocol Specification.
- .6 Department of Justice Canada (Jus).
 - .1 Canadian Environmental Assessment Act (CEAA), 1995, c. 37.
 - .2 Canadian Environmental Protection Act (CEPA), 1999, c. 33.
- .7 Electrical and Electronic Manufacturers Association (EEMAC).
 - .1 EEMAC 2Y-1-1958, Light Grey Colour for Indoor Switch Gear.
- .8 Health Canada/Workplace Hazardous Materials Information System (WHMIS).
 - .1 Safety Data Sheets (SDS).
- .9 Transport Canada (TC).
 - .1 Transportation of Dangerous Goods Act (TDGA), 1992, c. 34.

1.3 ABBREVIATIONS AND ACRONYMS

.1 Acronyms used in BAS:

- .1 AEL - Average Effectiveness Level
- .2 AI - Analog Input
- .3 AIT - Agreement on International Trade
- .4 AO - Analog Output
- .5 BACnet - Building Automation and Control Network.
- .6 BC(s) - Building Controller(s).
- .7 BECC - Building Environmental Control Centre.
- .8 CAD - Computer Aided Design.
- .9 CDL - Control Description Logic.
- .10 CDS - Control Design Schematic.
- .11 COSV - Change of State or Value.
- .12 CPU - Central Processing Unit.
- .13 DI - Digital Input.
- .14 DO - Digital Output.
- .15 DP - Differential Pressure.
- .16 ECU - Equipment Control Unit.
- .17 EMCS - Energy Monitoring and Control System.
- .18 HVAC - Heating, Ventilation, Air Conditioning.
- .19 IDE - Interface Device Equipment.
- .20 I/O - Input/Output.
- .21 ISA - Industry Standard Architecture.
- .22 LAN - Local Area Network.
- .23 LCU - Local Control Unit.
- .24 MCU - Master Control Unit.
- .25 NAFTA - North American Free Trade Agreement.
- .26 NC - Normally Closed.
- .27 NO - Normally Open.
- .28 OS - Operating System.
- .29 O&M - Operation and Maintenance.
- .30 OWS - Operator Workstation.
- .31 PC - Personal Computer.
- .32 PCI - Peripheral Control Interface.

- .33 PCMCIA - Personal Computer Micro-Card Interface Adapter.
- .34 PID - Proportional, Integral and Derivative.
- .35 RAM - Random Access Memory.
- .36 SP - Static Pressure.
- .37 ROM - Read Only Memory.
- .38 TCU - Terminal Control Unit.
- .39 USB - Universal Serial Bus.
- .40 UPS - Uninterruptible Power Supply.
- .41 VAV - Variable Air Volume.

1.4 DEFINITIONS

- .1 Point: may be logical or physical.
 - .1 Logical points: values calculated by system such as setpoints, totals, counts, derived corrections and may include, but not limited to result of and statements in CDL's.
 - .2 Physical points: inputs or outputs which have hardware wired to controllers which are measuring physical properties, or providing status conditions of contacts or relays which provide interaction with related equipment (stop, start) and valve or damper actuators.
- .2 Point Name: composed of two parts, point identifier and point expansion.
 - .1 Point identifier: comprised of three descriptors, "area" descriptor, "system" descriptor and "point" descriptor, for which database to provide 25 character field for each point identifier. "System" is system that point is located on.
 - .1 Area descriptor: building or part of building where point is located.
 - .2 System descriptor: system that point is located on.
 - .3 Point descriptor: physical or logical point description. For point identifier "area", "system" and "point" will be shortforms or acronyms. Database must provide 25 character field for each point identifier.
 - .2 Point expansion: comprised of three fields, one for each descriptor. Expanded form of shortform or acronym used in "area", "system" and "point" descriptors is placed into appropriate point expansion field. Database must provide 32 character field for each point expansion.
 - .3 Bilingual systems to include additional point identifier expansion fields of equal capacity for each point name for second language.
 - .1 System to support use of numbers and readable characters including blanks, periods or underscores to enhance user readability for each of the above strings.
- .3 Point Object Type: points fall into following object types:

- .1 AI (analog input).
- .2 AO (analog output).
- .3 DI (digital input).
- .4 DO (digital output).
- .5 Pulse inputs.
- .4 Symbols and engineering unit abbreviations utilized in displays: to ANSI/ISA S5.5.
 - .1 Printouts: to ANSI/IEEE 260.1.
 - .2 Refer also to Section 25 05 54 - BAS: Identification.

1.5 SYSTEM DESCRIPTION

- .1 Refer to control schematics for system architecture.
- .2 Work covered by sections referred to above consists of fully operational BAS, including, but not limited to, following:
 - .1 Building Controllers.
 - .2 Control devices as listed in I/O point summary tables.
 - .3 OWS(s).
 - .4 Data communications equipment necessary to effect BAS data transmission system.
 - .5 Field control devices.
 - .6 Software/Hardware complete with full documentation.
 - .7 Complete operating and maintenance manuals.
 - .8 Training of personnel.
 - .9 Acceptance tests, technical support during commissioning, full documentation.
 - .10 Wiring interface co-ordination of equipment supplied by others.
 - .11 Miscellaneous work as specified in these sections and as indicated.
- .3 Design Requirements:
 - .1 Design and provide conduit and wiring linking elements of system.
 - .2 Supply sufficient programmable controllers of types to meet project requirements. Quantity and points contents as reviewed by Consultant prior to installation.
 - .3 Location of controllers as reviewed by Consultant prior to installation.
 - .4 Provide utility power to BAS and emergency power to BAS as indicated.
 - .5 Metric references: in accordance with CAN/CSA Z234.1.
- .4 Language Operating Requirements:

- .1 Provide English operator selectable access codes.
- .2 Use non-linguistic symbols for displays on graphic terminals wherever possible. Other information to be in English.
- .3 Operating system executive: provide primary hardware-to-software interface specified as part of hardware purchase with associated documentation to be in English.
- .4 System manager software: include in English system definition point database, additions, deletions or modifications, control loop statements, use of high level programming languages, report generator utility and other OS utilities used for maintaining optimal operating efficiency.
- .5 Include:
 - .1 Input and output commands and messages from operator-initiated functions, field related changes and alarms as defined in CDL's or assigned limits (i.e. commands relating to day-to-day operating functions and not related to system modifications, additions, or logic re-definitions).
 - .2 Graphic "display" functions, point commands to turn systems on or off, manually override automatic control of specified hardware points.
 - .3 Reporting function such as trend log, trend graphics, alarm report logs, energy report logs, maintenance generated logs.

1.6 SHOP DRAWING SUBMITTALS

- .1 Make submittals in accordance with Section 01 33 00 - Submittal Procedures and 25 05 02 - BAS: Shop Drawings, Product Data and Review Process.
- .2 Submit for review:
 - .1 Equipment list and systems manufacturers within 10 days after award of contract.
 - .2 List existing field control devices to be re-used included in bid, along with unit price.
- .3 Quality Control:
 - .1 Provide equipment and material from manufacturer's regular production, CSA certified, manufactured to standard quoted plus additional specified requirements.
 - .2 Where CSA certified equipment is not available submit such equipment to inspection authorities for special inspection and approval before delivery to site.
 - .3 Submit proof of compliance to specified standards with shop drawings and product data in accordance with Section 25 05 02 - BAS: Shop Drawings, Product Data and Review Process. Label or listing of specified organization is acceptable evidence.

- .4 In lieu of such evidence, submit certificate from testing organization, approved by Consultant, certifying that item was tested in accordance with their test methods and that item conforms to their standard/code.
- .5 For materials whose compliance with organizational standards/codes/specifications is not regulated by organization using its own listing or label as proof of compliance, furnish certificate stating that material complies with applicable referenced standard or specification.
- .6 Permits and fees: in accordance with general conditions of contract.
- .7 Submit certificate of acceptance from authority having jurisdiction to Consultant.
- .8 Existing devices intended for re-use: submit test report.

1.7 QUALITY ASSURANCE

- .1 Have local office within 50 km of project staffed by trained personnel capable of providing instruction, routine maintenance and emergency service on systems,
- .2 Provide record of successful previous installations submitting tender showing experience with similar installations utilizing computer-based systems.
- .3 Have access to local supplies of essential parts and provide seven year guarantee of availability of spare parts after obsolescence.
- .4 Ensure qualified supervisory personnel continuously direct and monitor Work and attend site meetings.

1.8 DELIVERY, STORAGE AND HANDLING

- .1 Material Delivery Schedule: provide Consultant with schedule within two weeks after award of Contract.
- .2 Waste Management and Disposal:
 - .1 Separate waste materials for recycling in accordance with Section 01 74 19 - Waste Management and Disposal.
 - .2 Remove from site and dispose of packaging materials at appropriate recycling facilities.
 - .3 Place materials defined as hazardous or toxic in designated containers.
 - .4 Handle and dispose of hazardous materials in accordance with CEPA, TDGA, Regional, and Municipal regulations.
 - .5 Label location of salvaged material's storage areas and provide barriers and security devices.
 - .6 Ensure emptied containers are sealed and stored safely.

1.9 EXISTING- CONTROL COMPONENTS

- .1 Utilize existing control wiring and piping as indicated.

- .2 Re-use field control devices that are usable in their original configuration provided that they conform to applicable codes, standards specifications.
 - .1 Do not modify original design of existing devices without written permission from Consultant.
 - .2 Provide for new, properly designed device where re-usability of components is uncertain.
- .3 Inspect and test existing devices intended for re-use within 30 days of award of contract, and prior to installation of new devices.
 - .1 Furnish test report within 40 days of award of contract listing each component to be re-used and indicating whether it is in good order or requires repair.
 - .2 Failure to produce test report will constitute acceptance of existing devices by contractor.
- .4 Non-functioning items:
 - .1 Provide with report specification sheets or written functional requirements to support findings.
 - .2 Repair or replace existing items judged defective yet deemed necessary for BAS.
- .5 Submit written request for permission to disconnect controls and to obtain equipment downtime before proceeding with Work.
- .6 Assume responsibility for controls to be incorporated into BAS after written receipt of approval from Consultant.
 - .1 Be responsible for repair costs due to negligence or abuse of equipment.
- .7 Remove existing controls not re-used or not required. Place in approved storage for disposition as directed.

2. PRODUCTS

2.1 EQUIPMENT

- .1 Control Network Protocol and Data Communication Protocol: to CEA 709.1 and ASHRAE STD 135.
- .2 Complete list of equipment and materials to be used on project and forming part of bid documents by adding manufacturer's name, model number and details of materials, and submit for approval.

2.2 ADAPTORS

- .1 Provide adaptors between metric and imperial components.

3. EXECUTION

3.1 MANUFACTURER'S RECOMMENDATIONS

- .1 Installation: to manufacturer's recommendations.

3.2 PAINTING

- .1 Painting: in accordance with Section 09 91 23 - Interior Painting, supplemented as follows:
 - .1 Clean and touch up marred or scratched surfaces of factory finished equipment to match original finish.
 - .2 Restore to new condition, finished surfaces too extensively damaged to be primed and touched up to make good.
 - .3 Clean and prime exposed hangers, racks, fastenings, and other support components.
 - .4 Paint unfinished equipment installed indoors to EEMAC 2Y-1.

END OF SECTION

1. GENERAL

1.1 SUMMARY

- .1 Section Includes.
 - .1 Methods and procedures for shop drawings submittals, preliminary and detailed review process including review meetings, for Building Automation System (BAS).
- .2 Related Requirements:
 - .1 College Requirements and Standards.

1.2 DEFINITIONS

- .1 Acronyms and definitions: refer to Section 25 05 01 - BAS: General Requirements.

1.3 DESIGN REQUIREMENTS

- .1 Preliminary Design Review: to contain following contractor and systems information.
 - .1 Location of local office.
 - .2 Description and location of installing and servicing technical staff.
 - .3 Location and qualifications of programming design and programming support staff.
 - .4 List of spare parts.
 - .5 Location of spare parts stock.
 - .6 Names of sub-contractors and site-specific key personnel.
 - .7 Sketch of site-specific system architecture.
 - .8 Specification sheets for each item including memory provided, programming language, speed, type of data transmission.
 - .9 Descriptive brochures.
 - .10 Sample CDL and graphics (systems schematics).
 - .11 Response time for each type of command and report.
 - .12 Item-by-item statement of compliance.
 - .13 Proof of demonstrated ability of system to communicate utilizing BACnet.

1.4 SHOP DRAWING SUBMITTALS

- .1 Submittals in accordance with Division 01 - Submittal Procedures and coordinate with requirements in this Section.
- .2 Submit preliminary design document within 5 working days after tender closing and before contract award, for review by Consultant.

1.5 PRELIMINARY SHOP DRAWING REVIEW

- .1 Submit preliminary shop drawings within 30 working days of award of contract and include following:

- .1 Specification sheets for each item. To include manufacturer's descriptive literature, manufacturer's installation recommendations, specifications, drawings, diagrams, performance and characteristic curves, catalogue cuts, manufacturer's name, trade name, catalogue or model number, nameplate data, size, layout, dimensions, capacity, other data to establish compliance.
- .2 Detailed system architecture showing all points associated with each controller including, signal levels, pressures where new BAS ties into existing control equipment.
- .3 Spare point capacity of each controller by number and type.
- .4 Controller locations.
- .5 Auxiliary control cabinet locations.
- .6 Single line diagrams showing cable routings, conduit sizes, spare conduit capacity between control centre, field controllers and systems being controlled.
- .7 Valves: complete schedule listing including following information: designation, service, manufacturer, model, point ID, design flow rate, design pressure drop, required Cv, Valve size, actual Cv, spring range, pilot range, required torque, actual torque and close off pressure (required and actual).
- .8 Dampers: sketches showing module assembly, interconnecting hardware, operator locations, operator spring range, pilot range, required torque, actual torque.
- .9 Flow measuring stations: complete schedule listing designation, service, point ID, manufacturer, model, size, velocity at design flow rate, manufacturer, model and range of velocity transmitter.
- .10 Compressor schematic and sizing data.

1.6 DETAILED SHOP DRAWING REVIEW

- .1 Submit detailed shop drawings within 60 working days after award of contract and before start of installation and include following:
 - .1 Corrected and updated versions (hard copy only) of submissions made during preliminary review.
 - .2 Wiring diagrams.
 - .3 Piping diagrams and hook-ups.
 - .4 Interface wiring diagrams showing termination connections and signal levels for equipment to be supplied by others.
 - .5 Shop drawings for each input/output point, sensors, transmitters, showing information associated with each particular point including:
 - .1 Sensing element type and location.
 - .2 Transmitter type and range.
 - .3 Associated field wiring schematics, schedules and terminations.
 - .4 Complete Point Name Lists.
 - .5 Setpoints, curves or graphs and alarm limits (high and low, 3 types critical, cautionary and maintenance), signal range.

- .6 Software and programming details associated with each point.
- .7 Manufacturer's recommended installation instructions and procedures.
- .8 Input and output signal levels or pressures where new system ties into existing control equipment.
- .6 Control schematics, narrative description, CDL's fully showing and describing automatic and manual procedure required to achieve proper operation of project, including under complete failure of BAS.
- .7 Graphic system schematic displays of air and water systems with point identifiers and textual description of system, and typical floor plans as specified.
- .8 Complete system CDL's including companion English language explanations on same sheet but with different font and italics. CDL's to contain specified energy optimization programs.
- .9 Listing and example of specified reports.
- .10 Listing of time of day schedules.
- .11 Mark up to-scale construction drawing to detail control room showing location of equipment and operator work space.
- .12 Type and size of memory with statement of spare memory capacity.
- .13 Full description of software programs provided.
- .14 Sample of "Operating Instructions Manual" to be used for training purposes.
- .15 Outline of proposed start-up and verification procedures. Refer to Section 25 01 11 - BAS: Start-up, Verification and Commissioning.

2. PRODUCTS

2.1 NOT USED

- .1 Not Used.

3. EXECUTION

3.1 NOT USED

- .1 Not Used.

END OF SECTION

1. GENERAL

1.1 SUMMARY

- .1 Section Includes.
 - .1 Requirements and procedures for final control diagrams and operation and maintenance (O&M) manual, for Building Automation System (BAS) Work.
- .2 Related Requirements
 - .1 College Requirements and Standards.

1.2 DEFINITIONS

- .1 BECC - Building Environmental Control Centre.
- .2 OWS - Operator Work Station.
- .3 For additional acronyms and definitions refer to Section 25 05 01 - BAS: General Requirements.

1.3 SHOP DRAWING SUBMITTALS

- .1 Submittals in accordance with Section 01 78 00 - Closeout Procedures, supplemented and modified by requirements of this Section.

1.4 AS-BUILTS

- .1 Provide detailed shop drawings generated in Section 25 05 02 - BAS: Submittals and Review Process and include:
 - .1 Changes to Contract Documents as well as addenda and contract extras.
 - .2 Changes to interface wiring.
 - .3 Routing of conduit, wiring and control air lines associated with BAS installation.
 - .4 Locations of obscure devices to be indicated on drawings.
 - .5 Listing of alarm messages.
 - .6 Panel/circuit breaker number for sources of normal/emergency power.
 - .7 Names, addresses, telephone numbers of each sub-contractor having installed equipment, local representative for each item of equipment, each system.
 - .8 Test procedures and reports: provide records of start-up procedures, test procedures, checkout tests and final commissioning reports as specified in Section 25 01 11 - BAS: Start-up, Verification and Commissioning.
 - .9 Basic system design and full documentation on system configuration.
- .2 Submit for final review by Consultant.
- .3 Provide before acceptance copy incorporating changes made during final review.

1.5 O&M MANUALS

- .1 Custom design O&M Manuals (both hard and soft copy) to contain material pertinent to this project only, and to provide full and complete coverage of subjects referred to in this Section.
- .2 Provide two complete sets of hard and soft copies prior to system or equipment tests
- .3 Include complete coverage in concise language, readily understood by operating personnel using common terminology of functional and operational requirements of system. Do not presume knowledge of computers, electronics or in-depth control theory.
- .4 Functional description to include:
 - .1 Functional description of theory of operation.
 - .2 Design philosophy.
 - .3 Specific functions of design philosophy and system.
 - .4 Full details of data communications, including data types and formats, data processing and disposition data link components, interfaces and operator tests or self-test of data link integrity.
 - .5 Explicit description of hardware and software functions, interfaces and requirements for components in functions and operating modes.
 - .6 Description of person-machine interactions required to supplement system description, known or established constraints on system operation, operating procedures currently implemented for implementation in automatic mode.
- .5 System operation to include:
 - .1 Complete step-by-step procedures for operation of system including required actions at each OWS.
 - .2 Operation of computer peripherals, input and output formats.
 - .3 Emergency, alarm and failure recovery.
 - .4 Step-by-step instructions for start-up, back-up equipment operation, execution of systems functions and operating modes, including key strokes for each command so that operator need only refer to these pages for keystroke entries required to call up display or to input command.
- .6 Software to include:
 - .1 Documentation of theory, design, interface requirements, functions, including test and verification procedures.
 - .2 Detailed descriptions of program requirements and capabilities.
 - .3 Data necessary to permit modification, relocation, reprogramming and to permit new and existing software modules to respond to changing system functional requirements without disrupting normal operation.
 - .4 Software modules, fully annotated source code listings, error free object code files ready for loading via peripheral device

- .5 Complete program cross reference plus linking requirements, data exchange requirements, necessary subroutine lists, data file requirements, other information necessary for proper loading, integration, interfacing, program execution.
- .6 Software for each Controller and single section referencing Controller common parameters and functions.
- .7 Maintenance: document maintenance procedures including inspection, periodic preventive maintenance, fault diagnosis, repair or replacement of defective components, including calibration, maintenance, repair of sensors, transmitters, transducers, controller and interface firmware's, plus diagnostics and repair/replacement of system hardware.
- .8 System configuration document:
 - .1 Provisions and procedures for planning, implementing and recording hardware and software modifications required during operating lifetime of system.
 - .2 Information to ensure co-ordination of hardware and software changes, data link or message format/content changes, sensor or control changes in event that system modifications are required.
- .9 Programmer control panel documentation: provide where panels are independently interfaced with BECC, including interfacing schematics, signal identification, timing diagrams, fully commented source listing of applicable driver/handler.

2. PRODUCTS

2.1 NOT USED

- .1 Not Used.

3. EXECUTION

3.1 NOT USED

- .1 Not Used.

END OF SECTION

1. GENERAL

1.1 SUMMARY

- .1 Section Includes.
 - .1 Requirements and procedures for identification of devices, sensors, wiring tubing, conduit and equipment, for Building Automation System (BAS) Work and nameplates materials, colours and lettering sizes.
- .2 Related Requirements
 - .1 Section 25 05 01.

1.2 REFERENCE STANDARDS

- .1 CSA Group (CSA).
 - .1 CSA C22.1-02, The Canadian Electrical Code, Part I (19th Edition), Safety Standard for Electrical Installations.

1.3 DEFINITIONS

- .1 For acronyms and definitions refer to Section 25 05 01 - BAS: General Requirements.

1.4 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submittals in accordance with Division 01 - Submittal Procedures supplemented and modified by requirements of this Section.
- .2 Submit to Consultant for approval samples of nameplates, identification tags and list of proposed wording.

2. PRODUCTS

2.1 NAMEPLATES FOR PANELS

- .1 Identify by plastic laminate, 3 mm thick Melamine, matte white finish, black core, square corners, lettering accurately aligned and engraved into core.
- .2 Sizes: 25 x 67 mm minimum.
- .3 Lettering: minimum 7 mm high, black.
- .4 Inscriptions: machine engraved to identify function.

2.2 NAMEPLATES FOR FIELD DEVICES

- .1 Identify by plastic encased cards attached by chain.
- .2 Sizes: 50 x 100 mm minimum.
- .3 Lettering: minimum 5 mm high produced from laser printer in black.
- .4 Include point name and point address.
- .5 Companion cabinet: identify interior components using plastic enclosed cards with point name and point address.

2.3 NAMEPLATES FOR ROOM SENSORS

- .1 Identify by stick-on labels using point identifier.
- .2 Location: as directed by Consultant.
- .3 Letter size: to suit, clearly legible.

2.4 WARNING SIGNS

- .1 Equipment including motors, starters under remote automatic control: supply and install orange coloured signs warning of automatic starting under control of BAS.
- .2 Sign to read: "Caution: This equipment is under automatic remote control of BAS" as reviewed by Consultant.

2.5 WIRING

- .1 Supply and install numbered tape markings on wiring at panels, junction boxes, splitters, cabinets and outlet boxes.
- .2 Colour coding: to CSA C22.1. Use colour coded wiring in communications cables, matched throughout system.
- .3 Power wiring: identify circuit breaker panel/circuit breaker number inside each BAS panel.

2.6 PNEUMATIC TUBING

- .1 Numbered tape markings on tubing to provide uninterrupted tracing capability.

2.7 CONDUIT

- .1 Colour code BAS conduit.
- .2 Pre-paint box covers and conduit fittings.
- .3 Coding: use fluorescent orange paint and confirm colour with Consultant during "Preliminary Design Review".

3. EXECUTION

3.1 NAMEPLATES AND LABELS

- .1 Ensure that manufacturer's nameplates, CSA labels and identification nameplates are always visible and legible.

3.2 EXISTING PANELS

- .1 Correct existing nameplates and legends to reflect changes made during Work.

END OF SECTION

1. GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Refer to Section 25 01 01.

1.1 REFERENCE STANDARDS

- .1 American National Standards Institute (ANSI)
 - .1 ANSI/ASME B16.22-2013, Wrought Copper and Copper Alloy Solder Joint Pressures Fittings.
 - .2 ANSI C2-1990, National Electrical Safety Code.
 - .3 ANSI/NFPA 70-1990, National Electrical Code.
- .2 CSA Group (CSA)
 - .1 CSA C22.1-12,
 - .2 CAN/CSA-C22.3 No. 7-10, Underground Systems.
 - .3 CAN/CSA C22.2 No. 45.1-07(R2012), Electrical Rigid Metal Conduit.
 - .4 CAN/CSA C22.2 No. 56-13, Flexible Metal Conduit and Liquid-Tight Flexible Metal Conduit.
 - .5 CAN/CSA C22.2 No. 83-M1985(R2013), Electrical Metallic Tubing.
 - .6 CAN/CSA-C22.3 No. 1-10, Overhead Systems.

1.2 SYSTEM DESCRIPTION

- .1 Electrical:
 - .1 Provide power wiring from existing power panels to BAS field panels. Circuits to be for exclusive use of BAS equipment. Panel breakers to be identified on panel legends tagged and locks applied to breaker switches.
 - .2 Hard wiring between field control devices and BAS field panels.
 - .3 Communication wiring between BAS field panels and OWS's including main control centre BECC.
 - .4 Modify existing starters to provide for BAS as indicated in I/O Summaries and as indicated.
 - .5 Trace existing control wiring installation and provide updated wiring schematics including additions and/or deletions to control circuits for approval by engineer before commencing work.
- .2 Pneumatic:
 - .1 Pneumatic tubing, valves and fittings for field control devices.
- .3 Mechanical:
 - .1 Pipe Taps Required for BAS equipment will be supplied and installed by Division.
 - .2 Wells and Control Valves Shall Be Supplied by BAS Contractor and Installed by Division 23.

- .3 Installation of air flow stations, dampers, and other devices requiring sheet metal trades to be mounted by Division 23. Costs to be carried by designated trade.
- .4 VAV Terminal Units.
 - .1 Air flow probe for vav boxes to be supplied and installed under Section 23 36 00 - Air Terminal Units, Air flow differential sensor, actuator and associated vav controls to be supplied and installed by BAS contractor. Tubing from air probe to differential pressure sensor as well as installation and adjustment of air flow sensors and actuators to be the responsibility of BAS contractor. Coordinate air flow adjustments with balancing trade.
- .5 Structural:
 - .1 Special steelwork as required for installation of work.

1.3 PERSONNEL QUALIFICATIONS

- .1 Qualified supervisory personnel to:
 - .1 Continuously direct and monitor all work.
 - .2 Attend site meetings.

1.4 EXISTING CONDITIONS

- .1 Cutting and Patching: refer to Section 01 73 00 - Execution supplemented as specified herein.
- .2 Repair all surfaces damaged during execution of work.
- .3 Turn over to Consultant existing materials removed from work not identified for re-use.

2. PRODUCTS

2.1 PIPING

- .1 Domestic H&CWS: refer to Section 22 11 16
- .2 Sanitary, storm water: refer to Section 22 13 16.13 and 22 13 16.16
- .3 Refrigeration: refer to Section 23 23 00.
- .4 Sleeves, escutcheons: refer to Section 22 11 19.
- .5 Hangers and supports: refer to Section 22 05 00 and 23 05 29.
- .6 Insulation: refer to Section 22 07 19, 23 07 13, 23 07 16, and 23 07 19.

2.2 SPECIAL SUPPORTS

- .1 Structural grade steel, primed and painted after construction and before installation.

2.3 PIPING FOR PNEUMATIC CONTROL SYSTEMS

- .1 Copper:

- .1 Tubing: ASTM B88.
 - .1 Fittings: wrought copper solder type to ANSI/ASME B16.22, and 95.5 antimonial tin solder. At instruments use compression fittings.
 - .2 At panels and junction boxes where there is a transition from plastic to copper use bulkhead fittings.
- .2 Plastic:
 - .1 Flame retardant, black PVC with minimum burst strength 1.3 MPa at 23°C installed in conduit.
 - .2 Fittings: compression or barbed type as required.

2.4 WIRING

- .1 As per requirements of Division 26.
- .2 For 70V and above copper conductor with chemically cross-linked thermosetting polyethylene insulation rated RW90 and 600V. Colour code to CSA 22.1.
- .3 For wiring under 70 volts use FT6 rated wiring where wiring is not run in conduit. All other cases use FT4 wiring.
- .4 Sizes:
 - .1 120V Power supply: to match or exceed breaker, size #12 minimum.
 - .2 Wiring for safeties/interlocks for starters, motor control centres, to be stranded, #14 minimum.
 - .3 Field wiring to digital device: #18 AWG or 20 AWG stranded twisted pair.
 - .4 Analog input and output: shielded #18 minimum solid copper or #20 minimum stranded twisted pair. Wiring must be continuous without joints.
 - .5 More than 4 conductors: #22 minimum solid copper.
- .5 Terminations:
 - .1 Terminate wires with screw terminal type connectors suitable for wire size, and number of terminations.

2.5 CONDUIT

- .1 As per requirements of Division 26.
- .2 Electrical metallic tubing to CAN/CSA C22.2 No. 83. Flexible and liquid tight flexible metal conduit to CAN/CSA C22.2 No. 56. Rigid steel threaded conduit to CAN/CSA C22.2 No. 45.1.
- .3 Junction and pull boxes: welded steel.
 - .1 Surface mounting cast FS: screw-on flat covers.
 - .2 Flush mounting: covers with 25 mm minimum extension all round.
- .4 Cabinets: sheet steel, for surface mounting, with hinged door, latch lock, 2 keys, complete with perforated metal mounting backboard. Panels to be keyed alike for similar functions and or entire contract as approved.
- .5 Outlet boxes: 100 mm minimum, square.

- .6 Conduit boxes, fittings:
 - .1 Bushings and connectors: with nylon insulated throats.
 - .2 With push pennies to prevent entry of foreign materials.
- .7 Fittings for rigid conduit:
 - .1 Couplings and fittings: threaded type steel.
 - .2 Double locknuts and insulated bushings: use on sheet metal boxes.
 - .3 Use factory "ells" where 90 degree bends required for 25 mm and larger conduits.
- .8 Fittings for thin wall conduit:
 - .1 Connectors and couplings: steel, set screw type.

2.6 WIRING DEVICES, COVER PLATES

- .1 Conform to CSA.
- .2 Receptacles:
 - .1 Duplex: CSA type 5-15R.
 - .2 Single: CSA type 5-15R.
 - .3 Cover plates and blank plates: finish to match other plates in area.

2.7 STARTERS, CONTROL DEVICES

- .1 Across-the-line magnetic starters:
 - .1 Enclosures: CSA Type 1, except where otherwise specified.
 - .2 Size, type and rating: to suit motors.
- .2 Starter diagrams:
 - .1 Provide copy of wiring and schematic diagrams - mount one copy in each starter with additional copies for operation and maintenance manual.
- .3 Auxiliary Control Devices:
 - .1 Control transformers: 60 Hz, primary voltage to suit supply, 120 V single phase secondary, VA rating to suit load plus 20% margin.
 - .2 Auxiliary contacts: one "Normally Open" and one "Normally Closed" spare auxiliary contact in addition to maintained auxiliary contacts as indicated.
 - .3 Hand-Off-Automatic switch: heavy duty type, knob lever operator.
 - .4 Double voltage relays: with barrier to separate relay contacts from operating magnet. Operating coil voltage and contact rating as indicated.
- .4 Finish for starters:
 - .1 Exterior: in accordance with Section 26 05 00 - Common Work Results for Electrical.
 - .2 Interior: white.

2.8 SUPPORTS FOR CONDUIT, FASTENINGS, EQUIPMENT

- .1 Solid masonry, tile and plastic surfaces: lead anchors or nylon shields.
 - .1 Hollow masonry walls, suspended drywall ceilings: toggle bolts.
- .2 Exposed conduits or cables:
 - .1 50 mm diameter and smaller: one-hole steel straps.
 - .2 Larger than 50 mm diameter: two-hole steel straps.
- .3 Suspended support systems:
 - .1 Individual cable or conduit runs: support with 6 mm diameter threaded rods and support clips.
 - .2 Two or more suspended cables or conduits: support channels supported by 6 mm diameter threaded rod hangers.

3. EXECUTION

3.1 INSTALLATION

- .1 Install equipment, components so that manufacturer's and CSA labels are visible and legible after commissioning is complete.

3.2 PIPING

- .1 Domestic H&CWS: refer to Section 22 11 16
- .2 Sanitary, storm water: refer to Section 22 13 16.13 and 22 13 16.16
- .3 Refrigeration: refer to Section 23 23 00.
- .4 Sleeves, escutcheons: refer to Section 22 11 19.
- .5 Hangers and supports: refer to Section 22 05 00 and 23 05 29.
- .6 Insulation: refer to Section 22 07 19, 23 07 13, 23 07 16, and 23 07 19.

3.3 MECHANICAL PIPING

- .1 Install piping straight, parallel and close to building structure with required grades for drainage and venting.
- .2 Ream ends of pipes before assembly.
- .3 Copper tubing not to come into contact with dissimilar metal.
- .4 Use non-corrosive lubricant or Teflon tape on male screwed threads.
- .5 Clean ends of pipes, tubing and recesses of fittings to be brazed or soldered. Assemble joints without binding.
- .6 Install di-electric couplings where dissimilar metals joined.
- .7 Sleeves:
 - .1 Installation:
 - .1 Concrete, masonry walls, concrete floors on grade: terminate flush with finished surface.
 - .2 Other floors: terminate 25 mm above finished floor.

- .3 Before installation, paint exposed exterior surfaces with heavy application of zinc-rich paint.
- .2 Caulking:
 - .1 Foundation walls and below grade floors: fire retardant, waterproof non-hardening mastic.
 - .2 Elsewhere: provide space for fire stopping by Section 07 84 00 - Fire Stopping. Maintain the fire-resistance rating integrity of the fire separation.
 - .3 Sleeves installed for future use: fill with lime plaster or other easily removable filler.
 - .4 Ensure no contact between copper pipe or tube and sleeve.
- .8 Pressure tests:
 - .1 Pressure test piping systems modified under this contract to 1 1/2 times maximum working pressure or 860 kPa (whichever is greater) for 4 hours without loss of pressure.
 - .2 Isolate equipment, components, not designed to withstand test pressure.
- .9 Introduce system pressure carefully into new piping.

3.4 SUPPORTS

- .1 Install special supports as required and as indicated.

3.5 PNEUMATIC CONTROL SYSTEMS

- .1 General:
 - .1 Install tubing in accessible concealed locations, straight, parallel and close to building structure with required grades for drainage and venting.
 - .2 Install drip legs and drains at low points.
 - .3 Tubing to be free from surface damage.
 - .4 Tubing NOT to pass through or touch unheated ducts or enclosures.
 - .5 Do not cover pneumatic tubing with insulation.
 - .6 Test tubing, check joints after connection to system.
- .2 Copper tubing:
 - .1 Not to come into contact with dissimilar metal. Use non-metallic stand-offs on air handling systems.
 - .2 Install dielectric couplings where dissimilar metals are connected.
 - .3 Plastic tubing:
 - .1 Inaccessible locations: install plastic tubing in conduit.
 - .2 Inside panels: install in tube trays or racks, or clip individually to back of panel.
 - .3 Multiple tube bundles: install in tube trays, conduit or armoured flexible cable.

3.6 ELECTRICAL GENERAL

- .1 Do complete installation in accordance with requirements of:
 - .1 Division 26, this specification.
 - .2 CSA 22.1 Canadian Electrical Code.
 - .3 ANSI/NFPA 70.
 - .4 ANSI C2.
- .2 Fully enclose or properly guard electrical wiring, terminal blocks, high voltage contacts and mark to prevent accidental injury.
- .3 Do underground installation to CAN/CSA-C22.3 No.7, except where otherwise specified.
- .4 Conform to manufacturer's recommendations for storage, handling and installation.
- .5 Check factory connections and joints. Tighten where necessary to ensure continuity.
- .6 Install electrical equipment between 1000 and 2000 mm above finished floor wherever possible and adjacent to related equipment.
- .7 Protect exposed live equipment such as panel, mains, outlet wiring during construction for personnel safety.
- .8 Shield and mark live parts "LIVE 120 VOLTS" or other appropriate voltage.
- .9 Install conduits, and sleeves prior to pouring of concrete.
- .10 Holes through exterior wall and roofs: flash and make weatherproof.
- .11 Make necessary arrangements for cutting of chases, drilling holes and other structural work required to install electrical conduit, cable, pull boxes, outlet boxes.
- .12 Install cables, conduits and fittings which are to be embedded or plastered over, neatly and closely to building structure to minimize furring.

3.7 CONDUIT SYSTEM

- .1 Communication wiring shall be installed in conduit. Provide complete conduit system to link Building Controllers to BECC. Conduit sizes to suit wiring requirements and to allow for future expansion capabilities specified for systems. Maximum conduit fill not to exceed 40%. Design drawings do not show conduit layout.
- .2 Install conduits parallel or perpendicular to building lines, to conserve headroom and to minimize interference.
- .3 Do not run exposed conduits in normally occupied spaces unless otherwise indicated or unless impossible to do otherwise. Obtain approval from Consultant before starting such work. Provide complete conduit system to link field panels and devices with main control centre. Conduit size to match conductors plus future expansion capabilities as specified.
- .4 Locate conduits at least 150 mm from parallel steam or hot water pipes and at least 50 mm at crossovers.

- .5 Bend conduit so that diameter is reduced by less than 1/10th original diameter.
- .6 Field thread on rigid conduit to be of sufficient length to draw conduits up tight.
- .7 Limit conduit length between pull boxes to less than 30 m.
- .8 Use conduit outlet boxes for conduit up to 32 mm diameter and pull boxes for larger sizes.
- .9 Fastenings and supports for conduits, cables, and equipment:
 - .1 Provide metal brackets, frames, hangers, clamps and related types of support structures as indicated and as required to support cable and conduit runs.
 - .2 Provide adequate support for raceways and cables, sloped vertically to equipment.
 - .3 Use supports or equipment installed by other trades for conduit, cable and raceway supports only after written approval from Consultant.
- .10 Install polypropylene fish cord in empty conduits for future use.
- .11 Where conduits become blocked, remove and replace blocked sections.
- .12 Pass conduits through structural members only after receipt Consultant written approval.
- .13 Conduits may be run in flanged portion of structural steel.
- .14 Group conduits wherever possible on suspended or surface channels.
- .15 Pull boxes:
 - .1 Install in inconspicuous but accessible locations.
 - .2 Support boxes independently of connecting conduits.
 - .3 Fill boxes with paper or foam to prevent entry of construction material.
 - .4 Provide correct size of openings. Reducing washers not permitted.
 - .5 Mark location of pull boxes on record drawings.
 - .6 Identify AC power junction boxes, by panel and circuit breaker.
- .16 Install bonding conductor for 120 volt and above in conduit.

3.8 WIRING

- .1 Install multiple wiring in ducts simultaneously.
- .2 Do not pull spliced wiring inside conduits or ducts.
- .3 Use CSA certified lubricants of type compatible with insulation to reduce pulling tension.
- .4 Tests: use only qualified personnel. Demonstrate that:
 - .1 Circuits are continuous, free from shorts, unspecified grounds.
 - .2 Resistance to ground of all circuits is greater than 50 Megohms.
- .5 Provide Consultant with test results showing locations, circuits, results of tests.

- .6 Remove insulation carefully from ends of conductors and install to manufacturer's recommendations. Accommodate all strands in lugs. Where insulation is stripped in excess, neatly tape so that only lug remains exposed.
- .7 Wiring in main junction boxes and pull boxes to terminate on terminal blocks only, clearly and permanently identified. Junctions or splices not permitted for sensing or control signal covering wiring.
- .8 Do not allow wiring to come into direct physical contact with compression screw.
- .9 Install ALL strands of conductor in lugs of components. Strip insulation only to extent necessary for installation.

3.9 WIRING DEVICES, COVER PLATES

- .1 Receptacles:
 - .1 Install vertically in gang type outlet box when more than one receptacle is required in one location.
- .2 Cover plates:
 - .1 Install suitable common cover plate where wiring devices are grouped.
 - .2 Use flush type cover plates only on flush type outlet boxes.

3.10 STARTERS, CONTROL DEVICES

- .1 Install and make power and control connections as indicated.
- .2 Install correct over-current devices.
- .3 Identify each wire, terminal for external connections with permanent number marking identical to diagram.
- .4 Performance Verification:
 - .1 Operate switches and controls to verify functioning.
 - .2 Perform start and stop sequences of contactors and relays.
 - .3 Check that interlock sequences, with other separate related starters, equipment and auxiliary control devices, operate as specified.

3.11 GROUNDING

- .1 Install complete, permanent, continuous grounding system for equipment, including conductors, connectors and accessories.
- .2 Install separate grounding conductors in conduit within building.
- .3 Install ground wire in all PVC ducts and in tunnel conduit systems.
- .4 Tests: perform ground continuity and resistance tests, using approved method appropriate to site conditions.

3.12 TESTS

- .1 General:

- .1 Perform following tests in addition to tests specified Section 25 08 20 - BAS: Warranty and Maintenance.
- .2 Give 14 days written notice of intention to test.
- .3 Conduct in presence of Consultant and authority having jurisdiction.
- .4 Conceal work only after tests satisfactorily completed.
- .5 Report results of tests to Consultant in writing.
- .6 Preliminary tests:
 - .1 Conduct as directed to verify compliance with specified requirements.
 - .2 Make needed changes, adjustments, replacements.
 - .3 Insulation resistance tests:

3.13 IDENTIFICATION

- .1 Refer to Section 25 05 54 - BAS: Identification.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 25 01 01 and Division 01 - Commissioning.

1.2 COMMISSIONING AGENT

- .1 The CA has overall responsibility for planning and coordinating the commissioning process. Commissioning involves all parties to the design and construction process, including the Contractor and his sub-contractors and suppliers.

1.3 DESCRIPTION OF WORK

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

1.4 RELATED DOCUMENTS

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

1.5 REFERENCES

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

.4 NFPA Standards and Guidelines

1.6 SYSTEMS TO BE COMMISSIONED

- .1 The following Integrated Automation Systems shall be commissioned as part of the Work of this contract;
- .1 Building Automation System (BAS)
 - .2 Building Management System (BMS)
 - .3 Energy Management and Control System (EMCS)
 - .4 Facility Management System (FMS)

2 PRODUCTS

2.1 COMMISSIONING AUTHORITY

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

2.2 SYSTEMS START-UP/VERIFICATION CHECKLISTS

- .1 The Appendix specification section contains the system start-up and verification checklists as listed below:

2.3 FUNCTIONAL PERFORMANCE TEST CHECKLISTS

- .1 The Appendix specification section contains functional performance test checklists as listed below:

3 EXECUTION

3.1 COMMISSIONING AGENT'S RESPONSIBILITIES

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

3.2 MECHANICAL ENGINEER'S RESPONSIBILITIES

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

3.3 OWNER'S RESPONSIBILITIES

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

3.4 GENERAL CONTRACTOR'S RESPONSIBILITIES

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

3.5 DIVISION 25 SUBCONTRACTOR'S RESPONSIBILITIES

- .1 With respect to Integrated Automation Systems commissioning, the controls contractor shall:
 - .1 Include cost for commissioning requirements in the quoted price.
 - .2 Review design for controllability with respect to equipment selected for the project;
 - .1 Review and confirm in writing that a proper hardware specification exists to permit functional performance testing as required by specification and sequence of operation.
 - .2 Review and confirm in writing that proper safeties and interlocks are included in design.

- .3 Ensure the proper sizing of control valves and actuators, based on design pressure drops. Ensure that control valve authority will result in capacity control as specified. Include valve sizing and authority information in submittal to mechanical engineer.
- .4
- .5 Ensure the proper sizing of control dampers. Ensure damper authority to control air flows as specified. Review and confirm in writing proper damper positioning for mixing to prevent stratification. Ensure correct actuator vs. damper movement for smooth operation. Include damper sizing, control authority and actuator selection data in submittal to mechanical engineer.
- .6 Ensure the proper selection of sensor ranges, and include data with submittal to mechanical engineer.
- .7 Clarify all questions concerning sequences of operation with the mechanical engineer.
- .3 Attend commissioning meetings scheduled by the CA.
- .4 Provide the following submittals to the CA for review:
 - .1 Hardware and software submittals.
 - .2 Control panel construction shop drawings.
 - .3 Diagrams showing all control points, sensor locations, point names, actuators, controllers and where necessary, points of access, all superimposed on diagrams of the physical equipment.
 - .4 Narrative description of all control sequences for each piece of equipment controlled.
 - .5 Logic diagrams showing the logic flow of all control sequences.
 - .6 A list of all control points, including analog inputs, analog outputs, digital inputs and digital outputs. Include the values of all parameters for each system point. Provide a separate list for each stand-alone control unit.
 - .7 A complete control language program listing including all software routines employed in operating the control system. Also, provide a program write-up, organized in the same manner as the control software. This narrative shall describe the logic flow of the software and the functions of each routine and sub-routine. It should also explain individual math or logic operations that are not clear from reading the software listing.
 - .8 Hardware operation and maintenance manuals.
 - .9 Application software and project applications code manuals.
- .5 Inspect, check, and confirm the proper installation and performance of controls/BAS hardware and software provided by others.
- .6 Integrate installation and programming scheduling with construction and commissioning schedules.

- .7 Inspect, check and confirm the correct installation and operation of input and output field points and devices through documented and signed off point-to-point checkouts.
- .8 Provide thorough training to operating personnel on hardware operations and programming, and the application program for the system, in accordance with the O&M staff training program in the commissioning plan.
- .9 In conjunction with the Division 23 sub-contractor, demonstrate system performance to the CC including all modes of system operation (e.g. occupied, unoccupied, emergency) during the functional performance tests (FTP's). If improper functionality, incomplete work, or other deficiencies affecting system performance are discovered, the FTP's will be stopped by the CC. Those responsible for deficient or incomplete work will be responsible for costs in accordance with 3.4 in this Section.
- .10 Provide control system technician to assist during system verification and functional performance testing.
- .11 Provide support and coordination with CA on all interfaces between controls and CA scopes of work. Provide, at no additional cost to the CA and commissioning agencies, all devices, such as portable operator's terminals and all software for the CA agency to use in completing CA procedures.

3.6 DIVISION 26 SUBCONTRACTOR'S RESPONSIBILITIES

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

END OF SECTION

1. GENERAL

1.1 SUMMARY

- .1 Section Includes.
 - .1 Requirements and procedures for warranty and activities during warranty period and service contracts, for Building Automation System (BAS).
- .2 Related Requirements
 - .1 Section 25 05 01.
- .3 References.
 - .1 CSA Group (CSA).
 - .1 CSA Z204-94(R1999), Guidelines for Managing Indoor Air Quality in Office Buildings.

1.2 DEFINITIONS

- .1 BC(s) - Building Controller(s).
- .2 OWS - Operator Work Station.
- .3 For additional acronyms and definitions refer to Section 25 05 01 - BAS: General Requirements.

1.3 SHOP DRAWING SUBMITTALS

- .1 Submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Submit detailed preventative maintenance schedule for system components to Consultant.
- .3 Submit detailed inspection reports to Consultant.
- .4 Submit dated, maintenance task lists to Consultant. and include the following sensor and output point detail, as proof of system verification:
 - .1 Point name and location.
 - .2 Device type and range.
 - .3 Measured value.
 - .4 System displayed value.
 - .5 Calibration detail
 - .6 Indication if adjustment required,
 - .7 Other action taken or recommended.
- .5 Submit network analysis report showing results with detailed recommendations to correct problems found.
- .6 Records and logs: in accordance with Section 01 78 00 - Closeout Submittals.
 - .1 Maintain records and logs of each maintenance task on site.
 - .2 Organize cumulative records for each major component and for entire BAS chronologically.

- .3 Submit records to Consultant, after inspection indicating that planned and systematic maintenance have been accomplished.
- .7 Revise and submit to Consultant in accordance with Section 01 78 00 - Closeout Submittals "As-built drawings" documentation and commissioning reports to reflect changes, adjustments and modifications to BAS made during warranty period.

1.4 MAINTENANCE SERVICE DURING WARRANTY PERIOD

- .1 Provide services, materials, and equipment to maintain BAS for specified warranty period. Provide detailed preventative maintenance schedule for system components as described in Submittal article.
- .2 Emergency Service Calls:
 - .1 Initiate service calls when BAS is not functioning correctly.
 - .2 Qualified control personnel to be available during warranty period to provide service to "CRITICAL" components whenever required at no extra cost.
 - .3 Provide telephone number where service personnel may be reached at any time.
 - .4 Service personnel to be on site ready to service BAS two hours after receiving request for service.
 - .5 Perform Work continuously until BAS restored to reliable operating condition.
- .3 Operation: foregoing and other servicing to provide proper sequencing of equipment and satisfactory operation of BAS based on original design conditions and as recommended by manufacturer.
- .4 Work requests: record each service call request, when received separately on approved form and include:
 - .1 Serial number identifying component involved.
 - .2 Location, date and time call received.
 - .3 Nature of trouble.
 - .4 Names of personnel assigned.
 - .5 Instructions of work to be done.
 - .6 Amount and nature of materials used.
 - .7 Time and date work started.
 - .8 Time and date of completion.
- .5 Provide system modifications in writing.
 - .1 No system modification, including operating parameters and control settings, to be made without prior written approval of Consultant.

2. PRODUCTS

2.1 NOT USED

- .1 Not Used.

3. EXECUTION

3.1 FIELD QUALITY CONTROL

- .1 Perform as minimum (3) three minor inspections and one major inspection (more often if required by manufacturer) per year. Provide detailed written report to Consultant as described in Submittal article.
- .2 Perform inspections during regular working hours, 0800 to 1630 h, Monday through Friday, excluding statutory holidays.
- .3 Following inspections are minimum requirements and should not be interpreted to mean satisfactory performance:
 - .1 Perform calibrations using test equipment having traceable, certifiable accuracy at minimum 50% greater than accuracy of system displaying or logging value.
 - .2 Check and calibrate each field input/output device in accordance with CSA Z204.
 - .3 Provide dated, maintenance task lists, as described in Submittal article, as proof of execution of complete system verification.
- .4 Minor inspections to include, but not limited to:
 - .1 Perform visual, operational checks to BC's, peripheral equipment, interface equipment and other panels.
 - .2 Check equipment cooling fans as required.
 - .3 Visually check for mechanical faults, air leaks and proper pressure settings on pneumatic components.
 - .4 Review system performance with Consultant to discuss suggested or required changes.
- .5 Major inspections to include, but not limited to:
 - .1 Minor inspection.
 - .2 Clean OWS(s) peripheral equipment, BC(s), interface and other panels, micro-processor interior and exterior surfaces.
 - .3 Check signal, voltage and system isolation of BC(s), peripherals, interface and other panels.
 - .4 Verify calibration/accuracy of each input and output device and recalibrate or replace as required.
 - .5 Provide mechanical adjustments, and necessary maintenance on printers.
 - .6 Run system software diagnostics as required.
 - .7 Install software and firmware enhancements to ensure components are operating at most current revision for maximum capability and reliability.
 - .1 Perform network analysis and provide report as described in Submittal article.

- .6 Rectify deficiencies revealed by maintenance inspections and environmental checks.
- .7 Continue system debugging and optimization.
- .8 Testing/verification of occupancy and seasonal-sensitive systems to take place during four (4) consecutive seasons, after facility has been accepted, taken over and fully occupied.
 - .1 Test weather-sensitive systems twice: first at near winter design conditions and secondly under near summer design conditions.

END OF SECTION

1 GENERAL

1.1 RELATED SECTIONS

- .1 The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents. Consult the above for further instructions pertaining to this work. The Contractor is bound by the provisions of Division 0 and Division 1.

1.2 QUALITY ASSURANCE

- .1 BAS Manufacturer Qualifications
- .2 The BAS Manufacturer shall have factory trained and certified personnel providing all engineering, service, startup, and commissioning field labor for the project from their local office location. BAS manufacturer shall be able to provide training certifications for all local office personnel upon request.
- .3 Independent representatives of BAS manufacturers are not acceptable. BAS vendor must be corporate owned entity of BAS manufacturer.

1.3 CODES AND STANDARDS

- .1 Codes and Standards: Meet requirements of all applicable local standards and codes, except when more detailed or stringent requirements are indicated by the Contract Documents, including requirements of this Section. Electrical shall be installed per Section 26.
- .2 ASHRAE/ANSI 135-2012 (BACnet) - (System and Unit Level Devices) - Building Controllers and unit level controllers shall conform to the listed version of the BACnet specification in order to improve interoperability with various building system manufacturers' control systems and devices.
- .3 ASHRAE/ANSI 135-2012 (BACnet) - (Unit Level Devices) - Unit Controllers shall conform to the listed version of the BACnet specification in order to improve interoperability with various building system manufacturers' control systems and devices.

1.4 SYSTEM PERFORMANCE

- .1 Performance Standards - The BAS system shall conform to the following:
 - .1 Graphic Display: The system shall display a graphic with a minimum of 20 dynamic points. All current data shall be displayed within 10 seconds of the operator's request.
 - .2 Graphic Refresh: The system shall update all dynamic points with current data within 10 seconds.
 - .3 Object Command: The maximum time between the command of a binary object by the operator and the reaction by the device shall be 5 seconds. Analog objects shall start to adjust within 5 seconds.
 - .4 Object Scan: All changes of state and change of analog values shall be transmitted over the high-speed network such that any data used or

displayed at a controller or workstation will be current within the prior 10 seconds.

- .5 Alarm Response Time: The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed 10 seconds.
- .6 Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 seconds. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
- .7 Programmable Controllers shall be able to execute DDC PID control loops at a selectable frequency from at least once every 5 seconds. The controller shall scan and update the process value and output generated by this calculation at this same frequency.
- .8 Multiple Alarm Annunciations: All workstations on the network shall receive alarms within 5 seconds of each other.
- .9 Reporting Accuracy: Table 1 lists minimum acceptable reporting accuracies for all values reported by the specified system.

Table 1: Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±0.25°C [±0.45°F]
Ducted Air	±0.25°C [±0.45°F]
Outside Air	±0.25°C [±0.45°F]
Water Temperature	±0.26°C [±0.47°F]
Delta –T	±0.2°C [±0.36°F] <- 6-inch duct thermistor temp sensor
Relative Humidity	±3% RH
Water Flow	±2% of full scale
Air Flow (terminal)	±5% of reading *Note 1
Air Flow (measuring stations)	±3% of reading
`	±3% of full scale
Air Pressure (ducts)	±1% of full scale
Air Pressure (space)	±1% of full scale (Low Pressure Transducer) 41905050 <- Model number
Water Pressure	±1% of full scale *Note 2
Electrical Power	5% Solid-Core *Note 3

Note 1: (10%-100% of scale) (cannot read accurately below 10%)

Note 2: for both absolute and differential pressure

Note 3: * not including utility supplied meters

Table 2: Control Stability and Accuracy

Controlled Variable	Control Accuracy	Range of Medium
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	$\pm 10\%$ of full scale	
Space Temperature	$\pm 1.0^{\circ}\text{C}$ ($\pm 2.0^{\circ}\text{F}$)	
Duct Temperature	$\pm 1.5^{\circ}\text{C}$ ($\pm 3^{\circ}\text{F}$)	
Humidity	$\pm 5\%$ RH	
Fluid Pressure	± 10 kPa (± 1.5 psi) ± 250 Pa (± 1.0 in. w.g.)	MPa (1–150 psi) 0–12.5 kPa (0–50 in. w.g.)

1.5 SUBMITTAL REQUIREMENTS

- .1 Submittal information shall be provided to the Engineer or Owner electronically prior to commencing the project.
- .2 Quantities of items submitted shall be reviewed by the Engineer and Owner. Such review shall not relieve the BAS manufacturer of furnishing quantities required based upon contract documents.
- .3 Provide the Engineer and Owner, any additional information or data which is deemed necessary to determine compliance with the specifications or which is deemed valuable in documenting and understanding the system to be installed.
- .4 Submit the following within 90 days of contract award:
 - .1 A complete bill of materials of equipment to be used indicating quantities, manufacturers and model numbers.
 - .2 A schedule of all control valves including the valve size, pressure drop, model number (including pattern and connections), flow, CV, body pressure rating, and location.
 - .3 A schedule of all control dampers including damper size, pressure drop, manufacturer, and model number.
- .5 Provide all manufacturers' technical cut sheets for major system components. When technical cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Include:
 - .1 Building Controllers
 - .2 Custom Application Controllers
 - .3 Application Specific Controllers
 - .4 Auxiliary Control Devices
- .6 Provide proposed Building Automation System architectural diagram depicting various controller types, device locations, addresses, and communication cable requirements
- .7 Provide detailed termination drawings showing all required field and factory terminations, as well as terminal tie-ins to DDC controls provided by mechanical

equipment manufacturers. Terminal numbers shall be clearly labeled.

- .8 Provide points list showing all system objects and the proposed English language object names.
- .9 Provide a sequence of operation for each controlled mechanical system and terminal end devices.
- .10 Provide a BACnet Protocol Implementation Conformance Statement (PICS) for each BACnet system level device type. This defines the points list for proper coordination of interoperability with other building systems if applicable for this project.

1.6 WARRANTY REQUIREMENTS

- .1 Warrant all work as follows:
 - .1 BAS system labor and materials shall be warranted free from defects for a period of twelve (12) months after final completion acceptance by the Owner. BAS failures during the warranty period shall be adjusted, repaired, or replaced at no charge to the Owner. The BAS manufacturer shall respond to the Owner's request for warranty service within 24 hours of the initiated call and will occur during normal business hours (8AM-5PM).
 - .2 The BAS manufacturer shall provide a total of (16) hours of onsite Preventative Maintenance during Warranty Period. Eight (8) hours at six (6) months, and eight (8) hours at ten (10) months after Substantial Completion of onsite Preventative Maintenance into the Warranty period.
 - .3 At the end of the final start-up/testing, if equipment and systems are operating satisfactorily to the customer, the customer shall sign certificates certifying that the BAS is operational and has been tested and accepted in accordance with the terms of this specification. The date of customer acceptance shall be the start of the warranty period.
 - .4 Operator workstation software, project specific software, graphics, database, and firmware updates shall be provided to the customer at no charge during the warranty period. Written authorization by the customer must be granted prior to the installation of these updates.
 - .5 The BAS manufacturer shall provide a web-accessible Users Network for the proposed System and give the Owner free access to question/answer forum, user tips, upgrades, and training schedules for a one year period of time correlating with the warranty period.
- .2 The project's controls contractor shall provide and maintain secure remote access to the facilities Building Automation System (BAS) or other building systems until up to 1 year after substantial completion. Prior to transition from warranty, the building owner will provide and maintain the secured remote access.

1.7 DATA MONITORING & COLLECTION STANDARDS

- .1 The system shall record and store interval data, 24 hours/day, 7 days/week, 365

days/year.

- .2 Data to be collected for real-time continuous monitoring and collection of whole-building energy meters and sub-meters if the meters have been installed as part of the warranted project.
- .3 Data to be collected from building automation and control systems sub-meters and sensors data for equipment status, set points, and operational points.

1.8 DATA STORAGE STANDARDS

- .1 Data shall be stored in a Class 5 secure hosting location protected by ISO 5001-complaint firewall and intrusion detection systems with support for major network security protocols such as HTTPS and SFTP to securely access and store data.
- .2 Dashboard Web Interface: The dashboard interface shall allow display of energy and building system data in widgets, charts and tracking applications, and be available without requiring users to utilize external, third party tools.
 - .1 The Dashboard Web Interface shall be accessible via a web browser without requiring any “plug-ins” (i.e. JAVA Runtime Environment (JRE), Adobe Flash).
 - .2 The interface shall support common Internet web browsers at a minimum including: Internet Explorer 10.0+, Firefox 4.0+, Chrome 10.0+, Opera, Safari
 - .3 The interface shall support the following mobile web browsers at a minimum: iOS (iPad/iPhone) V9.1+, Android (Tablet) V4.3+, Android (Phone) V2.3+.
 - .4 Dashboards shall be customizable for each individual or group of users the to modify personal dashboards at any time using a library of widgets specific to the project site.
 - .5 Dashboards should be capable of tracking & displaying summary metrics and status of energy and emissions goals at various levels: floor/area, building, campus, portfolio.

1.9 DASHBOARD ACCESS SECURITY

- .1 Each user shall be required to login to the system with a user name and password in order to view, edit, add, or delete data
- .2 User Profiles shall restrict the user to only the objects, applications, and system functions as assigned by the system administrator.
- .3 Each user shall be allowed to change their user password.
- .4 The System Administrator shall be able to manage the security for all other users.
- .5 The system shall include pre-defined “roles” that allow a system administrator to quickly assign permissions to a user.

1.10 DASHBOARD WIDGET BUILDER/LIBRARY

- .1 BEMS dashboard shall include an object-based widget builder for the creation of custom widgets, as well as a library of off-the-shelf energy widgets to utilize:
 - .1 Users shall modify personal dashboards at any time using a library of widgets specific to the project site or drawing on a vendor-provided library of energy widgets with embedded logic for common energy calculations.
 - .2 Users are allowed to pick and choose which widgets are displayed, and where they are located.
- .2 Shall provide an object-based widget builder for the creation of custom widgets including:
 - .1 target a specific building or system/equipment
 - .2 configure time periods, parameter values (maximum/minimum), units of measure
 - .3 select display colors
 - .4 preview widgets using target object.
- .3 Energy Conservation Measure (ECM) Creation and Tracking
 - .1 The BEMS shall include embedded application for the creation and tracking of energy conservation measures (ECMs) and opportunities for facility improvements including:
 - .1 Capability to create and track the status of opportunities, energy efficiency projects and energy conservation measures (ECMs), including attaching documentation.
 - .2 Shall provide embedded cost estimator to quantify energy cost savings for each recommended energy conservation measure or system optimization recommendation.

1.11 SYSTEM MAINTENANCE

- .1 Perform Building Automation System preventative maintenance and support for a period of 1 year (beginning the date of substantial completion). The Automation system shall be connected prior to substantial completion for data collection, trending and analysis.
 - .1 Database back-up
 - .2 Operator coaching (4) hours during the warranty period
 - .3 Building Automation System Technician support (8) hours during the warranty period to diagnose issues remotely through secure remote access.
- .2 Fault Detection & Diagnostics Analytics shall diagnose performance against expectations for optimal operation and must indicate: most recent failure, count of failures and exceptions throughout building history for a particular point, most dramatic failure or exception for a particular point, first time the exception or failure was generated.
 - .1 Automated tests for building schedules, systems and equipment shall

- provide evidence of the onset of a problem and provide graphical data that demonstrates a resolution to the problem.
- .2 The Building Performance Service shall automatically provide a full range of building-specific FDD analytics without the need to utilize third party tools, external to the system in the following areas:
 - .1 VAV Air Systems/Equipment
 - .2 Laboratory Air Systems/Equipment
 - .3 Heating Systems/Equipment
 - .4 Glycol Systems/Equipment
 - .5 Terminal Equipment
 - .3 Professional Analysis: Provider shall have trained personnel with relevant professional credentials in HVAC systems, energy management and building optimization methodologies to prepare professional assessment reports including:
 - .1 Identify building system performance trends and deviations from normal operation
 - .2 Prepare actionable recommendations to optimize HVAC system performance
 - .3 Prepare recommendations for operational adjustments
 - .4 Prepare risk analysis of emergency maintenance or failure
 - .5 Develop Energy Conservation Measures (ECMs) with energy savings or performance improvement estimates
 - .4 Performance analytics and reports are to be developed and reviewed with building owner during scheduled performance review meetings. The meetings and reports shall be scheduled within (1) month of final completion and (9) months of final completion respectively.
 - .1 Provider shall include a minimum of (2) performance analysis fault detection reports.
 - .2 Provider shall schedule (2) performance review meetings with owner or designated representative to review performance reports.
 - .3 Provider shall provide a minimum of (2) ECM / Performance improvement opportunities at each review meeting.
 - .5 Do not assign or transfer maintenance service to agent or subcontractor without prior written consent of owner.

1.12 OWNERSHIP OF PROPRIETARY MATERIAL

- .1 Project specific software and documentation shall become the owner's property upon project completion. This includes the following:
 - .1 Operator Graphic files
 - .2 As-built hardware design drawings

- .3 Operating & Maintenance Manuals
- .4 BAS System software database
- .5 Controller application programming databases including where required to view and make necessary programming changes
- .6 Application Specific Controller configuration files

2 PRODUCTS

2.1 CONTROL SYSTEM

- .1 BAS Manufacturers:
 - .1 The BAS specified in this Section is a modular, expandable DDC building automation system as per drawing control diagrams and sequences, and points lists. Basis of design BAS manufacturers is:
 - .1 Johnson Controls

2.2 MATERIALS

- .1 Use new products that the manufacturer is currently manufacturing and that have been installed in a minimum of 50 installations. Do not use this installation as a product test site unless explicitly approved in writing by the owner or the owner's representative. Spare parts shall be available for at least five years after completion of this contract.

2.3 COMMUNICATION

- .1 Connectivity / Remote Access / Network Security
- .2 The Owner will provide up to Three (3) IP drops and IP addresses. If the project or controls system requires additionally IP drops or IP address, the controls contractor shall carry a minimum allowance of \$1000 for each additional drop. The control contractor shall coordinate with the Owners IT team, verify the proposed system shall meet all network security requirements and any other network configuration information necessary to each control contractor for the purpose of configuring each Area Controller on the network. The controls contractor shall coordinate the IP address for each Area Controller. It shall be the responsibility of the control contractor to coordinate with the owner for network connectivity.
- .3 Provide the integration device (gateway) to collect the required monitoring points from the facilities BAS. Interface between the cloud storage and BAS shall be via BACnet® IP.
- .4 Provide and maintain secure remote access to the facilities Building Automation System (BAS) or other building systems. Users accessing service shall not have access to the building owners network. Secure remote access to the BAS shall not require additional software to be installed on the client device (i.e. VPN client). Secure remote access to the BAS shall not require ANY inbound ports on a firewall to be "exposed" or "forwarded".

- .5 Secure remote access to the BAS shall be available anywhere, anytime, using a compatible client device (PC/tablet/phone)
- .6 This project shall be comprised of a high speed Ethernet network utilizing BACnet/IP communications between System Controllers. Each System Controller shall function as a BACnet Router to each unit controller providing a unique BACnet Device ID for all controllers within the system. Communications between System Controllers and sub-networks of Custom Application Controllers and/or Application Specific Controllers shall be as defined below.
- .7 Each System Controller shall perform communications to a network of Custom Application and Application Specific Controllers using BACnet:
 - .1 Each communication interface shall be Metasys Building Automation Certified product as defined by the BACnet Standard and the Zigbee Alliance.
 - .2 Each System Controller shall function as a BACnet Router to each unit controller providing a unique BACnet Device ID for all controllers within the system.
 - .3 Wireless equipment controllers and auxiliary control devices shall conform to:
 - .1 IEEE 802.15.4 radios to minimize risk of interference and maximize battery life, reliability, and range.
 - .2 Communication between equipment controllers shall conform to ZigBee Building Automation (ZBA) standard as BACnet tunneling devices to ensure future integration of other ZBA certified devices.
 - .3 Operating range shall be a minimum of 200 feet (60 m); open range shall be 2,500 ft. (762 m) with less than 2% packet error rate.
 - .4 To maintain robust communication, mesh networking and two-way communications shall be used to optimize the wireless network health.
 - .5 Wireless communication shall be capable of many-to-one sensors per controller to support averaging, monitoring, and multiple zone applications.
 - .6 Certifications shall include FCC CFR47 - RADIO FREQUENCY DEVICES - Section 15.247 & Subpart E
- .8 Each System Controller shall perform communications to a network of Custom Application and Application Specific Controllers using BACnet/MSTP (RS485) as defined by the BACnet standard.

Analytics and continuing commissioning are becoming standard in automation. Data is transferred to the cloud for long term trending, easy to interpret graphics and dashboards, and to be analyzed to create actionable recommendations for automation system improvement.

2.4 INTELLIGENT SERVICES ANALYTICS

- .1 Acceptable Building Energy Management System (BEMS) Providers:
 - .1 Johnson Controls
- .2 System Description:
 - .1 A Building Analytic Service is a cloud-based monitoring tool establishing the building operation baseline, assist in identify energy-saving opportunities and improve building performance.
- .3 Building Analytic Service Component Requirements and Term of Services:
 - .1 The service shall provide energy meter data collection and storage including advanced energy analytics for energy consumption and costs with display and reporting via Dashboard/widget technologies.
 - .2 The service shall provide data collection and storage for building systems and equipment, analytics and professional analysis, including at a minimum: general facility performance metrics, automated fault detection and diagnostics, building system/equipment analytics with display and reporting via dashboard/widget technologies.
 - .3 The service shall be provided for a 2-year term from substantial completion.
- .4 Connectivity / Remote Access / Network Security
 - .1 The Owner will provide up to Three (3) IP drops and IP addresses. If the project or controls system requires additionally IP drops or IP address, the controls contractor shall carry a minimum allowance of \$1000 for each additional drop. The control contractor shall coordinate with the Owners IT team, verify the proposed system shall meet all network security requirements and any other network configuration information necessary to each control contractor for the purpose of configuring each Area Controller on the network. The controls contractor shall coordinate the IP address for each Area Controller. It shall be the responsibility of the control contractor to coordinate with the owner for network connectivity.
 - .2 Provide the integration device (gateway) to collect the required monitoring points from the facilities BAS. Interface between the cloud storage and BAS shall be via BACnet® IP.
 - .3 Provide and maintain secure remote access to the facilities Building Automation System (BAS) or other building systems. Users accessing service shall not have access to the building owners network. Secure remote access to the BAS shall not require additional software to be installed on the client device (i.e. VPN client). Secure remote access to the BAS shall not require ANY inbound ports on a firewall to be "exposed" or "forwarded".
 - .4 Secure remote access to the BAS shall be available anywhere, anytime, using a compatible client device (PC/tablet/phone)
- .5 Data Monitoring & Collection Standards
 - .1 The system shall record and store interval data, 24 hours/day, 7 days/week, 365 days/year. Data to be collected for real-time continuous

- monitoring and collection of whole-building energy meters and sub-meters
- .2 Data to be collected from building automation and control systems sub-meters and sensors data for equipment status, set points, and operational points.
- .3 The system shall include an embedded automated weather feed.
- .4 Data shall be stored in a Class 5 secure hosting location protected by ISO 5001-complaint firewall and intrusion detection systems with support for major network security protocols such as HTTPS and SFTP to securely access and store data.
- .6 **Energy Analytics & Reports:**
 - .1 Provider shall provide interactive charts for a range of energy analytics. Reports and analytical data shall be exportable in multiple, standard formats such as .csv files, PDF images or vectors
 - .2 Energy Baseline Analytics, based on an advanced regression-based Energy Baseline Model with:
 - .1 Graphical charts covering: Predicted Baseline, Actual Energy Costs, Savings Estimate per baseline, Running tally of projected savings over baseline
 - .2 Users can record Energy Conservation Measures (ECMs) and link in related engineering analysis or other documentation
 - .3 Energy Intensity: generate/display energy cost and consumption per square foot.
 - .4 Heat-maps: display visualizations for energy usage or demand over a select period in a single graphic
 - .5 Load Profiles: plot kW and percentage of time at demand peaks, estimate cost savings of load-shedding strategies.
 - .6 Ratchet Demand: track demand and forecast cost of ratchet trigger.
- .7 **Building Analytics & Analysis:**
 - .1 Provider shall be perform automated benchmarks of facility performance including comparisons against how the building should operate normally. Provider shall deliver quarterly comparison of building month-to-month trends to Key Performance Indicators (KPI's) Automated tests for building schedules, systems and equipment shall provide evidence of the onset of a problem and provide graphical data that demonstrates a resolution to the problem. KPI's shall include the following:
 - .1 Percent Time in Normal Operations of HVAC Equipment, Systems and Facility
 - .2 Advisory Details for HVAC Equipment and Systems with indicators for Normal Operation, Warning, Critical Failure
 - .3 The Building Performance Service shall automatically provide a full range of building-specific FDD analytics for the system in the

following areas:

- .1 Heating Systems/Equipment
 - .2 VAV Air Systems/Equipment
 - .3 CV Air Systems/Equipment
 - .4 Terminal Equipment.
- .2 Professional Analysis: Provider shall have trained personnel with relevant professional credentials in HVAC systems, energy management and building optimization methodologies to prepare professional assessment reports including:
 - .1 Identify building system performance trends and deviations from normal operation
 - .2 Prepare actionable recommendations to optimize HVAC system performance
 - .3 Prepare recommendations for operational adjustments
 - .4 Prepare risk analysis of emergency maintenance or failure
 - .5 Develop Energy Conservation Measures (ECMs) with energy savings or performance improvement estimates
- .3 Performance analytics and reports are to be developed and reviewed with building owner during scheduled performance review meetings.
 - .1 Provider will include a minimum of [2] performance analysis fault detection reports annually.
 - .2 Provider shall schedule [2] performance review meetings annually with owner or owners designated representative to review performance reports.
 - .3 Provider shall provide a minimum of [2] ECM / Performance improvement opportunities at each review meeting.
- .8 Dashboard Web Interface: The dashboard interface shall allow display of energy and building system data in widgets, charts and tracking applications, and be available without requiring users to utilize external, third party tools.
 - .1 The Dashboard Web Interface shall be accessible via a web browser without requiring any "plug-ins" (i.e. JAVA Runtime Environment (JRE), Adobe Flash).
 - .2 The interface shall support common Internet web browsers at a minimum including: Internet Explorer 10.0+, Firefox 4.0+, Chrome 10.0+, Opera, Safari
 - .3 The interface shall support the following mobile web browsers at a minimum: iOS (iPad/iPhone) V9.1+, Android (Tablet) V4.3+, Android (Phone) V2.3+.
 - .4 Dashboards shall be customizable for each individual or group of users to modify personal dashboards at any time using a library of widgets specific to the project site.

- .5 Dashboards should be capable of tracking & displaying summary metrics and status of energy and emissions goals at various levels: floor/area, building, campus, portfolio.
- .9 Dashboard Widget Builder/Library:
 - .1 Dashboard shall include an object-based widget builder for the creation of custom widgets, as well as a library of off-the-shelf energy widgets to utilize:
 - .1 Users shall modify personal dashboards at any time using a library of widgets specific to the project site or drawing on a vendor-provided library of energy widgets with embedded logic for common energy calculations.
 - .2 Users are allowed to pick and choose which widgets are displayed, and where they are located.
 - .2 Shall provide an object-based widget builder for the creation of custom widgets including:
 - .1 Target a specific building or system/equipment
 - .2 Configure time periods, parameter values (maximum/minimum), units of measure
 - .3 Select display colors
 - .4 Preview widgets using target object.
- .10 ECM (Energy Conservation Measure) Creation and Tracking
 - .1 The service shall include embedded application for the creation and tracking of energy conservation measures (ECMs) and opportunities for facility improvements including:
 - .1 Capability to create and track the status of opportunities, energy efficiency projects and energy conservation measures (ECMs), including attaching documentation.
 - .2 Shall provide embedded cost estimator to quantify energy cost savings for each recommended energy conservation measure or system optimization recommendation.
- .11 Active Monitoring Service
 - .1 Remote Monitoring Facility and Staffing:
 - .1 This specification requires that, for 1 year, xyz will have 24/7/365 monitoring of up to 60 of their most critical alarms from a dedicated remote facility staffed with HVAC technical specialists.
 - .2 The Original Equipment Manufacturer (OEM) Monitoring center must have full redundancy in systems at the data center level to fully support a 24/7/365 operation. This includes, but is not limited to, the following systems: electrical, phone, database, and support.
 - .3 The center must have a staff of controls specialists who have field

expertise in HVAC applied systems operations.

- .4 Facility controls specialists must be factory trained and certified in Building Automation Systems (BAS).
 - .5 In the event of an outage at the primary remote center, a redundant site must be in place to provide additional backup and support.
 - .6 It will be the responsibility of the building owner to provide the connectivity medium required for remote monitoring to the DDC contractor, as well as the annual costs of maintaining that medium (for example, phone line, internet, et cetera). The remote connection is contingent on receiving permission for remote access from property owner.
- .12 Active Monitoring Response Requirements
- .1 Upon receipt of an alarm through an owner-provided connectivity medium (such as a phone line or internet access), an HVAC specialist from the remote monitoring facility will diagnose the issue and troubleshoot from his/her interface to the system in an attempt to correct the problem without initiating any on-site requirement. This will prevent xyz from placing any service calls that are not 100% necessary.
 - .2 If correcting the alarm remotely is not possible, the monitoring facility must intelligently dispatch a service technician with information about the issue and provide recommendations to correct the problem in the field.
 - .3 Use telephone support to dispatch a service technician, as dictated by xyz, to ensure that only the most appropriate owner contacts, technicians, and field support personnel are always involved. This allows for smarter and more efficient service that ensures accurate calls in cases where this type of maintenance is required.
 - .4 To guarantee continual monitoring, communication between the remote monitoring facility and the xyz building control system must be tested and proven each quarter. Damage caused by missed alarms, due to lost connectivity in between tests, will not be the liability of the DDC contractor. It is required to deliver to xyz each quarter, a record of this successful test, as well as a record of each automated critical alarm recorded (and the actions associated actions it).
 - .5 The remote facility must compile and store a history of all critical alarms, with this data being the owned property of the remote monitoring service provider, for further redundancy and protection from failures. During start-up and commissioning of the alarm reporting, xyz may trip an alarm to demonstrate remote capability prior to acceptance.

2.5 ADVANCED ANALYTICS & VISUALIZATIONS

- .1 3D Load Profiles shall allow users to view chart with axes representing time, date and demand with to dynamically change a range of parameters, add a 4th dimensional overlay, and rotate the graphic.

- .2 Load Density profile shall allow users to view demand levels as a density plot with a degree day reference strip and to overlay additional data source as a contour plot.
- .3 Daily Load profile shall allow users to group the days in accordance with their operational requirements.
- .4 Scatter Plots shall allow users to select parameters to evaluate trends and historical comparisons (year-over-year).
- .5 Time Series Plots shall allow users to modify the scale (normal, log or percent) allowing for improved insights into data with large absolute value differences.
- .6 Polar Time Series plot shall allow users to display time series data around a 24-hour clock, allowing users to understand how demand levels change at the same time on different days.
- .7 Best Normal Energy Savings analytic shall allow users to evaluate the building from the perspective of the best that it has done adjusting for type of day and weather.
- .8 Best Normal Demand Savings analytic shall allow users to calculate potential demand savings determined by evaluating peak demand by month with alignment to the utility tariff given how the building has operated to date.
- .9 What-If analysis shall allow users to modify the daily profiles to determine the value through improved performance and establish how the days and months should appropriately be grouped.

2.6 OPERATOR INTERFACE

- .1 Interface with existing operator interface. Coordinate work with owner's maintenance staff for exact location of the operator interface.
- .2 System Graphics. Building operator web interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each air handling equipment, humidifier, glycol plant and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using colors to represent zone temperature relative to zone set point.
 - .1 Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point and-click navigation between zones or equipment, and to edit set points and other specified parameters.
 - .2 Graphic imagery – graphics shall use 3D images for all standard and custom graphics. The only allowable exceptions will be photo images, maps, schematic drawings, and selected floor plans.
 - .3 Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
- .3 Custom Graphics
 - .1 The operator interface shall be capable of displaying custom graphics in order to convey the status of the facility to its operators.

- .2 Graphical Navigation. The building operator web interface shall provide dynamic color graphics of building areas, systems and equipment.
- .3 Graphical Data Visualization. The building operator web interface shall support dynamic points including analog and binary values, dynamic text, static text, and animation files.
- .4 Manual Control and Override
 - .1 Point Control. Provide a method for a user to view, override, and edit if applicable, the status of any object and property in the system. The point status shall be available by menu, on graphics or through custom programs.
 - .2 Temporary Overrides. The user shall be able to perform a temporary override wherever an override is allowed, automatically removing the override after a specified period of time.
 - .3 Override Owners. The system shall convey to the user the owner of each override for all priorities that an override exists.
 - .4 Provide a specific icon to show timed override or operator override, when a point, unit controller or application has been overridden manually.
- .5 Scheduling. A user shall be able to perform the following tasks utilizing the building operator web interface:
 - .1 Create a new schedule, defining the default values, events and membership.
 - .2 Create exceptions to a schedule for any given day.
 - .3 Apply an exception that spans a single day or multiple days.
 - .4 View a schedule by day, week and month.
 - .5 Exception schedules and holidays shall be shown clearly on the calendar.
 - .6 Modify the schedule events, members and exceptions.
- .6 Data Logs
 - .1 Data Logs Definition.
 - .1 The building operator web interface shall allow a user with the appropriate security permissions to define a Data Log for any data in the system.
 - .2 The building operator web interface shall allow a user to define any Data Log options as described in the Application and Control Software section.
 - .2 Data Log Viewer.
 - .1 The building operator web interface shall allow Data Log data to be viewed and printed.
 - .2 The building operator web interface shall allow a user to view Data Log data in a text-based format (time –stamp/value).
 - .3 The operator shall be able to view the data collected by a Data

- Log in a graphical chart in the building operator web interface.
- .4 Data Log viewing capabilities shall include the ability to show a minimum of 5 points on a chart.
- .5 Each data point data line shall be displayed as a unique color.
- .6 The operator shall be able to specify the duration of historical data to view by scrolling and zooming.
- .7 The system shall provide a graphical trace display of the associated time stamp and value for any selected point along the x-axis.
- .3 Export Data Logs.
 - .1 The building operator web interface shall allow a user to export Data Log data in CSV or PDF format for use by other industry standard word processing and spreadsheet packages.
- .7 Alarm/Event Notification
 - .1 An operator shall be notified of new alarms/events as they occur while navigating through any part of the system via an alarm icon.
 - .2 Alarm/Event Log. The operator shall be able to view all logged system alarms/events from any building operator web interface.
 - .3 The operator shall be able to sort and filter alarms from events. Alarms shall be sorted in a minimum of 4 categories based on severity.
 - .4 Alarm/event messages shall use full language, easily recognized descriptors.
 - .5 An operator with the proper security level may acknowledge and clear alarms/events.
 - .6 All alarms/events that have not been cleared by the operator shall be stored by the building controller.
 - .7 The alarm/event log shall include a comment field for each alarm/event that allows a user to add specific comments associated with any alarm.
 - .8 Alarm Processing.
 - .1 The operator shall be able to configure any object in the system to generate an alarm when transitioning in and out of a normal state.
 - .2 The operator shall be able to configure the alarm limits, warning limits, states, and reactions for each object in the system.
- .8 Reports and Logs.
 - .1 The building operator web interface shall provide a reporting package that allows the operator to select reports.
 - .2 The building operator web interface shall provide the ability to schedule reports to run at specified intervals of time.
 - .3 The building operator web interface shall allow a user to export reports and logs from the building controller in a format that is readily accessible

by other standard software applications including spreadsheets and word processing. Acceptable formats include:

- .1 CSV, HTML, XML, PDF
- .4 Reports and logs shall be readily printed to the system printer.
- .5 Provide a means to list and access the last 10 reports viewed by the user.
- .6 The following standard reports shall be available without requiring a user to manually configure the report:
 - .1 All Points in Alarm Report: Provide an on-demand report showing all current alarms.
 - .2 All Points in Override Report: Provide an on-demand report showing all overrides in effect.
 - .3 Commissioning Report: Provide a one-time report that lists all equipment with the unit configuration and present operation.
 - .4 Points report: Provide a report that lists the current value of all points

2.7 CONTROLLER SOFTWARE

- .1 Furnish the following applications software for building and energy management. All software applications shall reside and run in the system controllers. Editing of applications shall occur at the building operator interface.
 - .1 Scheduling. Provide the capability to schedule each object or group of objects in the system. Each of these schedules shall include the capability for start, stop, optimal start, optimal stop, and night economizer actions. Each schedule may consist of up to 10 events. When a group of objects are scheduled together, provide the capability to define advances and delays for each member. Each schedule shall consist of the following:
 - .1 Weekly Schedule:
Provide separate schedules for each day of the week.
 - .2 Exception Schedules:
Provide the ability for the operator to designate any day of the year as an exception schedule. This exception schedule shall override the standard schedule for that day. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed it will be discarded and replaced by the standard schedule for that day of the week.
 - .3 Holiday Schedules:
Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.
 - .4 Optimal Start:

The scheduling application outlined above shall support an optimal start algorithm. This shall calculate the thermal characteristics of a zone and start the equipment prior to occupancy to achieve the desired space temperature at the specified occupancy time. The algorithm shall calculate separate sets of heating and cooling rates for zones that have been unoccupied for less than and greater than 24 hours. Provide the ability to modify the start algorithm based on outdoor air temperature. Provide an early start limit in minutes to prevent the system from starting before an operator determined time limit.

- .2 Trend Log Application
 - .1 Trend log data shall be sampled and stored on the System Controller panel and shall be capable of being archived to a BACnet Workstation for longer term storage.
 - .2 Trend logs shall include interval, start-time, and stop-time.
 - .3 Trend log intervals shall be configurable as frequently as 1 minute and as infrequently as 1 year.
- .3 Trend Logs
 - .1 The system controller shall create trend logs for defined key performance indicators for each controlled HVAC device and HVAC application.
 - .2 The trend logs shall monitor these parameters for a minimum of 7 days at 15 minute intervals. The automatic trend logs shall be user adjustable.
- .4 Alarm/Event Log
 - .1 Any object in the system shall be configurable to generate an alarm when transitioning in and out of a normal or fault state.
 - .2 Any object in the system shall allow the alarm limits, warning limits, states, and reactions to be configured for each object in the system.
 - .3 An alarm/event shall be capable of triggering any of the following actions:
 - .1 Route the alarm/event to one or more alarm log
 - .2 The alarm message shall include the name of the alarm location, the device that generated the alarm, and the alarm message itself.
 - .3 Route an e-mail message to an operator(s)
 - .4 Log a data point(s) for a period of time
 - .5 Run a custom control program
- .5 Point Control. User shall have the option to set the update interval, minimum on/off time, event notification, custom programming on change of events.

- .6 Timed Override. A standard application shall be utilized to enable/disable temperature control when a user selects on/cancel at the zone sensor, building operator interface, or the local operator display. The amount of time that the override takes precedence will be selectable from the building operator interface.
- .7 Anti-Short Cycling. All binary output points shall be protected from short cycling

2.8 BUILDING CONTROLLERS

- .1 General: Provide an adequate number of Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), Smart Actuators (SA), and Smart Sensors (SS) as required to achieve performance specified in Section 23 09 23 Article 1.9 (System Performance). Every device in the system which executes control logic and directly controls HVAC equipment must conform to a standard BACnet Device profile as specified in ANSI/ASHRAE 135, BACnet Annex L. Unless otherwise specified, hardwired actuators and sensors may be used in lieu of BACnet Smart Actuators and Smart Sensors.
- .2 BACnet:
 - .1 Building Controllers (BCs). Each BC shall conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L, and shall be listed as a certified B-BC in the BACnet Testing Laboratories (BTL) Product Listing.
 - .2 Advanced Application Controllers (AACs). Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.
 - .3 Application Specific Controllers (ASCs). Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.
 - .4 Smart Sensors (SSs). Each SS shall conform to BACnet Smart Sensor (B-SS) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-SS in the BACnet Testing Laboratories (BTL) Product Listing.
 - .5 BACnet Communication.
 - .1 Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.
 - .2 BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.
 - .3 Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using the

ARCNET or MS/TP Data Link/Physical layer protocol.

- .4 Each ASC shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
 - .5 Each SA shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
 - .6 Each SS shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using ARCNET or MS/TP Data Link/Physical layer protocol.
- .3 Communication
- .1 Service Port. Each controller shall provide a service communication port for connection to a Portable Operator's Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.
 - .2 Signal Management. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.
 - .3 Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.
 - .4 Stand-Alone Operation. Each piece of equipment specified in Section 23 09 93 shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network such as outdoor air conditions, supply air or water temperature coming from source equipment, etc.
- .4 Environment. Controller hardware shall be suitable for anticipated ambient conditions.
- .1 Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -29°C to 60°C (-20°F to 140°F).
 - .2 Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).
- .5 Real-Time Clock. Controllers that perform scheduling shall have a real-time clock.
- .6 Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to a field-removable modular terminal strip or to a termination card connected by a ribbon cable. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.
- .7 Memory

- .1 Controller memory shall support operating system, database, and programming requirements.
- .2 Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.
- .3 Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.
- .8 Immunity to Power and Noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. 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).
- .9 Transformer. ASC power supply shall be fused or current limiting and shall be rated at a minimum of 125% of ASC power consumption.

2.9 POWER SUPPLIES AND LINE FILTERING

- .1 Power Supplies. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in 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 150% current overload for at least three seconds without trip-out or failure.
 - .1 Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
 - .2 Line voltage units shall be UL recognized and CSA listed.
- .2 Power Line Filtering.
 - .1 Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:
 - .1 Dielectric strength of 1000 V 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 greater at 40–100 Hz

2.10 INPUT AND OUTPUT INTERFACE

- .1 General. Hard-wire input and output points to BCs, AACs, ASCs, or SAs.
- .2 Protection. All input points and output points shall be protected such that shorting

of the point to itself, to another point, or to ground shall cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no controller damage.

- .3 Binary Inputs. Binary inputs shall allow the monitoring of ON/OFF signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.
- .4 Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to binary input requirements and shall also accumulate up to 10 pulses per second.
- .5 Analog Inputs. Analog inputs shall allow the monitoring of low-voltage (0–10 Vdc), current (4–20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.
- .6 Binary Outputs. Binary outputs shall provide for ON/OFF operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on Building Controllers shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.
- .7 Analog Outputs. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0–10 Vdc or a 4–20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.
- .8 Universal Inputs and Outputs. Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.
- .9 System Object Capacity. The system size shall be expandable to at least twice the number of input/ output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

2.11 AUXILLARY CONTROL DEVICES

- .1 Motorized dampers, unless otherwise specified elsewhere, shall be as follows:
 - .1 Damper frames shall be 16 gauge galvanized sheet metal or 1/8" extruded aluminum with reinforced corner bracing.
 - .2 Damper blades shall not exceed 8" in width or 48" in length. Blades are to be suitable for medium velocity performance (2,000 fpm). Blades shall be not less than 16 gauge.
 - .3 Damper shaft bearings shall be as recommended by manufacturer for

- application.
- .4 All blade edges and top and bottom of the frame shall be provided with compressible seals. Side seals shall be compressible stainless steel. The blade seals shall provide for a maximum leakage rate of 10 CFM per square foot at 2.5" w.c. differential pressure.
 - .5 All leakage testing and pressure ratings will be based on AMCA Publication 500.
 - .6 Individual damper sections shall not be larger than 48" x 60". Provide a minimum of one damper actuator per section.
- .2 Control dampers shall be parallel for 2 position control and opposed blade for modulating control unless detailed on the drawings.
- .3 Electric damper/valve actuators
- .1 The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator
 - .2 Where shown, for power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing.
 - .3 All rotary spring return actuators shall be capable of both clockwise or counter clockwise spring return operation. Linear actuators shall spring return to the retracted position.
 - .4 Proportional actuators shall accept a 0-10 VDC or 0-20 ma control signal and provide a 2-10 VDC or 4-20 ma operating range.
 - .5 All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.
 - .6 Actuators shall be provided with a conduit fitting and a minimum 1m electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
 - .7 Actuators shall be Underwriters Laboratories Standard 873 listed.
 - .8 Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque.
- .4 Control Valves
- .1 Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:
 - .1 Water Valves:
 - .1 Two-way: 150% of total system (pump) head.
 - .2 Three-way: Shall be installed in mixing configuration, 2 in 1 out. In the mixing configuration, actuator shall be rated for 100% of total system (pump) head

- .3 Steam Valves: 150% of operating (inlet) pressure.
 - .2 Water Valves:
 - .1 Body and trim style and materials shall be in accordance with manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.
 - .2 Sizing Criteria:
 - .1 Two-position service: Line size.
 - .2 Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply and return mains, or 34.5 kPa (5 psi), whichever is greater. Valve shall not be less than 1 line size smaller than design piping size.
 - .3 Three-way modulating service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), 34.5 kPa (5 psi) maximum. Valve shall not be less than 1 line size smaller than design piping size.
 - .4 Valves DN 15 (1/2 in.) through DN 50 (2 in.) shall be bronze body or cast brass ANSI Class 250, spring-loaded, PTFE packing, quick opening for two-position service. Two-way valves to have replaceable composition disc or stainless steel ball.
 - .5 Valves DN 65 (2 1/2 in.) and larger shall be cast iron ANSI Class 125 with guided plug and PTFE packing.
 - .3 Water valves shall fail in last position unless used for equipment protection application. Equipment protection shall fail in normally open or closed, as scheduled on plans, or as follows:
 - .1 Heating coils in air handlers - normally open
 - .2 Water zone valves – normally open
 - .3 Chilled water valves – normally closed
 - .4 Other applications—as scheduled or as required by sequences of operation
 - .4 Zone valves shall be sized to meet the control application and they shall maintain their last position in the event of a power failure.
 - .5 Compact Power and Energy Meter With BACnet Communication
 - .1 The power meter shall be fully electronic with multi-line backlit LCD display showing measured parameters as well as alarm functions and pulse output.
 - .2 The power meter shall perform the following measurements:
 - .1 Accumulated Real Energy (kWh) for each phase and total of all

- phases
- .2 Accumulated Reactive Energy (kVARh) and Apparent Energy (kVAh) totals for all phases
 - .3 Net Present Demand for Real (kW), Reactive (kVAR) and Apparent (kVA) Power over a user-specified interval (block or sliding window)
 - .4 Maximum (Peak) Real (kW), Reactive (kVAR) and Apparent (kVA) Demand Intervals
 - .5 Instantaneous Real (kW), Reactive (kVAR) and Apparent Power (kVA), by phase and in total
 - .6 Current (amps) for each phase and average of all phases
 - .7 Phase-to-phase voltage for each phase and average of all phase pairs
 - .8 Phase-to-neutral voltage for each phase pair and average of all phases
 - .9 Power factor for each phase and average of all phases
 - .10 AC frequency
- .3 The power meter shall communicate using the BACnet MS/TP protocol at speeds from 9600 to 115,200 baud (no parity). The meter shall provide a BACnet Device object, a set of writable Analog Value objects for remote configuration, a set of Analog Input objects to provide access to scaled 32-bit measurement values and their unit types, and a set of Binary Input objects for indicating individual alarm conditions.
 - .4 The meter shall be UL/CUL listed to the latest applicable safety standards.
 - .5 Power meter models must be available to directly accept voltage input over the range of 90 to 600 VAC (50 or 60Hz).
 - .6 The power meter shall accept either 0 to 0.333VAC or 0 to 1VAC input from up to three current transducers to 32000 amps.
 - .7 The measured energy consumption shall be retained in non-volatile memory for the life of the product warranty.
 - .8 The power meter shall have demand measurement programmable for up to 6 sub-intervals of 10 seconds to 546 minutes duration.
 - .9 Meter shall be optionally available in an outdoor NEMA 4X enclosure.
 - .10 The power meter shall operate from -30C to +70C.
 - .11 The power meter shall have dimensions not exceeding 4.2" x 3.6" x 2.3".
 - .12 The power meter shall be Schneider PM5560 or equivalent.
 - .13 The power meter shall meet both ANSI C12.20 .5% and IEC 62053-22 Class .5S real power and energy accuracy specifications.
 - .14 The power meter shall meet IEC 62053-22 Class 2 reactive power and

energy accuracy specifications.

- .15 The power meter shall be configurable for operation on Single Phase (AN or AB), Split Phase (ABN), Delta (ABC), and Wye (ABCN) systems.
 - .16 The power meter shall have automatic phase reversal compensation such that it is insensitive to the CT's load orientation.
 - .17 The power meter shall have separate control power inputs such that it may be powered from a different service than it measures.
 - .18 The power meter shall have Phase Loss Alarm contacts with a user configurable phase loss threshold.
 - .19 The power meter shall have a user-configurable Pulse Contact input to support measurement of other related energy (Gas, Water, Steam, etc.) via BACnet using a simple pulse-output transducer.
 - .20 The power meter shall be configurable for use with Potential Transformers to 32000 volts.
 - .21 The power meter shall support warnings for low power factor (phase current or voltage miss-wired), current over range, voltage over range, and frequency out of range.
 - .22 The product shall have a 5-year warranty.
- .6 Binary Temperature Devices
- .1 Low-voltage space thermostat shall be 24 V, bimetal-operated, mercury-switch type, with either adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C to 30°C (55°F to 85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
 - .2 Line-voltage space thermostat shall be bimetal-actuated, open contact type, or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listed for electrical rating, concealed setpoint adjustment, 13°C to 30°C (55°F to 85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
 - .3 Low-limit thermostats. Low-limit airstream thermostats shall be UL listed, vapor pressure type, with an element of 6 m (20 ft) minimum length. Element shall respond to the lowest temperature sensed by any 30 cm (1 ft) section. The low-limit thermostat shall be manual reset only.
- .7 Wired Temperature Sensors
- .1 Temperature sensors shall be RTD or thermistor.
 - .2 Duct sensors shall be single point or averaging as shown. Averaging sensors shall be a minimum of 1.5 m (5 ft) in length per 1 m² (10 ft²) of duct cross section.
 - .3 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.
 - .4 Space sensors shall be equipped with setpoint adjustment, override

- switch, display, and/or communication port as shown on plans.
- .5 Provide matched temperature sensors for differential temperature measurement.
- .8 Humidity Sensors.
- .1 Duct and room sensors shall have a sensing range of 20%–80%.
- .2 Duct sensors shall have a sampling chamber.
- .3 Outdoor air humidity sensors shall have a sensing range of 20%–95% RH and shall be suitable for ambient conditions of -40°C–75°C (-40°F–170°F).
- .4 Humidity sensors shall not drift more than 1% of full scale annually.
- .9 Flow Switches
- .1 Flow-proving switches shall be paddle (water service only) or differential pressure type (air or water service) as shown. Switches shall be UL listed, SPDT snap-acting, and pilot duty rated (125 VA minimum).
- .1 Paddle switches shall have adjustable sensitivity and NEMA 1 enclosure unless otherwise specified.
- .2 Differential pressure switches shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.
- .10 Static Pressure Sensors
- .1 Sensor shall have linear output signal. Zero and span shall be field-adjustable.
- .2 Sensor sensing elements shall withstand continuous operating conditions plus or minus 50% greater than calibrated span without damage.
- .3 Water pressure sensor shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Sensor shall be complete with 4-20 ma output, required mounting brackets, and block and bleed valves. Mount in location accessible for service.
- .4 Water differential pressure sensor shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over-range limit (DP) and maximum static pressure shall be 3,000 psi. Transmitter shall be complete with 4-20 ma output, required mounting brackets, and five-valve manifold. Mount in a location accessible for service.
- .5 Low-voltage space thermostat shall be 24 V, bimetal-operated, mercury-switch type, with either adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C to 30°C (55°F to 85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
- .6 Line-voltage space thermostat shall be bimetal-actuated, open contact type, or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listed for electrical rating, concealed setpoint adjustment, 13°C to 30°C (55°F to 85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.

- .11 Low Limit Thermostats
 - .1 Safety low limit thermostats shall be vapor pressure type with an element 6m [20 ft] minimum length. Element shall respond to the lowest temperature sensed by any one foot section.
 - .2 Low limit shall be manual reset only.
- .12 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 solidstate plug-in type with adjustable time delay. Delay shall be adjustable $\pm 200\%$ (minimum) from setpoint 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.
- .13 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.
- .14 Pressure Transducers.
 - .1 Transducers shall have linear output signal and field-adjustable zero and span.
 - .2 Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage.
 - .3 Water pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Transducer shall have 4–20 mA output, suitable mounting provisions, and block and bleed valves.
 - .4 Water differential pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Over-range limit (differential pressure) and maximum static pressure shall be 2000 kPa (300psi.) Transducer shall have 4–20 mA output, suitable mounting provisions, and 5-valve manifold.
- .15 Differential Pressure Type Switches (Air or Water Service)
 - .1 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 shown.
- .16 Local Control Panels
 - .1 All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable subpanels. A single key shall be common to all field panels and subpanels.
 - .2 Interconnections between internal and face-mounted devices shall be prewired with color-coded stranded conductors neatly installed in plastic

troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600 volt service, individually identified per control/ interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.

- .3 Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.

2.12 WIRING AND RACEWAYS

- .1 General. Provide copper wiring, plenum cable, and raceways as specified in applicable sections of Division 26.
- .2 Insulated wire shall use copper conductors and shall be UL listed for 90°C (200°F) minimum service.

2.13 FIBER OPTIC CABLE SYSTEM

- .1 Optical Cable. Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. Sheath shall be UL listed OFNP in accordance with NEC Article 770. Optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125mm.
- .2 Connectors. Field terminate optical fibers with ST type connectors. Connectors shall have ceramic ferrules and metal bayonet latching bodies.

3 EXECUTION

3.1 EXAMINATION

- .1 The Contract Documents shall be thoroughly examined for coordination of control devices, their installation, wiring, and commissioning. Coordinate and review mechanical equipment specifications, locations, and identify any discrepancies, conflicts, or omissions that shall be reported to the Architect/Engineer for resolution before rough-in work is started.
- .2 The BAS manufacturer shall inspect the jobsite in order to verify that control equipment can be installed as required, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.

3.2 PROTECTION

- .1 The BAS installation contractor shall protect all work and material from damage by their work or personnel, and shall be liable for all damage thus caused.
- .2 The BAS manufacturer shall be responsible for their work and equipment until final inspection, testing, and acceptance. The BAS installing contractor shall protect their work against theft or damage, and shall carefully store material and equipment received on site 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.

3.3 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 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 duration of 4 hours.
 - .3 In addition, the contractor shall provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.
 - .4 The tools used during the test and balance process shall be returned to the contractor at the completion of the testing and balancing.

.3 Life Safety

- .1 Duct smoke detectors required for air handler shutdown are provided under Division 28. Interlock smoke detectors to air handlers for shutdown as specified in Section 23 09 93 (Sequences of Operation).
 - .2 Smoke dampers and actuators required for duct smoke isolation are provided under Division 23. Interlock smoke dampers to air handlers as specified in Section 23 09 93 (Sequences of Operation).
 - .3 Fire and smoke dampers and actuators required for fire-rated walls are provided under Division 23. Fire and smoke damper control is provided under Division 28.
- .4 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 the "Communication" section of this specification
 - .2 Each supplier of a controls product is responsible for the configuration, programming, start-up, 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.
- .5 Parts supplied by controls contractor must be turned over to the mechanical contractor for installation. Parts include but are not limited to control valves, dampers, inline devices, thermal devices, thermal wells.

3.4 GENERAL WORKMANSHIP

- .1 Install equipment, piping, wiring/conduit, parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.
- .2 Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
- .3 Install all equipment in readily accessible locations as defined by Canadian Electric Code (CEC). Control panels shall be attached to structural walls or properly supported in a free-standing configuration, unless mounted in equipment enclosure specifically designed for that purpose. Panels shall be mounted to allow for unobstructed access for service.
- .4 Verify integrity of all control wiring to ensure continuity and freedom from shorts and grounds prior to commencing the startup and commissioning procedures.
- .5 All control device installation and wiring shall comply with Contract Documents, acceptable industry specifications, and industry standards for performance, reliability, and compatibility. Installation and wiring shall be executed in strict adherence to local codes and standard practices referenced in Contract

Documents.

3.5 FIELD QUALITY CONTROL

- .1 All work, materials, and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Contract Documents.
- .2 BAS manufacturer shall continually monitor the field installation for building code compliance and quality of workmanship. All visible piping and or wiring runs shall be installed parallel to building lines and properly supported.

3.6 WIRING

- .1 All control and interlock wiring shall comply with national and local electrical codes, and Division 26 of this specification, Where the requirements of this section differ from Division 26, the requirements of this section shall take precedence.
- .2 All NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway according to NEC and Division 26 requirements.
- .3 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.
- .4 Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL listed for the intended application.
- .5 All wiring in mechanical, electrical, or service rooms – or where subject to mechanical damage – shall be installed in raceway at levels below 3 m (10ft).
- .6 Do not install Class 2 wiring in raceways containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).
- .7 Do not install wiring in raceway containing tubing.
- .8 Where Class 2 wiring is run exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 3 m (10 ft) intervals.
- .9 Where plenum 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 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.
- .11 All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
- .12 Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers.
- .13 All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

- .14 Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.
- .15 Size of raceway and size and type of wire type shall be the responsibility of the contractor in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.
- .16 Include one pull string in each raceway 2.5 cm (1 in.) or larger.
- .17 Use color-coded conductors throughout with conductors of different colors. Not more than three (3) conductors shall be utilized with one solder wire nut. Four or more conductors shall utilize terminal blocks.
- .18 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.
- .19 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).
- .20 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.
- .21 Adhere to this specification's Division 26 requirements where raceway crosses building expansion joints.
- .22 Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of vertical raceways.
- .23 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.
- .24 Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 1 m (3 ft) in length and shall be supported at each end. Flexible metal raceway less than ½ in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.
- .25 Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

3.7 COMMUNICATION WIRING

- .1 The contractor shall adhere to the items listed in the "Wiring" article in Part 3 of the specification.
- .2 All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling
- .3 Do not install communication wiring in raceways and enclosures containing Class 1 or other Class 2 wiring.

- .4 Maximum pulling, tension, and bend radius for the cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.
- .5 Contractor shall verify the integrity of the entire network following cable installation. Use appropriate test measures for each particular cable.
- .6 When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lightning arrestor shall be installed according to manufacturer's instructions.
- .7 All runs of communication wiring shall be unspliced length when that length is commercially available.
- .8 All communication wiring shall be labeled to indicate origination and destination data.
- .9 Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."
- .10 BACnet MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standard 135. This includes but is not limited to:
 - .1 The network shall use shielded, twisted-pair cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 100 pF per meter (30 pF per foot.)
 - .2 The maximum length of an MS/TP segment is 1200 meters (4000 ft) with AWG 18 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.
 - .3 The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated by the use of repeaters.
 - .4 An MS/TP EIA-485 network shall have no T connections.

3.8 FIBER OPTIC CABLE

- .1 Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post-installation residual cable tension shall be within cable manufacturer's specifications.
- .2 All cabling and associated components shall be installed in accordance with manufacturers' instructions. Minimum cable and unjacketed fiber bend radii, as specified by cable manufacturer, shall be maintained.

3.9 INSTALLATION OF SENSORS

- .1 Sensors required for mechanical equipment operation shall be factory installed and wired as specified in mechanical equipment specifications. BAS manufacturer shall be responsible for coordinating these control devices and ensuring the sequence of operations will be met. Installation and wiring shall be in accordance with the BAS manufacturer's recommendations.
- .2 Sensors that require field mounting shall meet the BAS manufacturer's recommendations and be coordinated with the mechanical equipment they will be associated.

- .3 Mount sensors rigidly and adequately for the environment the sensor will operate.
- .4 Room temperature sensors shall be installed on concealed junction boxes properly supported by the block wall framing. For installation in dry wall ceilings, the low voltage sensor wiring can be installed exposed and must meet applicable National and Local Electrical Codes.
- .5 All wires attached to wall mounted sensors shall be sealed off to prevent air from transmitting in the associated conduit and affecting the room sensor readings.
- .6 Install duct static pressure tap with tube end facing directly down-stream of air flow.
- .7 Install space static pressure sensor with static sensing probe applicable for space installation where applicable.
- .8 Sensors used in mixing plenums, and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.
- .9 All pipe mounted temperature sensors shall be installed in matched thermowells. Install all liquid temperature sensors with heat conducting fluid in thermal wells for adequate thermal conductance.
- .10 Wiring for space sensors shall be concealed in building drywall. EMT conduit is acceptable within mechanical equipment and service rooms.
- .11 Install outdoor air temperature sensors on north wall complete with sun shield at manufacturer's recommended location and coordinated with Engineer.
- .12 Smoke detectors, freezestats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.
- .13 Install humidity sensors for duct mounted humidifiers at least 3 m (10 ft) downstream of the humidifier. Do not install filters between the humidifier and the sensor.

3.10 FLOW SWITCH INSTALLATION

- .1 Use correct paddle for pipe diameter.
- .2 Adjust flow switch according to manufacturer's instructions.

3.11 ACTUATORS

- .1 General: Mount and link control damper actuators according to manufacturer's instructions.
 - .1 To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
 - .2 Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed

positions.

- .3 Provide all mounting hardware and linkages for actuator installation.
- .2 Electric/Electronic
 - .1 Dampers: Actuators shall be direct mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° travel available for tightening the damper seal. 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.

3.12 GENERAL RE: INSTALLATION OF CONTROLS

- .1 Provide complete systems of control and instrumentation to control and supervise building equipment and systems in accordance with this Section of the Specification and the drawings.
- .2 The control systems are to generally be as indicated on drawing control diagrams and are to have all the elements therein indicated or implied.
- .3 The control diagrams show only the principal components controlling the equipment and systems. Supplement each control system with all relays, transformers, sensors, etc., required to enable each system to perform as specified and to permit proper operation and supervision.

3.13 SUPPLY OF CONTROL AIR DAMPERS AND OPERATORS

- .1 Unless otherwise specified, supply all required control dampers. Hand the dampers to the sheet metal trade at the site in the location where they are required for installation as part of the sheet metal work. Ensure that each damper is correctly located and mounted.
- .2 Provide linkage and operators for the dampers. Wherever possible locate damper operators so that they are accessible from outside duct, plenum, and equipment casings. Bracket mount operators on ducts or plenums clear of insulation where applicable.
- .3 Where sequence operation is indicated, or where multiple operators drive a series of dampers, provide pilot positioners to couple their action.
- .4 Ensure that dampers located in ductwork other than galvanized steel are constructed of type 316 stainless steel.

3.14 SUPPLY OF AUTOMATIC CONTROL VALVES AND OPERATORS

- .1 Unless otherwise specified, supply all required automatic control valves. Hand the valves to the appropriate piping trades at the site in the locations they are required for installation as part of the piping work. Ensure that each valve is properly sized, located and installed.
- .2 Provide an operator for each valve with on/off control for 2 position, 0-10vdc or 4-

20ma for modulating for control. Spring return actuators are required on as defined on the drawings for fail safe operation, or as needed to protect the equipment, such as Normal Closed position for outside air dampers.

3.15 INSTALLATION OF CONTROL SYSTEM COMPONENTS

- .1 Provide all required control system components and related hardware. Refer to drawing control diagrams and sequences.
- .2 Where components are pipe, duct, or equipment mounted supply the components at the proper time, coordinate installation with the appropriate trade, and ensure that the components are properly located and mounted.

3.16 WARNING LABELS

- .1 Permanent warning labels shall be affixed to all equipment that can be automatically started by the BAS system.
 - .1 Labels shall use white lettering (12-point type or larger) on a red background.
 - .2 Warning labels shall read as follows.

C A U T I O N

This equipment is operating under automatic control and may start or stop at any time without warning. 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.**

C A U T I O N

This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

3.17 IDENTIFICATION OF HARDWARE AND WIRING

- .1 All field wiring and cabling, including that within factory mounted, and wired control panels and devices for mechanical equipment, shall be labeled at each end within 2" of termination with a cable identifier and other descriptive information for troubleshooting, maintenance, and service purposes. BAS manufacturer to coordinate this labeling requirement with mechanical equipment manufacturer as it relates to controls.
- .2 Permanently label or code each point of field terminal strips to show the instrument or item served and correlate them to the BAS design drawings.

- .3 Identify control panels with minimum 1-cm letters on laminated plastic nameplates.
- .4 Identifiers shall match record documents. All plug-in components shall be labeled such that removal of the component does not remove the label.

3.18 CONTROLLERS

- .1 Provide a separate DDC Controller for individual HVAC mechanical equipment. DDC Controllers shall be factory mounted, installed, and wired by mechanical equipment manufacturer as specified. BAS manufacturer shall furnish and coordinate DDC controllers and control devices and ensure that installation and wiring adhere to BAS manufacturer's design recommendations. For those mechanical equipment units that do not have factory installed controls specified, the BAS manufacturer shall field mount controls and coordinate all installation and termination information to ensure the specified sequence of operations are met.
- .2 Provide 15% spare of each I/O type. Minimum of one point for each, at each DDC controller location.

3.19 PROGRAMMING

- .1 BAS Operator's Interface
 - .1 Provide color graphics for each piece of mechanical equipment depicting sufficient I/O to monitor and troubleshoot operation. Additionally, provide individual floor plans of the building allowing an operator to quickly view the overall floor plan area for any out of tolerance conditions that may need addressing. Operator color graphics shall include Chiller Plant, Cooling Tower System, Boiler Plant, Air Handling Units, Rooftop Units, VAV Terminal Boxes, Fan Coil Units, Unit Ventilators, Heat Exchangers, Exhaust Fans, etc. These standard graphics shall depict all points dynamically as specified in the points list and/or indicated in sequence of operation.
 - .2 As built drawings shall be linked to the graphics or accessible through the operator interface.
 - .3 BAS contractor shall provide a dedicated BAS graphic for all air systems on the project. A sample of all unique graphics shall be included in the engineering submittal. If the advanced sequences are provided, this graphic could quickly allow the engineer to verify;
 - .1 Static Pressure Reset
 - .2 Critical Valve Reset
 - .3 SA Temperature Reset
 - .4 The BAS manufacturer shall provide all the labor necessary to install, initialize, start-up, and trouble-shoot all operator interface software and their functions as described in this section. This includes any operating system software, the operator interface data base, and any third party software installation and integration required for successful operation of

the operator interface.

3.20 CONTROL SYSTEM CHECKOUT AND TESTING

- .1 Start-up testing. All testing in this section shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the owner's representative is notified of the system demonstration.
- .2 The contractor shall furnish all labor and test apparatus required to calibrate and prepare for service all of the instruments, controls, and accessory equipment furnished under this specification.
- .3 Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
- .4 Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturer's recommendations.
- .5 Verify all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starter, etc.) operate properly and normal positions are correct.
- .6 Verify 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.
- .7 Verify 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 optimal start/stop routines.

3.21 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

- .1 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 engineer will be present to observe and review these tests. The engineer 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 Demonstrate complete operation of operator interface.
- .9 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/engineer. 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.
- .10 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.

.2 Acceptance:

- .1 All tests described in this specification shall have been performed to the satisfaction of both the engineer 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 engineer. Such tests shall then be performed as part of the warranty.
- .2 The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in Part 1, "Submittals."

3.22 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.

3.23 SYSTEM CLOSEOUT REPORTS

- .1 The following standard reports shall be provided upon substantial completion:
 - .1 All Points in Alarm Report: Provide an on demand report showing all current alarms.
 - .2 All Points in Override Report: Provide an on demand report showing all overrides in effect.
 - .3 Commissioning Report: Provide a one-time report that lists all equipment with the unit configuration and present operation.
 - .4 Points report: Provide a report that lists the current value of all points

3.24 CONTROL VALVE INSTALLATION

- .1 Valve submittals shall be coordinated for type, quantity, size, and piping configuration to ensure compatibility with pipe design.
- .2 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.
- .3 Valves shall be installed in accordance with the manufacturer's recommendations.
- .4 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.

- .5 Isolation valves shall be installed so that the control valve body may be serviced without draining the supply/return side piping system. Unions shall be installed at all connections to screw-type control valves.
- .6 Provide tags for all control valves indicating service and number. Tags shall be brass, 1.5 inch in diameter, with ¼ inch high letters. Securely fasten with chain and hook. Match identification numbers as shown on approved controls shop drawings.

3.25 CONTROL DAMPER INSTALLATION

- .1 Damper submittals 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 ¼ in. 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 in.) 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.

3.26 DUCT SMOKE DETECTION

- .1 Submit data for coordination of duct smoke detector interface to HVAC systems as required in Part 1, "Submittals."
- .2 This Contractor shall provide a dry-contact alarm output in the same room as the HVAC equipment to be controlled.

3.27 FACILITY MONITORING SYSTEM (FMS) and LABORATORY VENTILATION CONTROL SYSTEM (LVCS) INTERFACES

- .1 The building will be equipped with a Facility Monitoring System (FMS) and a

Laboratory Ventilation Control System (LVCS) as specified in other sections of these specifications. The purpose of the FMS system is to analyze key elements of the indoor environment and to provide direction to the mechanical systems via the BAS. Directions to be achieved shall be accomplished by monitoring and analysis of airborne parameters such as particulates, volatile organic compounds (VOCs), moisture content, gases such as carbon monoxide and carbon dioxide (CO, CO₂), and others as indicated in the FMS specification. As a result of this analysis the FMS will provide the BAS with changes in operational parameters, most significantly airflow rates. The system will also provide analysis of how the indoor environment responds as a result of the mechanical system modes of operation, and provide performance reports and other data to building management.

- .2 BAS contractor's responsibility: The BAS contractor shall be required to implement an interface between the BAS and the FMS which shall communicate with the BAS via BacNet system signal or an analog signal from each router location to each air flow controller. The BAS contractor shall be responsible for:
 - .1 Entering the FMS in the BAS so it is a recognized component in the BAS, by providing a unique BACnet Device Object Instance Number, and fixed IP Address.
 - .2 Entering the necessary data points in the BAS data base. These data points shall be read from the FMS and serve as data values to be used as input points in the building control systems for values such as minimum outside air levels, overall ventilation rates, humidity levels, and others as indicated in the specification or on the drawings.
 - .3 Transmit values to the FMS that are indicators of the ventilation system and other components in the building.
 - .4 Implementing the necessary control sequences to respond to the directions from the FMS. These directions will be integrated from a priority standpoint so that other control actions such as smoke control are not impeded.
 - .5 Provide qualified on-site staff during start up of the FMS to insure that communication is functional, that data values are received from the FMS, that control BAS sequences as a result of this data are implemented properly and effectively, and that necessary data is transmitted to the FMS.
 - .6 In a Lab, Vivarium or other Critical Environment the BAS shall at a minimum provide the flow feedback of the supply flows and room's general exhaust that are being commanded as a result of the FMS information. This flow feedback shall be written to the Aircuity IMS via BACnet WRITE PROPERTY Service (DS-WP-A), unless otherwise stated.
 - .7 The BAS shall provide additional points as prescribed by the engineer. These points shall be written to the Aircuity IMS via BACnet WRITE PROPERTY Service (DS_WP-A), unless otherwise stated:
 - .1 The following points are required to perform analytic functions:

- .1 To calculate Air Change Rate
- .2 Total space supply flow feedback
- .3 Total space exhaust flow feedback
- .4 A means of determining effective occupancy state of the space:
 - .1 A BACnet variable to reflect effective occupied state
 - .2 A schedule that reflects the typical occupancy schedule
- .2 To perform fume hood analytics:
 - .1 Fume hood flow feedback
 - .2 Representation of fume hood sash opening percentage
 - .3 Representation of fume hood occupancy state

3.28 CLEANING

- .1 Provide The BAS manufacturer's installing contractor(s) shall clean up all debris resulting from their installation activities on a daily basis. The installation contractors shall remove all cartons, containers, crates, etc. under his control as soon as their contents have been removed. Waste shall be collected and placed in a location designated by the Owner, Construction Manager, General Contractor, and/or Mechanical Contractor.
- .2 At the completion of work in any area, the installation contractor shall clean all of their work, equipment, etc., making it free from dust, dirt and debris.
- .3 At the completion of work, all equipment furnished under this Section shall be checked for paint damage. Any factory finished paint that has been damaged shall be repaired to match the adjacent areas. Any metal cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.29 TRAINING

- .1 Provide minimum of (4) training sessions, and (4) hours for each session, throughout the contract period. The training will be provided for personnel designated by the Owner.
- .2 These objectives will be divided into logical groupings; participants may attend one or more of these, depending on level of knowledge required:
 - .1 Day-to-day BAS Operators
 - .2 BAS Troubleshooting & Maintenance
- .3 The instructor(s) shall be factory-trained and experienced in teaching this technical material.
- .4 Training will begin when the operating and maintenance manuals have been delivered to the Owner or reviewed by the Engineer's Representative.

- .5 Building Walk through and location of Control devices
- .6 Operating procedures
- .7 Maintenance procedures
- .8 Trouble-shooting procedures
- .9 Spare parts required
- .10 Project Record Documents: Upon completion of installation, submit three (3) copies of record (as-built) documents in addition to an electronic copy. The documents shall be submitted for approval prior to final completion and include:
 - .1 Project Record Drawings - These shall be as-built versions of the submittal shop drawings. One set of electronic media .pdf drawing files shall be provided.
 - .2 Testing and Commissioning Reports and Checklists signed off by trained factory (equipment manufacturers) and field (BAS) commissioning personnel.

3.30 OPERATING AND MAINTENANCE (O & M) MANUALS

- .1 These shall be as-built versions of the submittal product data. In addition to the information required for the submittals, Operating & Maintenance manual shall include:
 - .1 24-hour/7-day per week emergency service telephone numbers of Contractor service department along with names, address of service personnel responsible for supporting the ongoing warranty and services of the control system.
 - .2 Preventative Maintenance and calibration procedures; hardware troubleshooting; and hardware repair and/or replacement procedures.
 - .3 One set of electronic media containing files of all operator color graphic screens for the project.
 - .4 Local Supply store should have a minimum 3 unit controllers, System controllers, and room sensors available for same day purchase.
 - .5 Documentation, installation, and maintenance information for all third party hardware/software products provided including personal computers, printers, hubs, sensors, valves, etc.
 - .6 Original issue media for all software provided, including operating systems, programming language, operator workstation software, and graphics software.
 - .7 Licenses, Guarantee, and Warranty documents for all equipment and systems.
 - .8 Recommended preventive maintenance procedures for all system components including a schedule of tasks (inspection, cleaning, calibration, etc.) and task descriptions.

END OF SECTION

1. GENERAL

1.1 SUMMARY

- .1 This section describes the Master Systems Integrator's (MSI) scope for the Integration Platform for the project.
- .2 Coordinates the responsibilities of the Mechanical and Electrical and Control trade contractors pertaining to control products or systems, furnished by each trade, that will be integrated by this Division.
- .3 All labor, material, equipment, and software not specifically referred to herein or on the plans, that is required to meet the functional intent of this specification, shall be provided without additional cost to the owner.
- .4 It is the owner's goal to implement an Open System that will allow products from various suppliers to be integrated into a unified system to provide flexibility for expansion, maintenance, and service of the system. The owner shall be the named license holder of all software associated with any and all incremental work on the project(s).

1.2 MASTER SYSTEMS INTEGRATOR (MSI)

- .1 The Master Systems Integrator (MSI) shall connect the building stakeholders with their building control systems and provide useful, meaningful, and important information and control capabilities. The MSI is responsible for the integration of building control services such as HVAC, Life Safety, Electrical Distribution, Lighting Control, Security, various Cloud Services, IAQ and other controlled assets as shown in the systems architecture. The MSI shall provide a unified database and graphical user interface tools by collaboration with the owners building control needs. Division 23 shall provide certain Niagara based products, controls, and programming services that require extensive coordination with this division. Division 26 shall provide an integrated Lighting Control System that requires extensive coordination with this division.
- .2 MSI Roles & Responsibilities:
 - .1 Install Niagara Web Supervisor server software platform licensed to be capable of handling the entire portfolio in a location defined by the owner. Provide an Unlimited Niagara Supervisor license unless otherwise specified.
 - .2 Co-ordinate with owner on proper use of IT within the Enterprise to include but not limited to Authentication, Security Certificates, SSL, Active Directory and or any owner IT requirements. Jointly develop integrated software plan with the owners' building team and vendors to make sure all systems will communicate properly.
 - .3 Review and meet with building team to ensure the building control system information will be accessible and useful.
 - .4 Develop the software layer responsible for integration, aggregation and communications to the building control systems.

- .5 Standardize software tagging library, templates, and menu hierarchy system, develop strategy for long term template maintenance.
- .6 Create and maintain graphical controls, monitors and dashboards as defined by the functional requirements of the system.
- .7 Configure alarm interface / controls, scheduling, and user management capabilities.
- .8 Commission connected systems for usability and sustainability (all the software tools should be incorporated).
- .9 Document software maintenance strategy and upgrade procedures.
- .10 Configure and set up the Building Operations Center Console. Set up displays and software to manage displays. Add browser connection from console to Niagara Web Supervisor Server Software. PC Hardware and Displays will be provided by the owner. Mount displays, PC, Keyboards etc. in console.
- .3 Qualifications
 - .1 Experience in implementing Niagara framework similar for projects of similar size and scope.
 - .2 Must have a successful history in the design and installation of Niagara Framework
 - .3 Must have 5 years consecutive licensing capabilities with the Niagara Framework.
 - .4 Must have a minimum of 2 employed individuals who meet System Requirements per individual.
 - .5 Firms shall have specialized in and be experienced with the installation of the Niagara Framework for not less than five years from the date of final completion on at least three (3) projects of similar size and complexity. Submittals shall document this experience with references.
- .4 Specific Requirements: per individual
 - .1 Must have 3 years' experience with the firm represented.
 - .2 Proof of Niagara 4 Certification.
 - .3 List and describe a Niagara Enterprise (more than one building) integration project and the programmer's involvement.
 - .4 List and describe a Niagara integration project involving multiple communication protocols or databases.
- .5 List and describe a Niagara integration project involving multiple platforms such as HVAC, Lighting Control, Security, Life Safety, Utilities, and other building control and or monitoring systems.

1.3 APPROVED MASTER SYSTEMS INTEGRATORS

- .1 Vykon (or equivalent OEM) Authorized Master System Integrator

1.4 SCOPE OF WORK

- .1 Provide the following components/sub systems to provide a fully functional platform required for integrating the systems shown on the system architecture/topology on the Contract Documents:
 - .1 Niagara Web Supervisor
 - .2 Niagara Workbench
 - .3 Associated Niagara drivers and applications
 - .4 Niagara based hardware platforms (JACE)
 - .5 Installation, engineering, programming. Commissioning
- .2 The intent of this specification is to provide a system that is consistent with BMS systems throughout the owner's facilities running the Niagara 4 Framework.
- .3 Provide labor, materials, and equipment necessary for a complete and operating Integration Platform, utilizing Direct Digital Controls as shown on the drawings and as described herein. Drawings are diagrammatic only. All controllers furnished in this section shall communicate on a peer-to-peer bus over an open protocol bus (Examples: LonTalk, BACnet, MODBUS). The MSI shall submit a Data Plan that includes database standards, graphics, dashboards, data tagging and program guidelines for the Consultant's review.
- .4 Ensure data collected from disparate Operational Technology (OT) systems shall be placed in a single location (Centralized Database) that can be accessed and used by other integrated systems and software. Manage data in a logical and organized fashion that integrated systems can use.
- .5 All OT points shall include metadata tagging in accordance with the selected ontology of the Owner (Project Haystack, Brick, Custom...) The MSI shall lead at least one tagging workshop (see Section 3, Execution).
- .6 E. System architecture shall fully support a multi-vendor environment and be able to integrate third party systems via existing vendor protocols including, as a minimum, LonTalk, BACnet and MODBUS.
- .7 System architecture shall provide secure Web access using any of the current versions of Microsoft Edge, Mozilla Firefox, or Google Chrome browsers from any designated computer on the owner's LAN.
- .8 All control devices furnished with this Section shall be programmable directly from the Niagara 4 Workbench embedded toolset for this project. The use of configurable or programmable controllers that require additional software tools or tools that require a specific Niagara 4 license brand to operate for post-installation maintenance shall not be acceptable.
- .9 Any control vendor that shall provide additional BMS server software shall be unacceptable. Only systems that utilize the Niagara 4 Framework shall satisfy the requirements of this section.
- .10 The integration platform server shall host all graphic files for the control system. All graphics and navigation schemes for this project shall match those that are on the Niagara 4 Framework server.

- .11 A laptop computer shall be provided by the owner for installation of engineering/programming software (Niagara 4 Workbench) by the MSI.
- .12 Owner shall receive all Administrator level login and passwords for engineering toolset at first training session. The Owner shall have full licensing and full access rights for all network management, operating system server, engineering and programming software required for the ongoing maintenance and operation of the BMS.
- .13 OPEN NIC STATEMENTS - All Niagara 4 software licenses shall have unrestricted interoperability in accordance with the Niagara Compatibility Statement (NiCS) following the Tridium Open NiCS Specification and shall have a value of "All" for "Station Compatibility In", "Station Compatibility Out", "Tool Compatibility In" and "Tool Compatibility Out". Note that this will result in the following entries in the license.dat file:
 - .1 "accept.station.in=*"
 - .2 "accept.station.out=*"
 - .3 "accept.wb.in=*"
 - .4 "accept.wb.out=*"
- .14 In any case, the end user shall maintain the right to instruct the contractor to modify any software license, regardless of supplier, as desired by the end user. The contractor shall not install any "brand-specific" software, applications, or utilities on Niagara Framework-based devices. The use of any proprietary third-party translators, gateways or repeaters is not permitted. All existing controllers must have the latest security patches and firmware upgrades implemented on the devices.
- .15 All hardware and field-level devices installed shall not be limited in their ability to communicate with a specific brand of Niagara Framework JACE. They shall also be constructed in a modular fashion to permit the next generation and support components to be installed, in replacement of or in parallel with existing components.
- .16 All controllers must be able to be programmed within the Niagara Workbench. At the completion of the project, the owner shall be given all existing platform and station login credentials to include super user (admin) usernames, passwords and passphrases. Each device, controller, or other equipment intended for master system integration shall be delivered with all application software required to provide a complete and functional control system in accordance with these specifications.
- .17 All JACE hardware licenses and certificates shall be stored on local MicroSD memory card employing encrypted "safe boot" technology.
- .18 L. All products of the Integration Platform shall be provided with the following agency approvals. Verification that the approvals exist for all submitted products shall be provided on request, with the submittal package. Systems or products not currently offering the following approvals are not acceptable.
 - .1 Federal Communications Commission (FCC), Rules and Regulations, Volume II -July 1986 Part 15 Class A Radio Frequency Devices.

- .2 FCC, Part 15, Subpart B, Class B
- .3 FCC, Part 15, Subpart C
- .4 FCC, Part 15, Subpart J, Class A Computing Devices.
- .5 UL 504 - Industrial Control Equipment.
 - .1 UL 506 - Specialty Transformers.
- .6 UL 910 - Test Method for Fire and Smoke Characteristics of Electrical and Optical-Fiber Cables Used in Air-Handling Spaces.
- .7 UL 916 - Energy Management Systems All.

1.5 SPECIFICATION NOMENCLATURE

- .1 Acronyms used in this specification are as follows:
 - .1 FMCS - Facility Management and Control System
 - .2 NWS - Niagara Web Supervisor
 - .3 BMS - Building Management System
 - .4 OTN - Operational Technology Network
 - .5 TCS - Temperature Control System
 - .6 HVAC - Heating, Ventilating and Air Conditioning.
 - .7 JACE - Java Application Control Engine
 - .8 GUI - Graphical User Interface
 - .9 SPOG - Single Pane of Glass
 - .10 FDD - Fault Detection and Diagnostics
 - .11 DDC - Direct Digital Controls
 - .12 LAN - Local Area Network
 - .13 WAN - Wide Area Network
 - .14 AEL - Average Effectiveness Level
 - .15 AI - Analog Input
 - .16 AIT - Agreement on International Trade
 - .17 AO - Analog Output
 - .18 BACnet - Building Automation and Control Network.
 - .19 BC(s) - Building Controller(s).
 - .20 BECC - Building Environmental Control Centre.
 - .21 CAD - Computer Aided Design.
 - .22 CDL - Control Description Logic.
 - .23 CDS - Control Design Schematic.
 - .24 COSV - Change of State or Value.

- .25 CPU - Central Processing Unit.
- .26 DI - Digital Input.
- .27 DO - Digital Output.
- .28 DP - Differential Pressure.
- .29 ECU - Equipment Control Unit.
- .30 EMCS - Energy Monitoring and Control System.
- .31 HVAC - Heating, Ventilation, Air Conditioning.
- .32 IDE - Interface Device Equipment.
- .33 I/O - Input/Output.
- .34 ISA - Industry Standard Architecture.
- .35 LCU - Local Control Unit.
- .36 MCU - Master Control Unit.
- .37 NC - Normally Closed.
- .38 NO - Normally Open.
- .39 OS - Operating System.
- .40 O&M - Operation and Maintenance.
- .41 OWS - Operator Workstation.
- .42 PC - Personal Computer.
- .43 PCI - Peripheral Control Interface.
- .44 PCMCIA - Personal Computer Micro-Card Interface Adapter.
- .45 PID - Proportional, Integral and Derivative.
- .46 RAM - Random Access Memory.
- .47 SP - Static Pressure.
- .48 ROM - Read Only Memory.
- .49 TCU - Terminal Control Unit.
- .50 USB - Universal Serial Bus.
- .51 UPS - Uninterruptible Power Supply.
- .52 VAV - Variable Air Volume.
- .2 Definitions:
 - .1 Actuator: Control device that opens or closes valve or damper in response to control signal.
 - .2 AI: Analog Input.
 - .3 AO: Analog Output.
 - .1 Analog: Continuously variable state overstated range of values.

- .3 Discrete: Binary or digital state.
 - .1 DI: Discrete Input.
 - .2 DO: Discrete Output.
 - .3 FC: Fail Closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source.
 - .4 FO: Fail open (position of control device or actuator). Device moves to open position on loss of control signal or energy source.
 - .5 IBC: Interoperable BACnet Controller
 - .6 IDC: Interoperable Digital Controller.
 - .7 ILC: Interoperable LON Controller.
 - .8 Modulating: Movement of a control device through an entire range of values, proportional to an infinitely variable input value.
 - .9 Motorized: Control device with actuator.
 - .10 NAC: Network Area Controller.
 - .11 NC: Normally closed position of switch after control signal is removed or normally closed position of manually operated valves or dampers.
 - .12 NO: Normally open position of switch after control signal is removed; or the open position of a controlled valve or damper after the control signal is removed; or the usual position of a manually operated valve.
 - .13 OOT: Object Oriented Technology
 - .14 OSS: Operating System Server, host for system graphics, alarms, trends, etc.
 - .15 Operator: Same as actuator.
 - .16 PC: Personal Computer.
 - .17 Peer-to-Peer: Mode of communication between controllers in which each device connected to network has equal status and each shares its database values with all other devices connected to network.
 - .18 PICS: BACnet Product Interoperability Compliance Statement.
 - .19 PID: Proportional-Integral-Derivative control, control mode with continuous correction of final controller output element versus input signal based on proportional error, its time history (reset) and rate at which it's changing (derivative).
 - .20 Point: Analog or discrete instrument with addressable database value.
 - .1 Point: may be logical or physical.
 - .21 Logical points: values calculated by system such as setpoints, totals, counts, derived corrections and may include, but not limited to result of and statements in CDL's.

- .22 Physical points: inputs or outputs which have hardware wired to controllers which are measuring physical properties, or providing status conditions of contacts or relays which provide interaction with related equipment (stop, start) and valve or damper actuators.
 - .1 Point Name: composed of two parts, point identifier and point expansion.
 - .2 Point identifier: comprised of three descriptors, "area" descriptor, "system" descriptor and "point" descriptor, for which database to provide 25 character field for each point identifier. "System" is system that point is located on.
 - .3 Area descriptor: building or part of building where point is located.
- .23 System descriptor: system that point is located on.
- .24 Point descriptor: physical or logical point description. For point identifier "area", "system" and "point" will be shortforms or acronyms. Database must provide 25 character field for each point identifier.
- .25 Point expansion: comprised of three fields, one for each descriptor. Expanded form of shortform or acronym used in "area", "system" and "point" descriptors is placed into appropriate point expansion field. Database must provide 32 character field for each point expansion.
- .26 Bilingual systems to include additional point identifier expansion fields of equal capacity for each point name for second language.
- .27 System to support use of numbers and readable characters including blanks, periods or underscores to enhance user readability for each of the above strings.

1.6 SUBMITTALS

- .1 Make submittals in accordance with Division 01 - Submittal Procedures and 25 05 02 - BAS: Shop Drawings, Product Data and Review Process.
- .2 Submit for review:
- .3 Equipment list and systems manufacturers within 10 days after award of contract.
- .4 List existing field control devices to be re-used included in bid, along with unit price.
- .5 Eight copies (unless specified otherwise) of shop drawings of the entire Integrated Platform shall be submitted and shall consist of a complete list of equipment and materials, including manufacturers catalog data sheets and installation instructions. Shop drawings shall also contain complete wiring and schematic diagrams, software descriptions, calculations, and any other details required to demonstrate that the system has been coordinated and will properly function as a system. Terminal identification for all control wiring shall be shown on the shop drawings.

- .6 Include a trunk cable schematic diagram depicting operator workstations, control panel locations and a description of the communication type, media, and protocol. Though the Division 23 contractors shall provide these diagrams for their portions of work, the Master Systems Integrator shall be responsible for integrating those diagrams into the overall trunk cable schematic diagrams for the entire Virtual Local Area Network (VLAN).
- .7 Include a copy of each of the graphics developed for the Graphic User Interface including a flowchart (site map) indicating how the graphics are to be linked to one another for system navigation. The graphics are intended to be 80% - 90% complete at this stage with the only remaining changes to be based on review comments from the A/E design team and/or EMU.
- .8 Quality Control:
 - .1 Provide equipment and material from manufacturer's regular production, CSA certified, manufactured to standard quoted plus additional specified requirements.
 - .2 Where CSA certified equipment is not available submit such equipment to inspection authorities for special inspection and approval before delivery to site.
 - .3 Submit proof of compliance to specified standards with shop drawings and product data in accordance with Section 25 05 02 - BAS: Shop Drawings, Product Data and Review Process. Label or listing of specified organization is acceptable evidence.
 - .4 In lieu of such evidence, submit certificate from testing organization, approved by Consultant, certifying that item was tested in accordance with their test methods and that item conforms to their standard/code.
 - .5 For materials whose compliance with organizational standards/codes/specifications is not regulated by organization using its own listing or label as proof of compliance, furnish certificate stating that material complies with applicable referenced standard or specification.
 - .6 Permits and fees: in accordance with general conditions of contract.
 - .7 Submit certificate of acceptance from authority having jurisdiction to Consultant.
- .9 Existing devices intended for re-use: submit test report.
 - .1 Upon completion of the work, provide a complete set of 'as-built' drawings and application software on compact disk. Drawings shall be provided as AutoCAD™ or Visio™ compatible files. Eight copies of the 'as-built' drawings shall be provided in addition to the documents on compact disk. Division 23 and 26 contractors shall provide as-builts for their portions of work. The Division 25 contractor shall be responsible for as-builts pertaining to overall BMS architecture and network diagrams. All as built drawings shall also be installed into the integrated platform server in a dedicated directory.

1.7 REFERENCE STANDARDS

- .1 American National Standards Institute (ANSI)/The Instrumentation, Systems and Automation Society (ISA).
 - .1 ANSI/ISA 5.5-1985, Graphic Symbols for Process Displays.
- .2 American National Standards Institute (ANSI)/ Institute of Electrical and Electronics Engineers (IEEE).
 - .1 ANSI/IEEE 260.1-1993, American National Standard Letter Symbols Units of Measurement (SI Units, Customary Inch-Pound Units, and Certain Other Units).
- .3 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE).
 - .1 ASHRAE STD 135-R2001, BACNET - Data Communication Protocol for Building Automation and Control Network.
- .4 CSA Group (CSA).
 - .1 CAN/CSA-Z234.1-89(R1995), Canadian Metric Practice Guide.
- .5 Electrical and Electronic Manufacturers Association (EEMAC).
 - .1 EEMAC 2Y-1-1958, Light Grey Colour for Indoor Switch Gear.
- .6 National Fire Protection Association (NFPA)
 - .1 NFPA 33, Standard for Spray Application Using Flammable or Combustible Materials.
 - .2 NFPA 72, National Fire Alarm and Signalling Code
 - .3 NFPA 90A, Standard for Installation of Air Conditioning and Ventilating Systems
- .7 Health Canada/Workplace Hazardous Materials Information System (WHMIS).
 - .1 Safety Data Sheets (SDS).
- .8 Transport Canada (TC).
 - .1 Transportation of Dangerous Goods Act (TDGA), 1992, c. 34.

1.8 QUALITY ASSURANCE

- .1 The Master Systems Integrator shall have a full service DDC office within 50 miles of the job site. This office shall be staffed with applications engineers, software engineers and field technicians. This office shall maintain parts inventory and shall have all testing and diagnostic equipment necessary to support this work, as well as staff trained in the use of this equipment.

- .2 Single Source Responsibility of Supplier: The Master Systems Integrator shall be responsible for the complete installation and proper operation of the control system. Master Systems Integrator shall exclusively be in the regular and customary business of design, installation, and service of computerized building management systems similar in size and complexity to the system specified. The Master Systems Integrator shall be the manufacturer of the primary DDC system components or shall have been the authorized representative for the primary DDC components manufacturer for at least 5 years. All control panels shall be assembled by the Control System Contractor.
- .3 Equipment and Materials: Equipment and materials shall be cataloged products of manufacturers regularly engaged in the production and installation of specified Division 25 systems. Products shall be the manufacturer's latest standard design and the manufacturer's latest standard design and comply with Division 25 requirements.
- .4 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Division 01 - Health and Safety Requirements.

1.9 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials off ground, in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect condensers and cooling equipment from nicks, scratches, blemishes, theft, vandalism, and vermin.
 - .3 Replace defective or damaged materials with new.
- .4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, and packaging materials as specified in Construction Waste Management Plan in accordance with Division 01 - Waste Management and Disposal.

1.10 COORDINATION WORKSHOPS

- .1 Conduct Coordination Workshops that include, at a minimum, the following three session types listed below. The MSI, General Contractor and associated sub-contractors shall provision for as many workshops as are deemed necessary by the Owner to address all facets of the BAS components and configuration.
- .2 Network configuration workshop

- .1 Participate in a network configuration workshop for establishing the network parameters for the project. The ongoing network requirements and documentation shall be established during the workshop and presented as a submittal for approval following the meetings.
- .3 Graphics workshop
 - .1 Lead workshops establishing the graphics package for the project. The final graphics workshop shall be a live graphics review meeting.
- .4 Analytics and alarming workshop
 - .1 Lead analytics and alarming workshops with the Owner's Operations group, design team and commissioning agent for establishing the requirements for analytics and alarms for the project. The alarm standard shall include a holistic review of alarming standards to help facilitate a new paradigm for operations for alarms, faults, and operational efficiencies, moving to a proactive maintenance model.

1.11 EXISTING- CONTROL COMPONENTS

- .1 Utilize existing control wiring and piping as indicated.
- .2 Re-use field control devices that are usable in their original configuration provided that they conform to applicable codes, standards specifications.
- .3 Do not modify original design of existing devices without written permission from Consultant.
- .4 Provide for new, properly designed device where re-usability of components is uncertain.
- .5 Inspect and test existing devices intended for re-use within 30 days of award of contract, and prior to installation of new devices.
- .6 Furnish test report within 40 days of award of contract listing each component to be re-used and indicating whether it is in good order or requires repair.
- .7 Failure to produce test report will constitute acceptance of existing devices by contractor.
- .8 Non-functioning items:
- .9 Provide with report specification sheets or written functional requirements to support findings.
- .10 Repair or replace existing items judged defective yet deemed necessary for BAS.
- .11 Submit written request for permission to disconnect controls and to obtain equipment downtime before proceeding with Work.
- .12 Assume responsibility for controls to be incorporated into BAS after written receipt of approval from Consultant.
- .13 Be responsible for repair costs due to negligence or abuse of equipment.
- .14 Remove existing controls not re-used or not required. Place in approved storage for disposition as directed.

2. PRODUCTS

2.1 INTEGRATION PLATFORM

- .1 Tridium Niagara Framework version N4.x (current supported release – see Section 1.1)
- .2 The FMCS shall be comprised of Java Application Control Engine or Controllers (JACE) within each facility. The JACE shall connect to the owner's local network, wide area network, or operational technology network (OTN) depending on configuration. Each JACE is capable of communicating to LonMark/LonTalk (IDC) and/or BACnet (IBC) controllers and other open and legacy protocol systems/devices.
 - .1 Supervisory Control Software: Niagara Framework Web Supervisor N4.x (product info)
 - .2 Engineering Software: Niagara Workbench
 - .3 Network Controller Manufacturers:
 - .1 Subject to compliance with requirements, provide products and services by one of the following:
 - .2 Vykon JACE-9000 (JACE-9000), EDGE -10 (VEC-10) with corresponding IO and Communications modules

2.2 GENERAL

- .1 The Integration Platform shall be comprised of a network of interoperable, stand-alone digital controllers, a network area controller, graphics and programming and other control devices for a complete system as specified herein.
- .2 The installed system shall provide secure strong password access to all features, functions and data contained in the overall BMS.

2.3 ARCHITECTURE

- .1 The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system utilizing Open protocols in one open, interoperable system.
- .2 The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. Physical connection of any BACnet control equipment, such as chillers, shall be via Ethernet or IP.
- .3 All components and controllers supplied under this contract shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data shall not be acceptable.

- .4 The supplied system shall incorporate the ability to access all data using HTML5 enabled browsers without requiring proprietary operator interface and configuration programs or browser plug-ins. An Open Database Connectivity (ODBC) or Structured Query Language (SQL) or approved compliant server database is required for all system database parameter storage. This data shall reside on the Niagara Enterprise Web Supervisor VM hosted by the owner.
- .5 A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network.
- .6 Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
- .7 Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote connected user interfaces.

2.4 SERVER HARDWARE

- .1 The main server shall be mounted in the server rack in a location designated on the drawings. Server shall be provided with a keyboard and mouse.
- .2 Hardware and OS, VMM software will be provided by the owner.

2.5 FIREWALL AND DNS SERVER

- .1 Provided by Owner

2.6 SERVER RACK

- .1 Provide standard four post frame cabinets, wall mounted cabinets with 0.375" square mounting holes on front and back rails for a minimum of 42 standard EIA rack spaces. Provide with (25) 12-24 cage nuts and screws for square mounting holes.
- .2 Provide UL Listed, designed to be self-standing with leveling feet, constructed of steel or aluminum, shall be firmly fastened to the floor, fastened to ladder rack for extra support, and properly grounded.
- .3 Provide with perforated, quick release, lockable front, and rear doors.
- .4 Provide with (2) locking, easy to remove side panels.

2.7 IoT SERVER SOFTWARE

- .1 The IoT Server Software shall allow multiple Niagara-based JACE controllers, along with other IP-based controllers, to be networked together through the Enterprise OT Network. This software shall provide real-time graphical information to standard Web-browser clients and provide server-level functions. These functions include centralized data logging/trending, alarming, tagging, archiving to external databases, alarming, dashboarding, system navigation, master scheduling, database management, and integration with other enterprise software applications through custom APIs where required. A comprehensive graphical engineering toolset for application development shall be provided (Niagara 4 Workbench)
- .2 Provide system software based on server/thin-client architecture, designed around the open standards of web technology. The BAS server shall communicate using Ethernet and TCP. Server shall be accessed using a web browser over Owner intranet and remotely over the Internet.
- .3 The intent of the thin-client architecture is to provide the operator(s) complete access to the BAS system via a web browser. The thin-client web browser Graphical User Interface (GUI) shall be browser and operating system agnostic, meaning it will support HTML5 enabled browsers without requiring proprietary operator interface and configuration programs or browser plug-ins. Microsoft, Firefox, and Chrome browsers (current released versions), and Windows as well as non-Window operating systems. All browsers shall comply with the owner's IT standards.
- .4 Ensure the BAS server software supports the following server platforms (Windows 11 and 10 Pro x64-bit; Windows Server 2022 and 2019; Linux x64-bit: RedHat Enterprise Linux 8.7, Ubuntu 22.04). The BAS server software shall be developed and tested by the manufacturer of the system stand-alone controllers and network controllers/routers.
- .5 Graphical User Interface (GUI): Provide the Single Pane of Glass that displays all building, integrated building, and building-related information for: monitoring, management, and control. The GUI shall be browser-based utilizing HTML5 graphics with responsive web design (RWD) graphics for multi-platform support:
 - .1 Trending.
 - .2 Scheduling.
 - .3 Electrical demand limiting.
 - .4 Energy Aggregation and Analytics.
 - .5 Downloading Memory to field devices.
 - .6 Real time 'live' Graphic Programs.
 - .7 Tree Navigation.
 - .8 Parameter changes of properties.
 - .9 Set point adjustments.
 - .10 Alarm / event information.
 - .11 Configuration of operators.

- .12 Execution of global commands.
- .13 Add, delete, and modify graphics and displayed data.
- .6 Software Components: All software shall be the most current version. All software components of the BAS software shall be provided and installed as part of this project. BAS software components shall include:
 - .1 Server Software, Database and Web Browser Graphical User Interface.
 - .2 5 Year Software Maintenance license. Labor to implement not included.
 - .3 Embedded Configuration Utilities for future modifications to the system and controllers.
 - .4 Embedded Graphical Programming Tools.
 - .5 Embedded Direct Digital Control software.
 - .6 Embedded Application Software.
- .7 BAS Server Database: The BAS server software shall utilize a Java Database Connectivity (JDBC) compatible database such as: Niagara standard database, MS SQL 8.0, Oracle 8i or IBM DB2. Owner's IT will provide any non-Niagara DB licenses if required.
- .8 Thin Client - Web Browser Based: The GUI shall be thin client or browser based and shall meet the following criteria:
 - .1 Web Browser's for PC's: Only the current released browser (Explorer/Firefox/Chrome) will be required as the GUI and a valid connection to the server network. No installation of any custom software shall be required on the operator's GUI workstation/client. Connection shall be over secured owner's Operational Technology Network.
 - .2 Secure Socket Layers: Communication between the Web Browser GUI and BAS server shall offer encryption using 128-bit encryption technology within Secure Socket Layers (SSL). Communication protocol shall be TLS 1.3
- .9 Web Browser Graphical User Interface
 - .1 Web Browser Navigation: The Thin Client web browser GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to "feel" like a single application and provide a complete and intuitive mouse/menu driven operator interface. It shall be possible to navigate through the system using a web browser to accomplish requirements of this specification. The Web Browser GUI shall (as a minimum) provide for navigation, and for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic set point controls, configuration menus for operator access, reports and reporting actions for events.

- .2 Login: On launching the web browser and selecting the appropriate domain name or IP address, the operator shall be presented with a login page that will require a login name and strong password. Navigation in the system shall be dependent on the operator's role-based application control privileges.
- .3 Navigation: Navigation through the GUI shall be accomplished by clicking on the appropriate level of a navigation tree (consisting of an expandable and collapsible tree control and/or by selecting dynamic links to other system graphics. Both the navigation tree and action pane shall be displayed simultaneously, enabling the operator to select a specific system or equipment and view the corresponding graphic. The navigation tree shall as a minimum provide the following views: Geographic, Network, Groups and Configuration.
 - .1 Geographic View shall display a logical geographic hierarchy of the system including cities, sites, buildings, building systems, floors, equipment, and objects.
 - .2 Groups View shall display Scheduled Groups and custom reports.
 - .3 Configuration View shall display all the configuration categories (Operators, Schedule, Event, Reporting and Roles).
- .4 Action Pane: The Action Pane shall provide several functional views for each subsystem specified. A functional view shall be accessed by clicking on the corresponding button:
 - .1 Graphics: Using graphical format suitable for display in a web browser, graphics shall include aerial building/campus views, color building floorplans, equipment drawings, active graphic set point controls, web content and other valid HTML elements. The data on each graphic page shall automatically refresh.
 - .2 Dashboards: User customizable data using drag and drop HTML5 elements. Shall include Web Charts, Gauges, and other custom developed widgets for web browser. User shall have ability to save custom dashboards.
 - .3 Search: User shall have multiple options for searching data based upon Tags. Associated equipment, real time data, Properties, and Trends shall be available in result.
 - .4 Properties: Shall include graphic controls and text for the following: Locking or overriding objects, demand strategies, and any other valid data required for setup. Changes made to the properties pages shall require the operator to depress an 'accept/cancel' button.
 - .5 Schedules: Shall be used to create, modify/edit and view schedules based on the systems hierarchy (using the navigation tree).

- .6 Alarms: Shall be used to view alarm information geographically (using the navigation tree), acknowledge alarms, sort alarms by category, actions and verify reporting actions.
- .7 Charting: Shall be used to display associated trend and historical data, modify colors, date range, axis, and scaling. User shall have ability to create HTML charts through web browser without utilizing chart builder. User shall be able to drag and drop single or multiple data points, including schedules, and apply status colors for analysis.
- .8 Logic - Live Graphic Programs: Shall be used to display 'live' graphic programs of the control algorithm, (micro block programming) for the mechanical/electrical system selected in the navigation tree.
- .9 Other actions such as Print, Help, Command, and Logout shall be available via a drop-down window.
- .10 Color Graphics: The Web Browser GUI shall make extensive use of color in the graphic pane to communicate information related to set points and comfort. Animated. gifs or .jpg, vector scalable, active set point graphic controls shall be used to enhance usability. Graphics tools used to create Web Browser graphics shall be non-proprietary and conform to the following basic criteria:
 - .1 Display Size: The GUI workstation software shall graphically display in a minimum of 1024 by 768 pixels 24-bit True Color.
 - .2 General Graphic: General area maps shall show locations of controlled buildings in relation to local landmarks.
 - .3 Color Floor Plans: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, as selected by Owner. Provide a visual display of temperature relative to their respective set points. The colors shall be updated dynamically as a zone's actual comfort condition changes.
 - .4 Mechanical Components: Mechanical system graphics shall show the type of mechanical system components serving any zone using a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability.
 - .5 All graphics shall be compatible with any desktop, mobile device or tablet.
 - .6 Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:
 - .7 Each piece of equipment monitored or controlled including each terminal unit.
 - .8 Each building.
 - .9 Each floor and zone controlled.

- .11 Hierarchical Schedules: Utilizing the Navigation Tree displayed in the web browser GUI, an operator (with proper access credentials) shall be able to define a Normal, Holiday or Override schedule for an individual piece of equipment or room or choose to apply a hierarchical schedule to the entire system, site or floor area. For example, Independence Day ' Holiday' for every level in the system would be created by clicking at the top of the geographic hierarchy defined in the Navigation Tree. No further operator intervention would be required and every control module in the system with would be automatically downloaded with the ' Independence Day' Holiday. All schedules that affect the system/area/equipment highlighted in the Navigation Tree shall be shown in a summary schedule table and graph.
- .1 Schedules: Schedules shall comply with the LonWorks and BACnet standards, (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and shall allow events to be scheduled based on:
- .1 Types of schedules shall be Normal, Holiday or Override.
 - .2 A specific date.
 - .3 A range of dates.
 - .4 Any combination of Month of Year (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any).
 - .5 Wildcard (example, allow combinations like second Tuesday of every month).
- .2 Schedule Categories: The system shall allow operators to define and edit scheduling categories (different types of "things" to be scheduled; for example, lighting, HVAC occupancy, etc.). The categories shall include name, description, icon (to display in the hierarchy tree when icon option is selected) and type of value to be scheduled.
- .3 Schedule Groups: In addition to hierarchical scheduling, operators shall be able to define functional Schedule Groups, comprised of an arbitrary group of areas/rooms/equipment scattered throughout the facility and site. For example, the operator shall be able to define an 'individual tenant' group - who may occupy different areas within a building or buildings. Schedules applied to the ' tenant group' shall automatically be downloaded to control modules affecting spaces occupied by the ' tenant group'.
- .4 Intelligent Scheduling: The control system shall be intelligent enough to automatically turn on any supporting equipment needed to control the environment in an occupied space. If the operator schedules an individual room in a VAV system for occupancy, for example, the control logic shall automatically turn on the VAV air handling unit, chiller, boiler and/or any other equipment required to maintain the specified comfort and environmental conditions within the room.

- .5 Partial Day Exceptions: Schedule events shall be able to accommodate a time range specified by the operator (ex: board meeting from 6 pm to 9 pm overrides Normal schedule for conference room).
 - .6 Schedule Summary Graph: The schedule summary graph shall clearly show Normal versus Holiday versus Override Schedules and the net operating schedule that results from all contributing schedules. Note: In case of priority conflict between schedules at the different geographic hierarchy, the schedule for the more detailed geographic level shall apply.
- .12 Alarms. Alarms associated with a specific system, area, or equipment selected in the Navigation Tree, shall be displayed in the Action Pane by selecting an ' Alarms' view. Alarms, and reporting actions shall have the following capabilities:
- .1 Alarms View: Each Alarm shall display an Alarms Category (using a different icon for each alarm category), date/time of occurrence, current status, alarm report and a bold URL link to the associated graphic for the selected system, area or equipment. The URL link shall indicate the system location, address, and other pertinent information. An operator shall easily be able to sort events, edit event templates and categories, acknowledge, or force a return to normal in the Events View as specified in this section.
 - .2 Alarm Categories: The operator shall be able to create, edit or delete alarm categories such as HVAC, Maintenance, Fire, or Generator. An icon shall be associated with each alarm category, enabling the operator to easily sort through multiple events displayed.
 - .3 Alarm Templates: Alarm template shall define different types of alarms and their associated properties. As a minimum, properties shall include a reference name, verbose description, severity of alarm, acknowledgement requirements, and high/low limit and out of range information.
 - .4 Alarm Areas: Alarm Areas enable an operator to assign specific Alarm Categories to specific Alarm
 - .5 Reporting Actions. For example, it shall be possible for an operator to assign all HVAC Maintenance Alarm on the 1st floor of a building to email the technician responsible for maintenance. The Navigation Tree shall be used to setup Alarm Areas in the Graphic Pane. 5. Alarm Time/Date Stamp: All events shall be generated at the DDC control module level and comprise the Time/Date Stamp using the standalone control module time and date.
 - .6 Alarm Configuration: Operators shall be able to define the type of Alarm generated per object. A ' network' view of the Navigation Tree shall expose all objects and their respective Alarm Configuration. Configuration shall include assignment of Alarm, type of Acknowledgement and notification for return to normal or fault status.

- .7 Alarm Summary Counter: The view of Alarm in the Graphic Pane shall provide a numeric counter, indicating how many Alarms are active (in alarm), require acknowledgement and total number of Alarms in the BAS Server database.
- .8 Alarm Auto-Deletion: Alarms that are acknowledged and closed shall be auto-deleted from the database and archived to a text file after an operator defined period.
- .9 Alarm Reporting Actions: Alarm Reporting Actions specified shall be automatically launched (under certain conditions) after an Alarm is received by the BAS server software. Operators shall be able to easily define these Reporting Actions using the Navigation Tree and Graphic Pane through the web browser GUI. Reporting Actions shall be as follows:
 - .1 Print: Alarm information shall be printed to the BAS server's PC or a networked printer.
 - .2 Email: Email shall be sent via any POP3-compatible e-mail server (most Internet Service Providers use POP3). Email messages may be copied to several email accounts. Note: Email reporting action shall also be used to support alphanumeric paging services, where email servers support pagers.
 - .3 File Write: The ASCII File write reporting action shall enable the operator to append operator defined alarm information to any alarm through a text file. The alarm information that is written to the file shall be completely definable by the operator. The operator may enter text or attach other data point information (such as AHU discharge temperature and fan condition upon a high room temperature alarm).
 - .4 Write Property: The write property reporting action updates a property value in a hardware module.
 - .5 SNMP: The Simple Network Management Protocol (SNMP) reporting action sends an SNMP trap to a network in response to receiving an alarm.
 - .6 Run External Program: The Run External Program reporting action launches specified program in response to an event.
 - .7 Provide alarm recipients and escalation per direction from owner.
- .13 Trends: As system is engineered, all points shall be enabled to trend. Trends shall both be displayed and user configurable through the Web Browser GUI. Trends shall comprise analog, digital or calculated points simultaneously. A trend log's properties shall be editable using the Navigation Tree and Graphic Pane.
 - .1 Viewing Trends: The operator shall have the ability to view trends by using the Navigation Tree and selecting a Trends button in the Graphic Pane. The system shall allow y- and x-axis maximum ranges to be specified and shall be able to simultaneously graphically display multiple trends per graph.

- .2 Local Trends: Trend data shall be collected locally by Multi-Equipment/Single Equipment general-purpose controllers and periodically uploaded to the NWS server if historical trending is enabled for the object. Trend data, including run time hours and start time date shall be retained in non-volatile module memory. Systems that rely on a gateway/router to run trends are NOT acceptable.
- .3 Resolution. Each trended point will have the ability to be trended at a different trend interval. When multiple points are selected for displays that have different trend intervals, the system will automatically scale the axis. (see point list for details).
- .4 Dynamic Update. Trends shall be able to dynamically update at operator-defined intervals.
- .5 Zoom/Pan. It shall be possible to zoom-in on a particular section of a trend for more detailed examination and 'pan through' historical data by simply scrolling the mouse.
- .6 Numeric Value Display. It shall be possible to pick any sample on a trend and have the numerical value displayed.
- .7 Copy/Paste. The operator shall have the ability to pan through a historical trend and copy the data viewed to the clipboard using standard keystrokes (i.e. CTRL+C, CTRL+V).
- .14 Security Access: Systems Access from the web browser GUI to BAS server shall require a Login Name and Strong Password. Access to different areas of the BAS system shall be defined in terms of Role-Based Access Control privileges as specified:
 - .1 Roles: Roles shall reflect the actual roles of different types of operators. Each role shall comprise a set of 'easily understood English language' privileges. Roles shall be defined in terms of View, Edit and Function Privileges.
 - .1 View Privileges shall comprise: Navigation, Network, and Configuration Trees, Operators, Roles and Privileges, Alarm/Event Template and Reporting Action.
 - .2 Edit Privileges shall comprise: Set point, Tuning and Logic, Manual Override, and Point Assignment Parameters.
 - .3 Function Privileges shall comprise: Alarm/Event Acknowledgement, Control Module Memory Download, Upload, Schedules, Schedule Groups, Manual Commands, Print and Alarm/Event Maintenance.
 - .2 Geographic Assignment of Roles: Roles shall be geographically assigned using a similar expandable/collapsible navigation tree. For example, it shall be possible to assign two HVAC Technicians with similar competencies (and the same operator defined HVAC Role) to different areas of the system.
- .15 Graphical Programming. Niagara 4 Workbench 4.x or current version at commissioning.

.16 **Analytics - General**

- .1 Provide a fault detection and analytic framework that utilizes a high-performance calculation engine. The engine shall permit real-time data to be combined with historical data using a set of wire and property sheets. The visual programming interface shall be used to define the algorithms (formulas) that analyzes the real-time and trend data collected from the BMS.
- .2 The output from the analysis shall be able to be visualized in charts, graphs and dashboards and be used as inputs to standard Niagara logic. Faults shall be prioritized according to the associated system, location and the level of cost avoidance. When applied to historical and real-time data, the framework algorithms shall provide the following analysis features:
- .3 An open and extensible analytical environment that can easily customized.
 - .1 Analytic tools that apply to any data types available from building sub-systems.
 - .2 The ability to set-up complex analysis without custom programming.
 - .3 Support for third party API visualization application programs.

.17 **Niagara Cyber Security Dashboard**

- .1 Implement a Niagara Security Dashboard as a centralized, easy-to-read and actionable view on the security posture of the entire Niagara infrastructure. The dashboard shall provide visual alerts in the event that any Niagara station in your network is set to allow non-secure connections. It shall display the status of required certificates for each station and shall identify whether running software modules and program objects are signed by their developers. Cyber dashboard shall present all the potential cyber issues at a glance and user shall be able to remediate them quickly for the protection of the Niagara network.

2.8 EQUIPMENT

- .1 Control Network Protocol and Data Communication Protocol: to CEA 709.1 and ASHRAE STD 135.
- .2 Complete list of equipment and materials to be used on project and forming part of bid documents by adding manufacturer's name, model number and details of materials, and submit for approval.

3. EXECUTION

3.1 GENERAL

- .1 A. MSI shall furnish on-the-job supervision for the proper installation of devices in cooperation with, or as may be required by other trades. This supervision shall include the following:

- .1 Attend all GC and/or Owner meetings in order to disseminate pertinent information and action items to the respective trades.
- .2 Provide supervision as required by others to properly perform installation work.
- .3 Install, test, trouble-shoot and correct all system software provided under this specification.
- .2 Furnish all material and labor to provide a complete and functional system, which operates in accordance with the requirements of this specification.
- .3 Conduct all workshops as listed below
 - .1 Graphics Configuration Workshops
 - .1 Equipment and Floorplans
 - .2 Color Schema
 - .3 Navigation and Ease of Use
 - .4 Graphics Development Training
 - .2 Naming Conventions and Tagging Workshops
 - .1 Current Naming and future planned naming conventions
 - .2 Tagging in BMS Platform
 - .3 FDD, Analytics and Alarms workshops
 - .1 Current Alarms and trends
 - .2 Using FDD and Analytics on the BMS Platform
 - .3 Creating Custom Rules
- .4 Obtain all permits, approvals, fees, and charges required for this work.
- .5 Verify IP network connectivity and sub-system connectivity schedule is coordinated for the timely installation of the server and the software. Contractor is to notify MSI of any conflicts in schedule, and any scope of responsibility that are conflicting with deployment.
- .6 Furnish on-the-job supervision for the proper installation of devices in cooperation with, or as may be required by, other trades.
- .7 The MSI is responsible for delivering the hardware to the installation site, unloading, and securing the hardware.
- .8 Ensure that all components specified or required to complete the installation satisfactorily are included, are compatible with each other, and are compatible with the conditions of installation and expected use.
- .9 Ensure the overall effective integration and correctness of individual parts and of the whole system.
- .10 Provide a designated project manager who shall be responsible for the following:
 - .1 Construct and maintain project schedule.

- .2 On-site coordination with all applicable trades and subcontractors.
- .3 Authorized to accept and execute order and instructions from Owner/Architect
- .4 Act as the single point of contact.
- .11 Site and Schedule Coordination:
 - .1 Assist in coordinating space conditions to accommodate the work of each trade where work will be installed near or will interfere with work of other trades
 - .2 Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.
 - .3 Integrate all facets of the integrated systems installation into the project construction schedule.
- .12 The MSI shall schedule and perform all backups for Servers and Network Integration Appliances, including JACE's or Stations.
- .13 Provisioning of Backups
 - .1 Coordinate and document the backup policies for the following devices:
 - .1 Servers
 - .2 Databases
 - .3 Connected Devices including:
 - i. Network Area Controllers
 - ii. Network Integration Appliances
 - iii. Controls integrator Equipment Including
 - iv. All Field Device Controllers (AHU's, TU's, etc...)
 - .2 Coordinate the automation and frequency for all backups.
 - .3 For Off-site backups, Niagara Recover shall be used to provide an automated cyber-protected back-up and recovery solution.

3.2 INSTALLATION OF CONTROLLERS

- .1 The FMCS shall be comprised of Java Application Control Engine or Controllers (JACE) within each facility. The JACE shall connect to the owner's local network, wide area network, or operational technology network (OTN) depending on configuration. Each JACE is capable of communicating to LonMark/LonTalk (IDC) and/or BACnet (IBC) controllers and other open and legacy protocol systems/devices.
- .2 Approved JACE models
- .3 Vykon JACE-9000 (JACE-9000)
- .4 Vykon EDGE -10 (VEC-10)

- .5 Corresponding IO and Communications modules

3.3 CYBER SECURITY

- .1 Provide commissioning engineer for cyber security testing and set up using the Niagara Hardening Guide and under direction of the owner's Corporate Cyber Security Team.
- .2 Attend planning, engineering, and commissioning meetings as required by the owner's Cyber Team.
- .3 Configure and activate the Niagara Security Dashboard and Active Directory services.
- .4 The Station View shall show individual services including User Service, Fox Service, Web Service, Login Service, Authentication Service, and Module Permissions. The Supervisor view shall show all JACEs on the Niagara network, so Niagara users can quickly identify issues and triage outliers.
- .5 Provide necessary port and configuration data to owner's Cyber and IT teams.

3.4 NIAGARA SERVICES AND FEATURES

- .1 Enable audit logs for all functions including system operation and programming and cyber security.
- .2 Set up Alarm Service recipients and escalation levels as directed by owner for 25 users.
- .3 Set up all roles and responsibilities as directed by owner. Coordinate with owners LDAP/Active Directory systems. 25 Users.
- .4 Graphics. Provide Graphics as described in System Integration Matrix and point lists. All graphics shall be designed using Niagara "Responsive Pane" to utilize a single graphic implementation to render on a variety of devices and window or screen sizes (mobile, tablet desktop).
- .5 Set up schedules as directed by owner for each system and zone. Provide special schedules as directed by the owner.
- .6 Set up provisioning service to provide daily backups of all JACEs to the NWS.
- .7 Each point will be trended at default rate of 15 minutes unless otherwise directed.

3.5 TAGGING AND ANALYTICS/FDD

- .1 Coordinate with the Owner for ideal tagging methodology.
- .2 The Niagara Tagging standard shall be used for this project paired with a Building Location tagging Library. The building location tagging library shall include Compass Directional, which will be bi-directional (i.e., NE, SW, NW, SE) and the Building Level (i.e. 1st floor, 2nd floor, 3rd floor, etc.).

3.6 ANALYTICS/FAULT DETECTION AND DIAGNOSTICS

- .1 Utilize Niagara Analytics (or alternate Analytics Program) to provide an integrated solution for FDD that seamlessly presents in the SPOG.
- .2 Any alternative analytics engine must be integrated into the system and leveraged to its fullest potential. The analytics software must either be the system of record or be able to use the system of record in near real-time. The analytic engine must have the option for users to be able to write new analytic algorithms and rules, through a scripting language or otherwise. All integrated system points in the system shall be integrated and available for analytics in the software.
- .3 The analytic language must support Haystack, Brick or Owner selected Schema (determined through the tagging workshop). It must contain robust native functions, both mathematical and scripting specific.
- .4 Preconfigured Analytics:
- .5 End users must have the ability to tag specific data and have that data, whether current or historical, be available in one chart or page.
- .6 End users must have the ability to select points or graph types to better view data in a logical manner.
- .7 Historical data for any number of points must be available to be viewed on-demand and be user- sortable.
- .8 End directors must have the ability to view analytical data by selecting related equipment.
- .9 End users must have the ability to manipulate how data is presented. This includes choice among different styles of graphs and charts.
- .10 End users must have the ability to configure data of similar types to be viewed in the same chart or individually.
- .11 End users must have the ability to customize color coding for data visualizations.

3.7 ALARMS AND ESCALATIONS

- .1 Configure alarms to notify specified recipients and be recorded in the database. Normal conditions for an individual point are properties that may be set and edited, as desired, by a user with proper access and privileges. Alarms will notify that a device point has met a set of predefined conditions, such as the following:
- .2 Offnormal: A value is outside its appropriate or expected range.
- .3 Alert: Regular equipment maintenance or some other task is due to be performed.
- .4 Fault: Occasionally, a device may report a value, which is so far out of range that it is obvious a device or system needs immediate attention.
- .5 Alarm escalation shall be employed to re-routes unacknowledged alarms if they have not been acknowledged within a specified amount of time. Three levels of escalation provide up to three opportunities to re-route an alarm notification if the alarm remains unacknowledged.

- .6 The system specification should define what alarms are desired within the BMS (Alarm creation) as well as Alarm routing (specify destinations (including archival). Notification of recipient(s) via email, alarm console, printer, or remote stations should be defined along with an outlined Acknowledgment from those who are notified. In the event a required acknowledgment is not received within an optionally specified time, alarms can be escalated and re-routed to other designated alarm recipients.
- .7 Alarm Archives and Retention. Provide support for the Alarm Archive feature in the Alarm Service. The Orion Archive Alarm Provider added to the Alarm Service provides the mechanism to archive cleared and closed alarms.

3.8 WARRANTY

- .1 All components, system software, and parts furnished and installed by the MSI shall be guaranteed against defects in materials and workmanship for 1 year of substantial completion. Labor to repair, reprogram, or replace these components shall be furnished by the BSI at no charge during normal working hours during the warranty period. Materials furnished but not installed by the SI shall be covered to the extent of the product only. Installation labor shall be the responsibility of the trade contractor performing the installation. All corrective software modifications made during warranty periods shall be updated on all user documentation and on user and manufacturer archived software disks. The Contractor shall respond to the request for warranty service within 24 standard working hours.
- .2 Software Maintenance Agreement. Provide 5-year SMA for all Niagara software. MSI shall provide a 5-year SMA including Niagara Remote and Niagara Recover for remote engineering and off-site backup/recovery function.

3.9 STARTUP AND COMMISSIONING

- .1 Test each point in the system for both hardware and software functionality. In addition, each mechanical and electrical system under control of the BAS will be tested against the appropriate sequence of operation specified herein. Successful completion of the system test shall constitute the beginning of the warranty period. A written report will be submitted to the owner indicating that the installed system functions in accordance with the plans and specifications.
- .2 Commission and set in operating condition all major systems integrations with system manufacturer's representatives, as applicable, and the Owner and Architect.
- .3 Startup Testing shall be performed for each task on the startup test checklist, which shall be initialed by the technician and dated upon test was completion along with any recorded data such as voltages, offsets or tuning parameters. Any deviations from the submitted installation plan shall also be recorded.
- .4 Required elements of the startup testing include:
 - .1 Measurement of voltage sources, primary and secondary
 - .2 Verification of proper controller power wiring.

- .3 Verification of component inventory when compared to the submittals.
- .4 Verification of labeling on components and wiring.
- .5 Verification of connection integrity and quality (loose strands and tight connections).
- .6 Verification of bus topology, grounding of shields and installation of termination devices.
- .7 Verification of point checkout.
- .8 Each I/O device is landed per the submittals and functions per the sequence of control.
- .9 Analog sensors are properly scaled, and a value is reported
- .10 Binary sensors have the correct normal position, and the state is correctly reported.
- .11 Analog outputs have the correct normal position and move full stroke when so commanded.
- .12 Binary outputs have the correct normal state and respond appropriately to energize/de-energize commands.
- .13 Documentation of analog sensor calibration (measured value, reported value and calculated offset).
- .14 Documentation of Loop tuning (sample rate, gain and integral time constant).
- .5 Complete a performance verification test for the operator interaction with the system. Test elements shall be written to require the verification of all operator interaction tasks including, but not limited to the following:
 - .1 Graphics navigation.
 - .2 Trend data collection and presentation.
 - .3 Alarm handling, acknowledgement, and routing.
 - .4 Time schedule editing.
 - .5 Application parameter adjustment.
 - .6 Manual control.
 - .7 Report execution.
 - .8 Automatic backups.
 - .9 Web Client access.

3.10 TRAINING

- .1 Provide training to the Owner's representative and maintenance personnel on the NWS per the following description:

- .2 Training shall consist of a minimum of (40) hours of hands-on instruction geared at the operation and maintenance of the systems. MSI may use a combination of generic, Tridium approved, online and local system and project-specific operator training. The curriculum shall include:
- .1 System Overview
 - .2 System Software and Operation
 - .3 System access
 - .4 Software features overview
 - .5 Changing set-points and other attributes
 - .6 Scheduling
 - .7 Editing programmed variables
 - .8 Displaying color graphics
 - .9 Running reports
 - .10 Workstation maintenance
 - .11 Viewing application programming
 - .12 Operational sequences including start-up, shutdown, adjusting.

END OF SECTION

1. GENERAL

1.1 SUMMARY

- .1 Section Includes:
 - .1 System requirements for Local Area Network (LAN) for Building Energy Monitoring and Control System (EMCS).
- .2 Related Requirements
 - .1 Section 25 05 01.

1.2 REFERENCE STANDARDS

- .1 CSA Group (CSA).
 - .1 CSA T529-95(R2000), Telecommunications Cabling Systems in Commercial Buildings (Adopted ANSI/TIA/EIA-568-A with modifications).
 - .2 CSA T530-99(R2004), Commercial Building Standard for Telecommunications Pathways and Spaces (Adopted ANSI/TIA/EIA-569-A with modifications).
- .2 Institute of Electrical and Electronics Engineers (IEEE)/Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements.
 - .1 IEEE Std 802.3TM-2002, Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications.
- .3 Telecommunications Industries Association (TIA)/Electronic Industries Alliance (EIA)
 - .1 TIA/EIA-568-March 2004, Commercial Building Telecommunications Cabling Standards Set, Part 1 General Requirements Part 2 Balanced Twisted-Pair Cabling Components Part 3 Optical Fiber Cabling Components Standard.
 - .2 TIA/EIA-569-A-December 2001, Commercial Building Standard for Telecommunications Pathways and Spaces.
- .4 Treasury Board Information Technology Standard (TBITS).
 - .1 TBITS 6.9-2000, Profile for the Telecommunications Wiring System in Government Owned and Leased Buildings - Technical Specifications.

1.3 DEFINITIONS

- .1 Acronyms and definitions: refer to Section 25 05 01 - EMCS - General Requirements.

1.4 SYSTEM DESCRIPTION

- .1 Data communication network to link Operator Workstations and Master Control Units (MCU) in accordance with CSA T529, TIA/EIA-568, CSA T530, TIA/EIA-569-A, and TBITS 6.9.

- .1 Provide reliable and secure connectivity of adequate performance between different sections (segments) of network.
- .2 Allow for future expansion of network, with selection of networking technology and communication protocols.
- .2 Data communication network to include, but not limited to:
 - .1 EMCS-LAN.
 - .2 Modems.
 - .3 Network interface cards.
 - .4 Network management hardware and software.
 - .5 Network components necessary for complete network.

1.5 DESIGN REQUIREMENTS

- .1 EMCS Local Area Network (EMCS-LAN).
 - .1 High speed, high performance, local area network over which MCUs and OWSs communicate with each other directly on peer to peer basis in accordance with IEEE 802.3/Ethernet Standard.
 - .2 EMCS-LAN to: BACnet.
 - .3 Each EMCS-LAN to be capable of supporting at least 50 devices.
 - .4 Support of combination of MCUs and OWSs directly connected to EMCS-LAN.
 - .5 High speed data transfer rates for alarm reporting, quick report generation from multiple controllers, upload/download information between network devices. Bit rate to be 100 Megabits per second minimum.
 - .6 Detection and accommodation of single or multiple failures of either OWSs, MCUs or network media. Operational equipment to continue to perform designated functions effectively in event of single or multiple failures.
 - .7 Commonly available, multiple sourced, networking components and protocols to allow system to co-exist with other networking applications including office automation.
- .2 Dynamic Data Access.
 - .1 LAN to provide capabilities for OWSs, either network resident or connected remotely to access point status and application report data or execute control functions for other devices via LAN.
 - .2 Access to data to be based upon logical identification of building equipment.
- .3 Network Medium.
 - .1 Network medium: twisted cable, shielded twisted cable, or fibre optic cable compatible with network protocol to be used within buildings. Fibre optic cable to be used between buildings.

2. PRODUCTS

2.1 NOT USED

.1 Not Used.

3. EXECUTION

3.1 NOT USED

.1 Not Used.

END OF SECTION

1. GENERAL

1.1 SUMMARY

- .1 Section Includes:
 - .1 Materials and installation for building automation controllers including:
 - .1 Master Control Unit (MCU).
 - .2 Local Control Unit (LCU).
 - .3 Equipment Control Unit (ECU).
 - .4 Terminal Control Unit (TCU).
- .2 Related Requirements
 - .1 Section 25 05 01.

1.2 REFERENCE STANDARDS

- .1 American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc. (ASHRAE).
 - .1 ASHRAE Applications Handbook (latest edition).
- .2 CSA Group (CSA).
 - .1 C22.2 No.205, Signal Equipment.
- .3 Institute of Electrical and Electronics Engineers (IEEE).
 - .1 IEEE C37.90.1, Surge Withstand Capabilities (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.

1.3 DEFINITIONS

- .1 Acronyms and definitions: refer to Section 25 05 01 - EMCS: General Requirements.

1.4 DESCRIPTION

- .1 General: Network of controllers comprising of MCU('s), LCU('s), ECU('s) or TCU('s) to be provided as indicated in System Architecture Diagram to support building systems and associated sequence(s) of operations as detailed in these specifications.
 - .1 Provide sufficient controllers to meet intents and requirements of this section.
 - .2 Controller quantity, and point contents to be approved Consultant at time of preliminary design review.
- .2 Controllers: stand-alone intelligent Control Units.
 - .1 Incorporate programmable microprocessor, non-volatile program memory, RAM, power supplies, as required to perform specified functions.
 - .2 Incorporate communication interface ports for communication to LANs to exchange information with other Controllers.

- .3 Capable of interfacing with operator interface device.
- .4 Execute its logic and control using primary inputs and outputs connected directly to its onboard input/output field terminations or slave devices, and without need to interact with other controller. Secondary input used for reset such as outdoor air temperature may be located in other Controller(s).
 - .1 Secondary input used for reset such as outdoor air temperature may be located in other Controller(s).
- .3 Interface to include provisions for use of router interconnection with remote access points.

1.5 DESIGN REQUIREMENTS

- .1 To include:
 - .1 Scanning of AI and DI connected inputs for detection of change of value and processing detection of alarm conditions.
 - .2 Perform On-Off digital control of connected points, including resulting required states generated through programmable logic output.
 - .3 Perform Analog control using programmable logic, (including PID) with adjustable dead bands and deviation alarms.
 - .4 Control of systems as described in sequence of operations.
 - .5 Execution of optimization routines as listed in this section.
- .2 Total spare capacity for MCUs and LCUs: at least 25 % of each point type distributed throughout the MCUs and LCUs.
- .3 Field Termination and Interface Devices:
 - .1 To: CSA C22.2 No.205.
 - .2 Electronically interface sensors and control devices to processor unit.
 - .3 Include, but not be limited to, following:
 - .1 Programmed firmware or logic circuits to meet functional and technical requirements.
 - .2 Power supplies for operation of logics devices and associated field equipment.
 - .3 Lockable wall cabinet.
 - .4 Required communications equipment and wiring (if remote units).
 - .5 Leave controlled system in "fail-safe" mode in event of loss of communication with, or failure of, processor unit.
 - .6 Input Output interface to accept as minimum AI, AO, DI, DO functions as specified.
 - .7 Wiring terminations: use conveniently located screw type or spade lug terminals.
 - .4 AI interface equipment to:
 - .1 Convert analog signals to digital format with 10 bit analog-to-digital resolution.
 - .2 Provide for following input signal types and ranges:

- .3 Meet IEEE C37.90.1 surge withstand capability.
- .4 Have common mode signal rejection greater than 60 dB to 60 Hz.
- .5 Where required, dropping resistors to be certified precision devices which complement accuracy of sensor and transmitter range specified.
- .5 AO interface equipment:
 - .1 Convert digital data from controller processor to acceptable analog output signals using 8 bit digital-to-analog resolution.
 - .2 Provide for following output signal types and ranges:
 - .3 Meet IEEE C37.90.1 surge withstand capability.
- .6 DI interface equipment:
 - .1 Able to reliably detect contact change of sensed field contact and transmit condition to controller.
 - .2 Meet IEEE C37.90.1 surge withstand capability.
 - .3 Accept pulsed inputs up to 2 kHz.
- .7 DO interface equipment:
 - .1 Respond to controller processor output, switch respective outputs. Each DO hardware to be capable of switching up to 0.5 amps at 24 V AC.
 - .2 Switch up to 5 amps at 220 V AC using optional interface relay.
- .4 Controllers and associated hardware and software: operate in conditions of 0 degrees C to 44 degrees C and 20 % to 90 % non-condensing RH.
- .5 Controllers (MCU, LCU): mount in wall mounted cabinet with hinged, keyed-alike locked door.
 - .1 Provide for conduit entrance from top, bottom or sides of panel.
 - .2 ECUs and TCUs to be mounted in equipment enclosures or separate enclosures.
 - .3 Mounting details as approved by Consultant for ceiling mounting.
- .6 Cabinets to provide protection from water dripping from above, while allowing sufficient airflow to prevent internal overheating.
- .7 Provide surge and low voltage protection for interconnecting wiring connections.

1.6 SHOP DRAWING SUBMITTALS

- .1 Make submittals in accordance with Division 01 - Submittal Procedures and Section 25 05 02 - EMCS: Shop Drawings, Product Data and Review Process.
 - .1 Submit product data sheets for each product item proposed for this project.

1.7 MAINTENANCE

- .1 Provide manufacturers recommended maintenance procedures for insertion in Section 25 05 03 - EMCS: Project Record Documents.

2. PRODUCTS

2.1 MASTER CONTROL UNIT (MCU)

- .1 General: primary function of MCU is to provide co-ordination and supervision of subordinate devices in execution of optimization routines such as demand limiting or enthalpy control.
- .2 Include high speed communication LAN Port for Peer to Peer communications with OWS(s) and other MCU level devices.
 - .1 MCU must support BACnet.
- .3 MCU local I/O capacity as follows:
 - .1 MCU I/O points as allocated in I/O Summary Table referenced in MD13800.
 - .2 LCUs may be added to support system functions.
- .4 Central Processing Unit (CPU).
 - .1 Processor to consist of minimum 64 bit microprocessor capable of supporting software to meet specified requirements.
 - .2 CPU idle time to be more than 30% when system configured to maximum input and output with worst case program use.
 - .3 Minimum addressable memory to be at manufacturer's discretion but to support at least performance and technical specifications to include but not limited to:
 - .1 Non-volatile EEPROM to contain operating system, executive, application, sub-routine, other configurations definition software. Tape media not acceptable.
 - .2 Battery backed (72 hour minimum capacity) RAM (to reduce the need to reload operating data in event of power failure) to contain CDLs, application parameters, operating data or software that is required to be modifiable from operational standpoint such as schedules, setpoints, alarm limits, PID constants and CDL and hence modifiable on-line through operator panel or remote operator's interface. RAM to be downline loadable from OWS.
 - .4 Include uninterruptible clock accurate to plus or minus 1 secs/month, capable of deriving year/month/day/hour/minute/second, with rechargeable batteries for minimum 72 hour operation in event of power failure.
- .5 Local Operator Terminal (OT): Provide OT for each MCU unless otherwise specified in Section 25 90 01 - EMCS: Site Requirements, Applications and System Sequences of Operation.
 - .1 Mount access/display panel in MCU or in suitable enclosure beside MCU as approved by Consultant.
 - .2 Support operator's terminal for local command entry, instantaneous and historical data display, programs, additions and modifications.

- .3 Display simultaneously minimum of 32 point identifiers to allow operator to view single screen dynamic displays depicting entire mechanical systems.
- .4 Functions to include, but not be limited to, following:
 - .1 Start and stop points.
 - .2 Modify setpoints.
 - .3 Modify PID loop parameters.
 - .4 Override PID control.
 - .5 Change time/date.
 - .6 Add/modify/start/stop weekly scheduling.
 - .7 Add/modify setpoint weekly scheduling.
 - .8 Enter temporary override schedules.
 - .9 Define holiday schedules.
 - .10 View analog limits.
 - .11 Enter/modify analog warning limits.
 - .12 Enter/modify analog alarm limits.
 - .13 Enter/modify analog differentials.
- .5 Provide access to real and calculated points in controller to which it is connected or to other controller in network. This capability not to be restricted to subset of predefined "global points" but to provide totally open exchange of data between OT and other controller in network.
- .6 Operator access to OTs: same as OWS user password and password changes to automatically be downloaded to controllers on network.
- .7 Provide prompting to eliminate need for user to remember command format or point names. Prompting to be consistent with user's password clearance and types of points displayed to eliminate possibility of operator error.
- .8 Identity of real or calculated points to be consistent with network devices. Use same point identifier as at OWS's for access of points at OT to eliminate cross-reference or look-up tables.

2.2 LOCAL CONTROL UNIT (LCU)

- .1 Provide multiple control functions for typical built-up and package HVAC systems, hydronic systems and electrical systems.
- .2 Minimum of 16 I/O points of which minimum be 4 AOs, 4 AIs, 4 DIs, 4 DOs.
- .3 Points integral to one Building System to be resident on only one controller.
- .4 Microprocessor capable of supporting necessary software and hardware to meet specified requirements as listed in previous MCU article with following additions:
 - .1 Include minimum two interface ports for connection of local computer terminal.
 - .2 Design so that shorts, opens or grounds on input or output will not interfere with other input or output signals.

- .3 Physically separate line voltage (70V and over) circuits from DC logic circuits to permit maintenance on either circuit with minimum hazards to technician and equipment.
- .4 Include power supplies for operation of LCU and associated field equipment.
- .5 In event of loss of communications with, or failure of, MCU, LCU to continue to perform control. Controllers that use defaults or fail to open or close positions not acceptable.
- .6 Provide conveniently located screw type or spade lug terminals for field wiring.

2.3 TERMINAL/EQUIPMENT CONTROL UNIT (TCU/ECU)

- .1 Microprocessor capable of supporting necessary software and hardware to meet TCU/ECU functional specifications.
 - .1 TCU/ECU definition to be consistent with those defined in ASHRAE HVAC Applications Handbook section 45.
- .2 Controller to communicate directly with EMCS through EMCS LAN and provide access from EMCS OWS for setting occupied and unoccupied space temperature setpoints, flow setpoints, and associated alarm values, permit reading of sensor values, field control values (% open) and transmit alarm conditions to EMCS OWS.
- .3 VAV Terminal Controller.
 - .1 Microprocessor based controller with integral flow transducer, including software routines to execute PID algorithms, calculate airflow for integral flow transducer and measure temperatures as per I/O Summary required inputs. Sequence of operation to ASHRAE HVAC Applications Handbook.
 - .2 Controller to support point definition; in accordance with Section 25 05 01 - EMCS: General Requirements.
 - .3 Controller to operate independent of network in case of communication failure.
 - .4 Controller to include damper actuator and terminations for input and output sensors and devices.

2.4 SOFTWARE

- .1 General.
 - .1 Include as minimum: operating system executive, communications, application programs, operator interface, and systems sequence of operation - CDL's.
 - .2 Include "firmware" or instructions which are programmed into ROM, EPROM, EEPROM or other non-volatile memory.
 - .3 Include initial programming of Controllers, for entire system.
- .2 Program and data storage.
 - .1 Store executive programs and site configuration data in ROM, EEPROM or other non-volatile memory.

- .2 Maintain CDL and operating data including setpoints, operating constants, alarm limits in battery-backed RAM or EEPROM for display and modification by operator.
- .3 Programming languages.
 - .1 Program Control Description Logic software (CDL) using English like or graphical, high level, general control language.
 - .2 Structure software in modular fashion to permit simple restructuring of program modules if future software additions or modifications are required. GO TO constructs not allowed unless approved by Consultant.
- .4 Operator Terminal interface.
 - .1 Operating and control functions include:
 - .1 Multi-level password access protection to allow user/manager to limit workstation control.
 - .2 Alarm management: processing and messages.
 - .3 Operator commands.
 - .4 Reports.
 - .5 Displays.
 - .6 Point identification.
- .5 Pseudo or calculated points.
 - .1 Software to provide access to value or status in controller or other networked controller in order to define and calculate pseudo point. When current pseudo point value is derived, normal alarm checks must be performed or value used to totalize.
 - .2 Inputs and outputs for process: include data from controllers to permit development of network-wide control strategies. Processes also to permit operator to use results of one process as input to number of other processes (e.g. cascading).
- .6 Control Description Logic (CDL):
 - .1 Capable of generating on-line project-specific CDLs which are software based, programmed into RAM or EEPROM and backed up to OWS. Owner must have access to these algorithms for modification or to be able to create new ones and to integrate these into CDLs on BC(s) from OWS.
 - .2 Write CDL in high level language that allows algorithms and interlocking programs to be written simply and clearly. Use parameters entered into system (e.g. setpoints) to determine operation of algorithm. Operator to be able to alter operating parameters on-line from OWS and BC(s) to tune control loops.
 - .3 Perform changes to CDL on-line.
 - .4 Control logic to have access to values or status of points available to controller including global or common values, allowing cascading or interlocking control.

- .5 Energy optimization routines including enthalpy control, supply temperature reset, to be LCU or MCU resident functions and form part of CDL.
- .6 MCU to be able to perform following pre-tested control algorithms:
 - .1 Two position control.
 - .2 Proportional Integral and Derivative (PID) control.
- .7 Control software to provide ability to define time between successive starts for each piece of equipment to reduce cycling of motors.
- .8 Provide protection against excessive electrical-demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.
- .9 Power Fail Restart: upon detection of power failure system to verify availability of Emergency Power as determined by emergency power transfer switches and analyse controlled equipment to determine its appropriate status under Emergency power conditions and start or stop equipment as defined by I/O Summary. Upon resumption of normal power as determined by emergency power transfer switches, MCU to analyse status of controlled equipment, compare with normal occupancy scheduling, turn equipment on or off as necessary to resume normal operation.
- .7 Event and Alarm management: use management by exception concept for Alarm Reporting. This is system wide requirement. This approach will ensure that only principal alarms are reported to OWS. Events which occur as direct result of primary event to be suppressed by system and only events which fail to occur to be reported. Such event sequence to be identified in I/O Summary and sequence of operation. Examples of above are, operational temperature alarms limits which are exceeded when main air handler is stopped, or General Fire condition shuts air handlers down, only Fire alarm status shall be reported. Exception is, when air handler which is supposed to stop or start fails to do so under event condition.
- .8 Energy management programs: include specific summarizing reports, with date stamp indicating sensor details which activated and or terminated feature.
 - .1 MCU in coordination with subordinate LCU, TCU, ECU to provide for the following energy management routines:
 - .1 Time of day scheduling.
 - .2 Calendar based scheduling.
 - .3 Holiday scheduling.
 - .4 Temporary schedule overrides.
 - .5 Optimal start stop.
 - .6 Night setback control.
 - .7 Enthalpy (economizer) switchover.
 - .8 Peak demand limiting.
 - .9 Temperature compensated load rolling.
 - .10 Fan speed/flow rate control.
 - .11 Cold deck reset.

- .12 Hot deck reset.
- .13 Hot water reset.
- .14 Chilled water reset.
- .15 Condenser water reset.
- .16 Chiller sequencing.
- .17 Night purge.
- .2 Programs to be executed automatically without need for operator intervention and be flexible enough to allow customization.
- .3 Apply programs to equipment and systems as specified or requested by the Consultant.
- .9 Function/Event Totalization: features to provide predefined reports which show daily, weekly, and monthly accumulating totals and which include high rate (time stamped) and low rate (time stamped) and accumulation to date for month.
 - .1 MCUs to accumulate and store automatically run-time for binary input and output points.
 - .2 MCU to automatically sample, calculate and store consumption totals on daily, weekly or monthly basis for user-selected analog or binary pulse input-type points.
 - .3 MCU to automatically count events (number of times pump is cycled off and on) daily, weekly or monthly basis.
 - .4 Totalization routine to have sampling resolution of one min or less for analog inputs.
 - .5 Totalization to provide calculations and storage of accumulations up to 99,999.9 units (eg. kWh, litres, tonnes, etc.).
 - .6 Store event totalization records with minimum of 9,999,999 events before reset.
 - .7 User to be able to define warning limit and generate user-specified messages when limit reached.

2.5 LEVELS OF ADDRESS

- .1 Upon operator's request, EMCS to present status of any single 'point', 'system' or point group, entire 'area', or entire network on printer or OWS as selected by operator.
 - .1 Display analog values digitally to one place of decimals with negative sign as required.
 - .2 Update displayed analog values and status when new values received.
 - .3 Flag points in alarm by blinking, reverse video, different colour, bracketed or other means to differentiate from points not in alarm.
 - .4 Updates to be change-of-value (COV)-driven or if polled not exceeding 2 second intervals.

2.6 POINT NAME SUPPORT

- .1 Controllers (MCU, LCU) to support PWGSC point naming convention as defined in Section 25 05 01 - EMCS: General Requirements.

3. EXECUTION

3.1 LOCATION

- .1 Location of Controllers to be approved by Consultant.

3.2 INSTALLATION

- .1 Install Controllers in secure locking enclosures.
- .2 Provide necessary power from local 120V branch circuit panel for equipment.
- .3 Install tamper locks on breakers of circuit breaker panel.
- .4 Use uninterruptible Power Supply (UPS) and emergency power when equipment must operate in emergency and co-ordinating mode.

END OF SECTION

1. GENERAL

1.1 SUMMARY

- .1 Section Includes:
 - .1 Control devices integral to the Building Automation System (BAS): transmitters, sensors, controls, meters, switches, transducers, dampers, damper operators, valves, valve actuators, and low voltage current transformers.
 - .2 Related Sections:
 - .1 Division 01 - Execution.
 - .2 Division 07 - Fire stopping.
 - .3 Section 23 33 15 - Dampers - Operating.
 - .4 Section 25 01 11 - BAS: Start-Up, Verification and Commissioning.
 - .5 Section 25 05 01 - BAS: General Requirements.
 - .6 Section 25 05 02 - BAS: Shop Drawings, Product Data and Review Process.
 - .7 Section 25 05 54 - BAS: Identification.
 - .8 Section 25 90 01 - BAS: Site Requirements Applications and Systems Sequences of Operation.
 - .9 Section 26 05 00 - Common Work Results for Electrical.
 - .10 Section 26 27 10 - Modular Wiring System.
 - .11 Section 26 27 26 - Wiring Devices.

1.2 REFERENCE STANDARDS

- .1 American National Standards Institute (ANSI).
 - .1 ANSI C12.7 Requirements for Watthour Meter Sockets.
 - .2 ANSI/IEEE C57.13, Standard Requirements for Instrument Transformers.
- .2 ASTM International (ASTM)
 - .1 ASTM B148, Standard Specification for Aluminum-Bronze Sand Castings.
- .3 National Electrical Manufacturer's Association (NEMA).
 - .1 NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
- .4 Air Movement and Control Association, Inc. (AMCA).
 - .1 AMCA Standard 500-D, Laboratory Method of Testing Dampers For Rating.
- .5 CSA Group CSA Group
 - .1 CSA-C22.1, Canadian Electrical Code, Part 1 (19th Edition), Safety Standard for Electrical Installations.

1.3 DEFINITIONS

- .1 Acronyms and Definitions: refer to Section 25 05 01 - BAS: General Requirements.

1.4 SHOP DRAWING SUBMITTALS

- .1 Submit shop drawings and manufacturer's installation instructions in accordance with Section 25 05 02 - BAS: Submittals and Review Process.
- .2 Pre-Installation Tests.
 - .1 Submit samples at random from equipment shipped, as requested by Consultant for testing before installation. Replace devices not meeting specified performance and accuracy.
- .3 Manufacturer's Instructions:
 - .1 Submit manufacturer's installation instructions for specified equipment and devices.

1.5 EXISTING CONDITIONS

- .1 Cutting and Patching: in accordance with Division 01 - Execution Requirements supplemented as specified herein.
- .2 Repair surfaces damaged during execution of Work.
- .3 Turn over to Owner existing materials removed from Work not identified for re-use.

2. PRODUCTS

2.1 GENERAL

- .1 Control devices of each category to be of same type and manufacturer.
- .2 External trim materials to be corrosion resistant. Internal parts to be assembled in watertight, shockproof, vibration-proof, heat resistant assembly.
- .3 Operating conditions: 0-40°C with 95% RH (non-condensing) unless otherwise specified.
- .4 Terminations: use standard conduit box with slot screwdriver compression connector block unless otherwise specified.
- .5 Transmitters and sensors to be unaffected by external transmitters including walkie talkies.
- .6 Account for hysteresis, relaxation time, maximum and minimum limits in applications of sensors and controls.
- .7 Outdoor installations: use weatherproof construction in NEMA 4 enclosures.
- .8 Provide devices installed in user occupied space that do not exceed Noise Criteria (NC) of 35. Noise generated by any device must not be detectable above space ambient conditions.
- .9 Range: including temperature, humidity, pressure, as indicated in I/O summary in Section 25 90 01 - BAS: Site Requirements, Applications and System Sequences of Operation.

2.2 TEMPERATURE SENSORS

- .1 General: except for room sensors to be resistance or thermocouple type to following requirements:200
 - .1 Thermocouples: limit to temperature range of 200°C and over.
 - .2 RTD's: 100 or 1000 ohm at 0°C (plus or minus 0.2 ohms) platinum element with strain minimizing construction, 3 integral anchored leadwires. Coefficient of resistivity: 0.00385 ohms/ohm degrees C.
 - .3 Sensing element: hermetically sealed.
 - .4 Stem and tip construction: copper or type 304 stainless steel.
 - .5 Time constant response: less than 3 seconds to temperature change of 10°C.
 - .6 Immersion wells: NPS 3/4, stainless steel spring loaded construction, with heat transfer compound compatible with sensor. Insertion length 150 mm as indicated.
- .2 Room temperature sensors and display wall modules.
 - .1 Temperature sensing and display wall module.
 - .1 LCD display to show space temperature and temperature setpoint.
 - .2 Buttons for occupant selection of temperature setpoint and occupied/unoccupied mode.
 - .3 Jack connection for plugging in laptop personal computer contractor supplied zone terminal unit for access to zone bus.
 - .4 Integral thermistor sensing element 10,000 ohm at 24 degrees.
 - .5 Accuracy 0.2 degrees C over range of 0 to 70 degrees C.
 - .6 Stability 0.02 degrees C drift per year.
 - .7 Separate mounting base for ease of installation.
 - .2 Room temperature sensors.
 - .1 Wall mounting, in slotted type covers having brushed stainless steel finish, with guard
 - .2 Element 10-50mm long RTD with ceramic tube or equivalent protection or thermistor, 10,000 ohm, accuracy of plus or minus 0.2 degrees C.
- .3 Duct temperature sensors:
 - .1 General purpose duct type: suitable for insertion into ducts at various orientations, insertion length 460 mm.
 - .2 Averaging duct type: incorporates numerous sensors inside assembly which are averaged to provide one reading. Minimum insertion length 6096 mm. Bend probe at field installation time to 100 mm radius at point along probe without degradation of performance.

- .4 Outdoor air temperature sensors:
 - .1 Outside air type: complete with probe length 100 - 150 mm long, non-corroding shield to minimize solar and wind effects, threaded fitting for mating to 13 mm conduit, weatherproof construction in NEMA 4 enclosure.

2.3 TEMPERATURE TRANSMITTERS

- .1 Requirements:
 - .1 Input circuit: to accept 3-lead, 100 or 1000 ohm at 0 degrees C, platinum resistance detector type sensors.
 - .2 Power supply: 24 VDC into load of 575 ohms. Power supply effect less than 0.01 degrees C per volt change.
 - .3 Output signal: 4 - 20 mA into 500 ohm maximum load.
 - .4 Input and output short circuit and open circuit protection.
 - .5 Output variation: less than 0.2% of full scale for supply voltage variation of plus or minus 10%.
 - .6 Combined non-linearity, repeatability, hysteresis effects: not to exceed plus or minus 0.5% of full scale output.
 - .7 Maximum current to 100 or 1000 ohm RTD sensor: not to exceed 25 mA.
 - .8 Integral zero and span adjustments.
 - .9 Temperature effects: not to exceed plus or minus 1.0% of full scale/ 50 degrees C.
 - .10 Long term output drift: not to exceed 0.25% of full scale/ 6 months.
 - .11 Transmitter ranges: select narrowest range to suit application from following:
 - .1 Minus 50 degrees C to plus 50 degrees C, plus or minus 0.5 degrees C.
 - .2 0 to 100 degrees C, plus or minus 0.5 degrees C.
 - .3 0 to 50 degrees C, plus or minus 0.25 degrees C.
 - .4 0 to 25 degrees C, plus or minus 0.1 degrees C.
 - .5 10 to 35 degrees C, plus or minus 0.25 degrees C.

2.4 HUMIDITY SENSORS

- .1 Room and Duct Requirements:
 - .1 Range: 5 - 90% RH minimum.
 - .2 Operating temperature range: 0 - 60 degrees C.
 - .3 Absolute accuracy:
 - .1 Duct sensors: plus or minus 3%.
 - .2 Room sensors: plus or minus 2%.

- .4 Sheath: stainless steel with integral shroud for specified operation in air streams of up to [10] m/s.
- .5 Maximum sensor non-linearity: plus or minus 2% RH with defined curves.
- .6 Room sensors: locate as indicated.
- .7 Duct mounted sensors: locate so that sensing element is in air flow in duct.
- .2 Outdoor Humidity Requirements:
 - .1 Range: 0 - 100% RH minimum.
 - .2 Operating temperature range: -40 - 50 degrees C.
 - .3 Absolute accuracy: plus or minus 2%.
 - .4 Temperature coefficient: plus or minus 0.03%RH/ degrees C over 0 to 50 degrees C.
 - .5 Must be unaffected by condensation or 100% saturation.
 - .6 No routine maintenance or calibration is required.

2.5 HUMIDITY TRANSMITTERS

- .1 Requirements:
 - .1 Input signal: from RH sensor.
 - .2 Output signal: 4 - 20 mA onto 500 ohm maximum load.
 - .3 Input and output short circuit and open circuit protection.
 - .4 Output variations: not to exceed 0.2 % of full scale output for supply voltage variations of plus or minus 10 %.
 - .5 Output linearity error: plus or minus 1.0% maximum of full scale output.
 - .6 Integral zero and span adjustment.
 - .7 Temperature effect: plus or minus 1.0 % full scale/ 6 months.
 - .8 Long term output drift: not to exceed 0.25 % of full scale output/ 6 months.

2.6 PRESSURE TRANSDUCERS

- .1 Requirements:
 - .1 Combined sensor and transmitter measuring pressure.
 - .1 Internal materials: suitable for continuous contact with industrial standard instrument air, compressed air, water, steam, as applicable.
 - .2 Output signal: 4 - 20 mA into 500 ohm maximum load.
 - .3 Output variations: less than 0.2 % full scale for supply voltage variations of plus or minus 10 %.
 - .4 Combined non-linearity, repeatability, and hysteresis effects: not to exceed plus or minus 0.5 % of full scale output over entire range.

- .5 Temperature effects: not to exceed plus or minus 1.5% full scale/ 50 degrees C.
- .6 Over-pressure input protection to at least twice rated input pressure.
- .7 Output short circuit and open circuit protection.
- .8 Accuracy: plus or minus 1% of full scale.

2.7 DIFFERENTIAL PRESSURE TRANSMITTERS

- .1 Requirements:
 - .1 Internal materials: suitable for continuous contact with industrial standard instrument air, compressed air, water, steam, as applicable.
 - .2 Output signal: 4 - 20 mA into 500 ohm maximum load.
 - .3 Output variations: less than 0.2% full scale for supply voltage variations of plus or minus 10%.
 - .4 Combined non-linearity, repeatability, and hysteresis effects: not to exceed plus or minus 0.5% of full scale output over entire range.
 - .5 Integral zero and span adjustment.
 - .6 Temperature effects: not to exceed plus or minus 1.5% full scale/ 50 degrees C.
 - .7 Over-pressure input protection to at least twice rated input pressure.
 - .8 Output short circuit and open circuit protection.
 - .9 Unit to have 12.5 mm N.P.T. conduit connection. Enclosure to be integral part of unit.

2.8 STATIC PRESSURE SENSORS

- .1 Requirements:
 - .1 Multipoint element with self-averaging manifold.
 - .1 Maximum pressure loss: 160 Pa at 10 m/s. (Air stream manifold).
 - .2 Accuracy: plus or minus 1% of actual duct static pressure.

2.9 STATIC PRESSURE TRANSMITTERS

- .1 Requirements:
 - .1 Output signal: 4 - 20 mA linear into 500 ohm maximum load.
 - .2 Calibrated span: not to exceed 150% of duct static pressure at maximum flow.
 - .3 Accuracy: 0.4% of span.
 - .4 Repeatability: within 0.5% of output.
 - .5 Linearity: within 1.5% of span.
 - .6 Deadband or hysteresis: 0.1% of span.
 - .7 External exposed zero and span adjustment.

- .8 Unit to have 12.5 mm N.P.T. conduit connection. Enclosure to be integral part of unit

2.10 VELOCITY PRESSURE SENSORS

- .1 Requirements:
 - .1 Multipoint static and total pressure sensing element with self-averaging manifold with integral air equalizer and straightener section.
 - .2 Maximum pressure loss: 37 Pa at 1000 m/s.
 - .3 Accuracy: plus or minus 1% of actual duct velocity.

2.11 VELOCITY PRESSURE TRANSMITTERS

- .1 Requirements:
 - .1 Output signal: 4 - 20 mA linear into 500 ohm maximum load.
 - .2 Calibrated span: not to exceed 125 % of duct velocity pressure at maximum flow.
 - .3 Accuracy: 0.4% of span.
 - .4 Repeatability: within 0.1% of output.
 - .5 Linearity: within 0.5% of span.
 - .6 Deadband or hysteresis: 0.1% of span.
 - .7 External exposed zero and span adjustment.
 - .8 Unit to have 12.5 mm N.P.T. conduit connection. Enclosure to be integral part of unit.

2.12 LIQUID AND STEAM FLOW METERS

- .1 Requirements:
 - .1 Pressure rating: as specified in I/O summaries.
 - .2 Temperature rating: as specified in I/O summaries.
 - .3 Repeatability: plus or minus 0.2 %.
 - .4 Accuracy and linearity: plus or minus 1.0%.
 - .5 Flow rangability: at least 10:1.
 - .6 Body material: cast or ductile iron.
 - .7 Ends:
 - .1 NPS 2 and under: screwed.
 - .2 NPS 2.1/2 and over: flanged.

2.13 PRESSURE AND DIFFERENTIAL PRESSURE SWITCHES

- .1 Requirements:
 - .1 Internal materials: suitable for continuous contact with compressed air, water, steam, etc., as applicable.

- .2 Adjustable setpoint and differential.
- .3 Switch: snap action type, rated at 120V, 15 amps AC or 24 V DC.
- .4 Switch assembly: to operate automatically and reset automatically when conditions return to normal. Over-pressure input protection to at least twice rated input pressure.
- .5 Accuracy: within 2% repetitive switching.
- .6 Provide switches with isolation valve and snubber, where code allows, between sensor and pressure source.
- .7 Switches on steam and high temperature hot water service: provide pigtail syphon.

2.14 TEMPERATURE SWITCHES

- .1 Requirements:
 - .1 Operate automatically. Reset automatically, except as follows:
 - .1 Low temperature detection: manual reset.
 - .2 High temperature detection: manual reset.
 - .2 Adjustable setpoint and differential.
 - .3 Accuracy: plus or minus 1 degrees C.
 - .4 Snap action rating: 120V, 15 amps or 24V DC as required. Switch to be DPST for hardwire and BAS connections.
 - .5 Type as follows:
 - .1 Room: for wall mounting on standard electrical box with or without protective guard as indicated.
 - .2 Duct, general purpose: insertion length = 460 mm.
 - .3 Thermowell: stainless steel, with compression fitting for NPS 3/4 thermowell. Immersion length: 100 mm.
 - .4 Low temperature detection: continuous element with 6096 mm insertion length, duct mounting, to detect coldest temperature in any 30 mm length.
 - .5 Strap-on: with helical screw stainless steel clamp.

2.15 TANK LEVEL SWITCHES

- .1 Requirements:
 - .1 Indicate high/low water level and to alarm.
 - .2 For mounting on top of tank.
 - .3 Maximum operating temperature: 120 degrees C.
 - .4 Snap action contacts rated 15 amp at 120 V.
 - .5 Adjustable setpoint and differential.

2.16 SUMP LEVEL SWITCHES

- .1 Requirements:
 - .1 Liquid level activated switch sealed in waterproof and shockproof enclosure.
 - .2 Complete with float, flexible cord, weight. Instrument casing to be suitable for immersion in measured liquid.
 - .3 N.O./N.C. Contacts rated at 15 amps at 120V AC. CSA approval for up to 250 volt 10 amps AC.

2.17 WIND VELOCITY TRANSMITTERS

- .1 Requirements:
 - .1 3-cup anemometer and airfoil vane mounted on common vertical axis, designed for mast mounting.
 - .2 Anemometer:
 - .1 Range: 0-160 km/h.
 - .2 Threshold: 3.0 km/h.
 - .3 Accuracy: +/- 2%.
 - .3 Airfoil vane
 - .1 Range: 0-360 degrees with infinite resolution potentiometer with no loss of reading at transition point.
 - .2 Starting threshold: 1.1 M/s.
 - .3 Accuracy: +/- 0.5%.
 - .4 Output signals: 4 to 20mA into 500 ohm load.
 - .5 Provide two output signals: velocity, direction.
 - .6 Mast: aluminum, size and height as indicated.

2.18 SOLAR SENSORS

- .1 Monitor solar radiation as indicated.
- .2 Pyranometer, black and white, producing proportional 0-50 mV signal. Include converter for 4-20 mA signal.

2.19 CURRENT / PNEUMATIC (I/P) TRANSDUCERS

- .1 Requirements:
 - .1 Input range: 4 to 20 mA.
 - .2 Output range: proportional 20-104 kPa or 20-186 kPa as applicable.
 - .3 Housing: dustproof or panel mounted.
 - .4 Internal materials: suitable for continuous contact with industrial standard instrument air.
 - .5 Combined non-linearity, repeatability, hysteresis effects: not to exceed plus or minus 2% of full scale over entire range.

- .6 Integral zero and span adjustment.
- .7 Temperature effect: plus or minus 2.0 % of full scale/ 50degrees C or less.
- .8 Regulated supply pressure: 206 kPa maximum.
- .9 Air consumption: 16.5 ml/s maximum.
- .10 Integral gauge manifold c/w gauge (0-206 kPa).

2.20 SOLENOID CONTROL AIR VALVES

- .1 Coil: 120V AC or 24V DC, as indicated.
- .2 Capacity: to pass a minimum of 0.15 l/s air at 140 kPa differential.

2.21 AIR PRESSURE GAUGES

- .1 Diameter: 38 mm minimum.
- .2 Range: zero to two times operating pressure of measured pressure media or nearest standard range.

2.22 ELECTROMECHANICAL RELAYS

- .1 Requirements:
 - .1 Double voltage, DPDT, plug-in type with termination base.
 - .2 Coils: rated for 120V AC or 24V DC. Other voltage: provide transformer.
 - .3 Contacts: rated at 5 amps at 120 V AC.
 - .4 Relay to have visual status indication

2.23 SOLID STATE RELAYS

- .1 General:
 - .1 Relays to be socket or rail mounted.
 - .2 Relays to have LED Indicator
 - .3 Input and output Barrier Strips to accept 14 to 28 AWG wire.
 - .4 Operating temperature range to be -20 degrees C to 70 degrees C.
 - .5 Relays to be CSA Certified.
 - .6 Input/output Isolation Voltage to be 4000 VAC at 25 degrees C for 1 second maximum duration.
 - .7 Operational frequency range, 45 to 65 HZ.
- .2 Input:
 - .1 Control voltage, 3 to 32 VDC.
 - .2 Drop out voltage, 1.2 VDC.
 - .3 Maximum input current to match AO (Analog Output) board.
- .3 Output:
 - .1 AC or DC Output Model to suit application.

2.24 CURRENT TRANSDUCERS

- .1 Requirements:
- .2 Purpose: combined sensor/transducer, to measure line current and produce proportional signal in one of following ranges:
 - .1 4-20 mA DC.
 - .2 0-1 volt DC.
 - .3 0-10 volts DC.
 - .4 0-20 volts DC.
- .3 Frequency insensitive from 10 - 80 hz.
- .4 Accuracy to 0.5% full scale.
- .5 Zero and span adjustments. Field adjustable range to suit motor applications.
- .6 Adjustable mounting bracket to allow for secure/safe mounting inside MCC.

2.25 CURRENT SENSING RELAYS

- .1 Requirements:
 - .1 Suitable to detect belt loss or motor failure.
 - .2 Trip point adjustment, output status LED.
 - .3 Split core for easy mounting.
 - .4 Induced sensor power.
 - .5 Relay contacts: capable of handling 0.5 amps at 30 VAC / DC. Output to be NO solid state.
 - .6 Suitable for single or 3 phase monitoring. For 3-Phase applications: provide for discrimination between phases.
 - .7 Adjustable latch level.

2.26 CONTROL DAMPERS

- .1 Construction: blades, 152 mm wide, 1219 mm long, maximum. Modular maximum size, 1219 mm wide x 1219 mm high. Three or more sections to be operated by jack shafts.
- .2 Materials:
 - .1 Frame: 2.03 mm minimum thickness extruded aluminum. For outdoor air and exhaust air applications, frames to be insulated.
 - .2 Blades: extruded aluminum. For outdoor air/exhaust air applications, blades to be internally insulated.
 - .3 Bearings: maintenance free, synthetic type of material.
 - .4 Linkage and shafts: aluminum, zinc and nickel plated steel.
 - .5 Seals: synthetic type, mechanically locked into blade edges.
 - .1 Frame seals: synthetic type, mechanically locked into frame sides.

- .3 Performance: minimum damper leakage meet or exceed AMCA Standard 500-D] ratings.
 - .1 Size/Capacity: refer to damper schedule
 - .2 25 L/s/m² maximum allowable leakage against 1000 Pa static pressure for outdoor air and exhaust air applications.
 - .3 Temperature range: minus 40 degrees C to plus 100 degrees C.
- .4 Arrangements: dampers mixing warm and cold air to be parallel blade, mounted at right angles to each other, with blades opening to mix air stream.
- .5 Jack shafts:
 - .1 25 mm diameter solid shaft, constructed of corrosion resistant metal complete with required number of pillow block bearings to support jack shaft and operate dampers throughout their range.
 - .2 Include corrosion resistant connecting hardware to accommodate connection to damper actuating device.
 - .3 Install using manufacturers installation guidelines.
 - .4 Use same manufacturer as damper sections.

2.27 PNEUMATIC CONTROL DAMPER ACTUATORS

- .1 Requirements:
 - .1 Piston type with spring return for "fail-safe" in Normally Open or Normally Closed position, as indicated.
 - .2 Operator: size to control dampers against maximum pressure and dynamic opening/closing pressure, whichever is greater.
 - .3 Adjustable spring and stroke external stops to limit strokes in either direction.
 - .4 For modulating applications provide with full relay type positioner with interconnecting linkage for mechanical feedback. Adjust to operate between range of 20-90 kPa unless otherwise indicated in control sequence of operation or input/output summary sheet.
 - .5 Positioners not required on single damper sections with less than 1 m² face area.

2.28 ELECTRONIC CONTROL DAMPER ACTUATORS

- .1 Requirements:
 - .1 Direct mount proportional type as indicated.
 - .2 Spring return for "fail-safe" in Normally Open or Normally Closed position as indicated.
 - .3 Operator: size to control dampers against maximum pressure and dynamic closing/opening pressure, whichever is greater.
 - .4 Power requirements: 5 VA maximum at 24 V AC.
 - .5 Operating range: 0 - 10 V DC or 4 - 20 mA DC.

- .6 For VAV box applications floating control type actuators may be used.
- .7 Damper actuator to drive damper from full open to full closed in less than 120 seconds.

2.29 CONTROL VALVES

- .1 Body: globe style or characterized ball.
 - .1 Flow characteristic as indicated on control valve schedule: linear, equal percentage, or quick opening.
 - .2 Flow factor (KV) as indicated on control valve schedule: CV in imperial units.
 - .3 Normally open or normally closed as indicated.
 - .4 Two or Three port, as indicated.
 - .5 Leakage rate ANSI class IV, 0.01% of full open valve capacity.
 - .6 Packing easily replaceable.
 - .7 Stem, stainless steel.
 - .8 Plug and seat, stainless steel.
 - .9 Disc, replaceable, material to suit application.
 - .10 NPS 2 and under:
 - .1 Screwed National Pipe Thread (NPT) tapered female connections.
 - .2 Valves to ANSI Class [250], valves to bear ANSI mark.
 - .3 Rangeability 50:1 minimum.
 - .11 NPS 2½ and larger:
 - .1 Flanged connections.
 - .2 Valves to ANSI Class 150 or 250 as indicated, valves to bear ANSI mark.
 - .3 Rangeability 100:1 minimum.
- .2 Butterfly Valves NPS 2 and larger:
 - .1 Body: for chilled water ANSI Class 150 or 250 as indicated cast iron lugged body installed in locations as indicated. For steam and heating water ANSI Class 150 or 250 as indicated carbon steel lugged body.
 - .2 Extended stem neck to provide adequate clearance for flanges and insulation.
 - .3 Pressure limit: bubble tight sealing to [170] kilopascals.
 - .4 Disc/vane: 316 stainless steel.
 - .5 Seat: for service on chilled water [PTFE (polytetrafluoroethylene)], [EPDM (ethylene propylene diene monomer)]. For service on steam and heating water [PTFE], [RTFE (reinforced PTFE)].
 - .6 Stem: 316 stainless steel.

- .7 Flow factor (KV) as indicated on control valve schedule: CV in imperial units.
- .8 Flow characteristic linear.
- .9 Maximum flow requirement as indicated on control valve schedule.
- .10 Maximum pressure drop as indicated on control valve schedule: pressure drop not to exceed one half of inlet pressure.
- .11 Normally open or normally closed, as indicated.
- .12 Valves are to be provided complete with mounting plate for installation of actuators.

2.30 PNEUMATIC VALVE ACTUATORS

- .1 Requirements:
 - .1 Construction: steel, cast iron, aluminum.
 - .2 Diaphragm: moulded Buna-N rubber, nylon reinforced.
 - .3 Spring return to normal position.
 - .4 Spring range adjustment and position indicator.
 - .5 Provide pilot positioners on modulating control valves over 50 mm and where indicated on drawings and I/O summary. Positioners to operate between 20 to 90 kPa unless otherwise noted or required by sequence.
 - .6 Minimum shut-off pressure: refer to control valve schedule.

2.31 ELECTRONIC / ELECTRIC VALVE ACTUATORS

- .1 Requirements:
 - .1 Construction: steel, cast iron, aluminum.
 - .2 Control signal: 0-10V DC or 4-20 mA DC.
 - .3 Positioning time: to suit application. 90 sec maximum.
 - .4 Fail to normal position as indicated.
 - .5 Scale or dial indication of actual control valve position.
 - .6 Size actuator to meet requirements and performance of control valve specifications.
 - .7 For interior and perimeter terminal heating and cooling applications floating control actuators are acceptable.
 - .8 Minimum shut-off pressure: refer to control valve schedule.

2.32 WATTHOUR METERS AND CURRENT TRANSFORMERS

- .1 Requirements:

- .1 Include three phases, test and terminal blocks for watthour metre connections and connections for monitoring of current. Provide two transformers for 600 V 3 wire systems for watthour metre use. Accuracy: plus or minus 0.25% of full scale. For chiller applications: to have instantaneous indicator with analog or digital display.
- .2 Watthour metre sockets: to ANSI C12.7.
- .3 Potential and current transformers: to ANSI/IEEE C57.13.
- .4 Potential transformers: provide two primary fuses.
- .5 Demand meters: configure to measure demand at [15] minute intervals.

2.33 SURFACE WATER DETECTORS

- .1 Requirements:
 - .1 Provide alarm on presence of water on floor.
 - .2 Expendable cartridge sensor.
 - .3 Internal waterproof switch.
 - .4 One set of dry contacts 2 amps at 24 V.
 - .5 Unaffected by moisture in air.
 - .6 Self-powered.

2.34 PANELS

- .1 Enamelled steel cabinets with hinged and key-locked front door.
- .2 Additional space to accommodate 25% additional capacity as required without adding additional cabinets.
- .3 Panels to be lockable with same key.

2.35 CONTROL AIR COMPRESSOR STATIONS

- .1 Requirements: provide 2 high pressure, base mounted, each complete with belts, guards, intake muffler, replaceable cartridge intake cleaner, starter, pressure switches, alternator.
- .2 Capacity: size to maintain air pressure, meet control air requirements on 25% maximum running time.
- .3 Receiver: size to suit running time. Complete with electronic automatic drain with strainer, pressure relief valve, pressure gauge ASME code rated for 1400 kPa.
- .4 Vibration isolation: 5% transmissibility.
- .5 Refrigerated air drier:
 - .1 Two continuous operating type, complete with refrigerant evaporator, mechanical condensate separator, installed with 2 isolating valves. Designed for 1400 kPa maximum operating pressure.
 - .2 Capacity: sized for full capacity of compressors, to reduce dewpoint to minus 10 degrees C when dehydrating at 700 kPa. Maximum pressure drop 19 kPa at rated capacity.

- .3 Provide 2 filter and PRV assemblies, with isolating valves and filter element, having 99% efficiency in removal of 0.5 micron diameter solid particles and oil aerosols and with indication of degree of saturation.
Piping: ensure one dryer is always in circuit and active.

2.36 WIRING

- .1 In accordance with Section 26 27 10 - Modular Wiring System or 26 27 26 - Wiring Devices as applicable.
- .2 For wiring under 70 volts use FT6 rated wiring where wiring is not run in conduit. Other cases use FT4 wiring.
- .3 Wiring must be continuous without joints.
- .4 Sizes:
 - .1 Field wiring to digital device: #18AWG or 20AWG stranded twisted pair.
 - .2 Analog input and output: shielded #18 minimum solid copper or #20 minimum stranded twisted pair.

3. EXECUTION

3.1 INSTALLATION

- .1 Install equipment, components so that manufacturer's and CSA labels are visible and legible after commissioning is complete.
- .2 Install field control devices in accordance with manufacturers recommended methods, procedures and instructions.
- .3 Temperature transmitters, humidity transmitters, current-to-pneumatic transducers, solenoid air valves, controllers, relays: install in NEMA I enclosure or as required for specific applications. Provide for electrolytic isolation in cases when dissimilar metals make contact.
- .4 Support field-mounted panels, transmitters and sensors on pipe stands or channel brackets.
- .5 Fire stopping: provide space for fire stopping in accordance with Division 07 - Fire Stopping. Maintain the fire-resistance rating integrity of the fire separation.
- .6 Electrical:
 - .1 Complete installation in accordance with Section 26 05 00 - Common Work Results for Electrical.
 - .2 Modify existing starters to provide for BAS as indicated in I/O Summaries and as indicated.
 - .3 Refer to electrical control schematics included as part of control design schematics in Section [25 90 01 - BAS: Site Requirements Applications and Systems Sequences of Operation or on drawings. Trace existing control wiring installation and provide updated wiring schematics including additions, deletions to control circuits for review by Consultant before beginning Work.
 - .4 Terminate wires with screw terminal type connectors suitable for wire size, and number of terminations.

- .5 Install communication wiring in conduit.
 - .1 Provide complete conduit system to link Building Controllers, field panels and OWS(s).
 - .2 Conduit sizes to suit wiring requirements and to allow for future expansion capabilities specified for systems.
 - .3 Maximum conduit fill not to exceed 40%.
 - .4 Design drawings do not show conduit layout.
- .6 Do not run exposed conduits in normally occupied spaces unless otherwise indicated or unless impossible to do otherwise. Consultant to review before starting Work. Wiring in mechanical rooms, wiring in service rooms and exposed wiring must be in conduit.
- .7 Pneumatic: provide Pneumatic tubing, valves and fittings for field control devices in accordance with Section 23 09 43 - Pneumatic Control System for HVAC.
- .8 Mechanical: supply and install in accordance with Section 23 09 43 - Pneumatic Control System for HVAC.
 - .1 Pipe Taps.
 - .2 Wells and Control Valves.
 - .3 Air flow stations, dampers, and other devices.
- .9 VAV Terminal Units: supply, install and adjust as required.
 - .1 Air probe, actuator and associated vav controls.
 - .2 Tubing from air probe to dp sensor as well as installation and adjustment of air flow sensors and actuators.
 - .3 Co-ordinate air flow adjustments with balancing trade.

3.2 TEMPERATURE AND HUMIDITY SENSORS

- .1 Stabilize to ensure minimum field adjustments or calibrations.
- .2 Readily accessible and adaptable to each type of application to allow for quick easy replacement and servicing without special tools or skills.
- .3 Outdoor installation:
 - .1 Protect from solar radiation and wind effects by non-corroding shields.
 - .2 Install in NEMA 4 enclosures.
- .4 Duct installations:
 - .1 Do not mount in dead air space.
 - .2 Locate within sensor vibration and velocity limits.
 - .3 Securely mount extended surface sensor used to sense average temperature.
 - .4 Thermally isolate elements from brackets and supports to respond to air temperature only.

- .5 Support sensor element separately from coils, filter racks.
- .5 Averaging duct type temperature sensors.
 - .1 Install averaging element horizontally across the ductwork starting 305 mm from top of ductwork. Each additional horizontal run to be no more than 305 mm from one above it. Continue until complete cross sectional area of ductwork is covered. Use multiple sensors where single sensor does not meet required coverage.
 - .2 Wire multiple sensors in series for low temperature protection applications.
 - .3 Wire multiple sensors separately for temperature measurement.
 - .4 Use software averaging algorithm to derive overall average for control purposes.
- .6 Thermowells: install for piping installations.
 - .1 Locate well in elbow where pipe diameter is less than well insertion length.
 - .2 Thermowell to restrict flow by less than 30%.
 - .3 Use thermal conducting paste inside wells.

3.3 PANELS

- .1 Arrange for conduit and tubing entry from top, bottom or either side.
- .2 Wiring and tubing within panels: locate in trays or individually clipped to back of panel.
- .3 Identify wiring and conduit clearly.

3.4 MAGNEHELIC PRESSURE INDICATORS

- .1 Install adjacent to fan system static pressure sensor and duct system velocity pressure sensor as reviewed by Consultant.
- .2 Locations: as indicated.

3.5 PRESSURE AND DIFFERENTIAL PRESSURE SWITCHES AND SENSORS

- .1 Install isolation valve and snubber on sensors between sensor and pressure source where code allows.
 - .1 Protect sensing elements on steam and high temperature hot water service with pigtail syphon between valve and sensor.

3.6 I/P TRANSDUCERS

- .1 Install air pressure gauge on outlet.

3.7 AIR PRESSURE GAUGES

- .1 Install pressure gauges on pneumatic devices, I/P, pilot positioners, motor operators, switches, relays, valves, damper operators, valve actuators.
- .2 Install pressure gauge on output of auxiliary cabinet pneumatic devices.

3.8 IDENTIFICATION

- .1 Identify field devices in accordance with Section 25 05 54 - BAS: Identification.

3.9 AIR FLOW MEASURING STATIONS

- .1 Protect air flow measuring assembly until cleaning of ducts is completed.

3.10 TESTING AND COMMISSIONING

- .1 Calibrate and test field devices for accuracy and performance in accordance with Section 25 01 11 - BAS: Start-up, Verification and Commissioning.

END OF SECTION