

MECHANICAL SPECIFICATIONS
for
University of Toronto – QIS Laboratory & CQIQC
Suite
Project No. P078-24-109

November, 2025

ISSUED FOR TENDER

mcCallumSather

286 Sanford Avenue North
Hamilton Ontario L8L 6A1

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Mechanical Work General Instructions

1 GENERAL

1.01 REFERENCES

- .1 The General Conditions of the Contract, any Supplementary Conditions, and all Sections of Division 01 apply to and are a part of this Section of the specification.

1.02 APPLICATION

- .1 This Section specifies requirements that are common to mechanical work Sections of the Specification and it is a supplement to each Section and is to be read accordingly.

1.03 SUBMITTALS

- .1 As specified in this Section, submit the following to the Consultant:
 - .1 **Project Close-Out Documentation:** O & M Manuals, record as-built drawings, and all associated data.
 - .2 **Progress Payment Breakdown:** a detailed breakdown of the mechanical work cost
 - .3 **O & M Training Schedules & Modules:** a proposed schedule of demonstration and training dates and times, and a preliminary copy of the training manual developed for operational and maintenance training

1.04 DEFINITIONS

- .1 The following are definitions of words found in mechanical work Sections of the Specification and on associated drawings:
 - .1 "concealed" – means work hidden from normal sight in furred spaces, shafts, tunnels, ceiling spaces, walls and partitions
 - .2 "exposed" – means work normally visible, including work in equipment rooms and similar spaces
 - .3 "provide" (and tenses of provide) – means supply and install complete
 - .4 "install" (and tenses of install) – means install and connect complete
 - .5 "supply" – means supply only
 - .6 "finished area" - means any area or part of an area which receives a finish such as paint, or is factory finished
 - .7 "governing authority" and/or "regulatory authority" and/or "Municipal authority" – means all government departments, agencies, standards, rules and regulations that apply to and govern the mechanical work and to which the work must adhere
 - .8 "Consultant" – means the Architect or Consulting Engineer who has prepared the Contract Documents on behalf of the Owner.
- .2 Wherever the words "indicated", "shown", "noted", "listed", or similar words or phrases are used in the specification they are understood, unless otherwise defined, to mean that the product referred to is "indicated", "shown", "listed", or "noted" on the drawings.

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- .3 Wherever the words "approved", "satisfactory", "as directed", "submit", "permitted", "inspected" or similar words or phrases are used in the specification or on the drawings they are understood, unless otherwise defined, to mean that work or product referred to is "approved by", "inspected by", etc., the Consultant.
- .4 In the mechanical specification, singular may be read as plural, and vice-versa.

1.05 CODES, REGULATIONS, AND STANDARDS

- .1 All Codes, Regulations, and Standards referred to in this Section and in Sections to which this Section applies are the latest edition of the Codes, Regulations, and Standards in effect at the time of bidding on this Project.
- .2 All work is to be in accordance with requirements with Codes, Regulations, and Standards applied by governing authorities.
- .3 All mechanical piping system work, including equipment, must comply in all respects with requirements of local technical standards authorities and ANSI Z9.5-2003, CSA B149-15, & other applicable codes. Where required, mechanical work products must bear a ULC & CRN number.
- .4 Where any governing Code, Regulation, or Standard requires preparation and submission of special details or drawings for review they are to be prepared and submitted. Pay all associated costs associated with these submittals.
- .5 All electrical items associated with mechanical equipment are to be certified and bear the stamp or seal of a recognized testing agency such as CSA, UL, ULC, ETL, etc., or bear a stamp to indicate special electrical utility approval.
- .6 Requirements of the Contract Documents are to take precedence when they are more stringent than codes, ordinances, standards, and statutes.

1.06 EXAMINATION OF SITE AND DOCUMENTS

- .1 When estimating the cost of the work and prior to submitting a bid for the work carefully examine all of the bid documents and visit the site to determine and review all existing site conditions that will or may affect the work, and include for all such conditions in the bid price.

1.07 DRAWINGS AND SPECIFICATION

- .1 The mechanical drawings are performance drawings, diagrammatic, and show approximate locations of equipment and connecting services. Any information regarding accurate measurement of the building are to be taken at the site. Do not scale the drawings, and do not use the drawings for prefabrication work.
- .2 The drawings are intended to convey the scope of work and do not show architectural and structural details. Provide, at your cost, all offsets, fittings, transformations, and similar products required as a result of obstructions and other architectural and structural details but not shown on the drawings.
- .3 The locations of equipment and materials shown may be altered, when reviewed by the Consultant, to meet requirements of the equipment and/or materials, other equipment or systems being installed, and of the building, all at your cost.

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- .4 Sections of the mechanical specification are not intended to delegate functions nor to delegate work and supply of materials to any specific trade, but rather to generally designate a basic unit of work, and the Sections are to be read as a whole.
- .5 The mechanical specification does not generally indicate the specific number of items or extent of material required. The specification is intended to provide product data and installation requirements. It is necessary to refer to drawing schedules, layouts, schematic diagrams, riser diagrams, and details to determine correct quantities.
- .6 The mechanical drawings and specification are intended to be cooperative. Perform all work that is shown, specified, or reasonably implied on the drawings but not mentioned in the specification, or vice-versa, as though fully covered by both.
- .7 When the scale and date of the drawings are the same, or when the discrepancy exists within the specification, the most costly arrangement will take precedence.
- .8 In the case of discrepancies between the drawings and specifications, the documents will govern in the order specified in the General Conditions, however, when the scale and date of the drawings are the same, or where the discrepancy exists within the specification, the most costly arrangement will take precedence.

1.08 PLANNING AND LAYOUT OF THE WORK, AND ASSOCIATED DRAWINGS

- .1 Properly plan, coordinate, and establish the locations and routing of services with all subcontractors affected prior to installation such that the services will clear each other as well as any obstructions, including structural components of the building. Unless otherwise specified, the order of right-of-way for services is to be as follows:
 - .1 piping requiring uniform pitch
 - .2 piping 4" diameter and larger
 - .3 large ducts (main runs)
 - .4 electrical cable tray and bus duct
 - .5 conduit 4" diameter and larger
 - .6 piping less than 4" diameter
 - .7 smaller branch ductwork
 - .8 conduit less than 4" diameter
- .2 Unless otherwise shown or specified, conceal all work in finished areas, and conceal work in partially finished or unfinished areas to the extent made possible by the area construction. Install piping, ductwork, and similar services as high as possible to conserve headroom and/or ceiling space. Notify the Consultant where headroom or ceiling space appears to be inadequate prior to installation of the work.
- .3 Revise or alter the arrangement of work that has been installed without proper coordination, study and review, even if it was completed in accordance with the Contract Documents, in order to conceal the work behind finishes, or to allow the installation of other work, at no additional cost. In addition, pay for the cost of alterations in other work required by the alterations to your work.

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- .4 All shut-off valves, balancing devices, air vents, equipment and similar products, particularly such products located above suspended ceilings must be located for easy access for servicing and/or removal. Products which do not meet this location requirement are to be relocated to an accessible location at no additional cost.
- .5 **Layout Drawings:** Do not use the Contract Drawing measurements for prefabrication and layout of piping and sheet metal work. Locations and routing are to generally be in accordance with the Contract Drawings, however, layout drawings are to be prepared for all such work. Use established bench marks for both horizontal and vertical measurements. Confirm inverts, coordinate with and make allowances for the work of other trades, accurately layout the work, and be entirely responsible for all work installed in accordance with layout drawings. Where any invert, grade, or size is at variance with the Contract Drawings, notify the Consultant prior to proceeding with the work.
- .6 **Interference Drawings:** Prepare dimensioned working interference drawings, supplementary to the Contract Drawings for all areas where multiple services and/or equipment occur, or where the work due to architectural and structural considerations requires special study and treatment. Review interference drawings with the Consultant before the work is installed. Where your work has been installed in such areas without preparation of interference drawings and conflicts occur, revise your work to suit at no additional cost.

1.09 COORDINATION OF THE WORK

- .1 Review all the Contract Documents and coordinate the work with the work of all subcontractors. Coordination requirements are to include, but not be limited to, the following:
 - .1 preparation of electronic coordination drawings as required, submitted as for shop drawings, with drawing scale as required to indicate the necessary details
 - .2 written notification of all concrete work such as housekeeping pads required for mechanical work, and including required dimensions, operating weight of equipment, location, etc.
 - .3 schematic wiring for all wiring work required for mechanical equipment and systems but not specified to be done as part of the mechanical work, including termination points, wiring type and size, and any other requirements

1.10 GENERAL RE: INSTALLATION OF EQUIPMENT

- .1 Unless otherwise specified all equipment is to be installed in accordance with the equipment manufacturer's recommendations and instructions, and requirements of governing Codes, Standards, and Regulations. Governing Codes, Standards, and Regulations take precedence over manufacturer's instructions.
- .2 Ensure that proper access and service clearances are maintained around equipment, and, where applicable, access space for future equipment removal or replacement is not impeded. Remove and replace any equipment which does not meet this requirement.

1.11 PERMITS, FEES, AND CERTIFICATES

- .1 Apply for, obtain and pay for all permits required to complete the mechanical work.

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- .2 Submit to the Consultant, all approval/inspection certificates issued by governing authorities to confirm that the work as installed is in accordance with the rules and regulations of the governing authorities. Pay any costs associated with issue of the certificates.
- .3 Include a copy of all approval/inspection certificates in each operating and maintenance manual.

1.12 WORKPLACE SAFETY

- .1 Comply with requirements of the Workplace Hazardous Materials Information System (WHMIS) regarding the use, handling, storage and disposal of hazardous materials. Submit WHMIS MSDS (Material Safety Data Sheets) for all products where required, and maintain one copy at the site in a visible and accessible location available to all personnel.
- .2 Comply with all requirements of Occupational Health and Safety Regulations and all other regulations pertaining to health and safety, including worker's compensation/ insurance board and fall protection regulations.

1.13 SHOP DRAWINGS AND PRODUCT DATA SHEETS

- .1 Prior to supplying any products to the site, submit for review, shop drawings and/or product data sheets indicating in detail the design, construction, and performance of products as requested in Sections of this Specification. The number of copies of shop drawings and/or product data sheets will be as later directed.
- .2 Shop drawings are those prepared specifically for the Project. Product data sheets are copies of manufacturer's standard catalogue, etc., literature.
- .3 Shop drawings and product data sheets must confirm that the product proposed meets all requirements of the Contract Documents.
- .4 Each shop drawing or product data sheet is to be properly identified with the project name and the product drawing or specification reference, i.e. "Exhaust Fan EF-1", and all shop drawing or product data sheet dimensions are to be either SI or Imperial to match dimensions on the drawings.
- .5 **Carefully review each shop drawing and product data sheet prior to submittal to ensure that the proposed product is correct and meets with all requirements of the Project.** Endorse each copy of each shop drawing or product data sheet "Correct for Review By Consultant", or "Certified to Be In Accordance With All Requirements" and include your company name, the submittal date, and the signature of an officer of your company to indicate your review and approval as above.
- .6 The Consultant will review shop drawings and product data sheets and will indicate the review status by stamping the shop drawings and product data sheets as follows:
 - .1 **"Reviewed" or "Reviewed As Noted"** to indicate that his review is final and no re-submittal is required
 - .2 **"Returned For Correction"** to indicate that the submission is rejected and is to be revised in accordance with comments marked on the shop drawings and product data sheets by the Consultant and re-submitted

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- .7 The Consultant will retain one or two copies of each shop drawing or product data sheet submission.
- .8 The following is to be read in conjunction with the wording on the Consultant's review stamp applied to each and every mechanical work shop drawing or product data sheet submitted:

"This review is for the sole purpose of ascertaining conformance with the general design concept. This review does not approve the detail design inherent in the shop drawings, responsibility for which remains with the Contractor, and such review does not relieve the Contractor of the responsibility for errors or omissions in the shop drawings or of his responsibility for meeting all requirements of the Contract Documents. Be 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."

1.14 CHANGES OR REVISIONS TO THE WORK

- .1 Whenever the Consultant proposes in writing to make a change or revision to the design, arrangement, quantity or type of any work from that required by the Contract Documents, prepare and submit to the Consultant for approval, a quotation being your proposed cost for executing the change or revision.
- .2 Your quotation is to be a detailed and itemized estimate of all products, material, labour, and equipment costs associated with the change or revision, plus overhead and profit percentages and all applicable taxes and duties.
- .3 Unless otherwise stated in the Contract Documents, the following requirements apply to all quotations submitted:
 - .1 when the change or revision involves deleted work as well as additional work, the cost of the deleted work (less overhead and profit percentages but including taxes and duties) is to be subtracted from the cost of the additional work before overhead and profit percentages are applied to the additional work
 - .2 material costs are not to exceed those published in local estimating price guides such as Allpriser, less applicable trade discounts.
 - .3 mechanical material labour unit costs are to be in accordance with the Mechanical Contractors Association of *Canada* Estimating Manual, Less 25%.
 - .4 electrical material labour unit costs are to be in accordance with the National Electrical Contractors Association of *Canada* Manual of Labor Units, less 25%.
 - .5 costs for journeyman and apprentice labour must not exceed prevailing rates at the time of execution of the Contract and must reflect the actual personnel performing the work
 - .6 cost for the site superintendent shall be included as part of the total hours of labour estimated for the change or revision, and the change or revision must be such that the site superintendent's involvement is necessary
 - .7 costs for rental tools and/or equipment are not to exceed local rental costs

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- .8 if overhead and profit percentages are not specified in the General Conditions of the Contract, Supplementary Conditions, or elsewhere in preceding Sections of the Specification, but allowable under the Contract, then allowable percentages for overhead and profit are to be 5% and 5% respectively
- .9 the overhead percentage will be deemed to cover all quotation costs other than actual site labour, product and materials, and rentals
- .10 All quotations, including those for deleted work, must include a figure for any required change to the Contract time.
- .4 Quotations submitted that are not in accordance with requirements specified above will be rejected and returned for re-submittal. Failure to submit a proper quotation to enable the Consultant to expeditiously process the quotation and issue a Change Order will not be grounds for any additional change to Contract time.
- .5 If, in your opinion, changes or revisions to the work should be made, inform the Consultant in writing and, if the Consultant agrees a Notice of Change will be issued.
- .6 Do not execute any change or revision until written authorization for the change or revision has been obtained

1.15 SCAFFOLDING, RIGGING, AND HOISTING

- .1 Unless otherwise specified or directed, supply, erect and operate all scaffolding, rigging, hoisting equipment and associated hardware required for your work. Immediately remove from the site all scaffolding, rigging, and hoisting equipment when no longer required.

1.16 PROJECT CLOSEOUT SUBMITTALS

- .1 Prior to application for Substantial Performance, submit all required items and documentation specified, including the following:
 - .1 Operating and Maintenance Manuals
 - .2 as-built record drawings and associated data
 - .3 extended warranties for equipment as specified
 - .4 final commissioning report and TAB report
 - .5 identified keys for mechanical equipment and/or panels for which keys are required, and all other items required to be submitted
 - .6 other data or products specified
- .2 **Operating and Maintenance Manuals:** Submit three hard copies of operating and maintenance manuals consolidated in hardcover three "D" ring binders, each binder sized to include approximately 25% spare space for future data, and identified permanently with the Project name, "MECHANICAL OPERATING AND MAINTENANCE MANUAL" wording, and the date. Manuals are to include the following:
 - .1 an Introduction sheet listing the Consultant's, Contractor's, and Subcontractor names, street addresses, telephone and fax numbers, and e-mail addresses;

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- .2 a Table of Contents sheet, and corresponding index tab sheets;
- .3 a copy of each "Reviewed" or "Reviewed As Noted" shop drawing or product data sheet, with manufacturer's/supplier's name, telephone and fax numbers, email address, and the email address for local source of parts and service;
- .4 pressure test reports, and certificates issued by governing authorities;
- .5 **Operating Data:** Operating data is to include:
 - .1 a description of each system and its controls
 - .2 control schematics for equipment/systems including building environmental controls
 - .3 if applicable, the building automation system (BAS) architecture and all required operating data
 - .4 description of operation of each system at various loads together with reset schedules and seasonal variances
 - .5 operation instruction for each system and each component
 - .6 description of actions to be taken in event of emergencies and/or equipment failure
 - .7 valve tag schedule, and flow diagrams to indicate valve locations
- .6 **Maintenance Data:** Maintenance data is to include:
 - .1 servicing maintenance, operation and trouble-shooting instructions for each item of equipment and each system
 - .2 schedules of tasks, frequency, tools required, and estimated task time
 - .3 complete parts lists with numbers
- .7 **Performance Data:** Performance data is to include:
 - .1 equipment and system start-up data sheets
 - .2 equipment performance verification test results, and final commissioning report
 - .3 final testing adjusting and balancing reports
- .8 **Review Submittal:** Assemble one copy of the O & M Manual and submit to the Consultant for review prior to Owner training and instructions, and assembling the remaining copies. Incorporate all comments into the final submission.
- .9 **Digital O & M Manuals:** Submit four digital versions of the hard copy manual using the latest version of Adobe Acrobat Portable Document Format and enhanced with bookmarks, internet links, and internal document links. The digital copies are to be copied to CDR with custom labels which indicate the project name, date, the Consultant's name, and "Operating & Maintenance Manual for Mechanical Systems".

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- .3 **Record "As-Built" Drawings and Data:** As work progresses at the site, clearly mark in red in a neat and legible manner on a set of white prints of the Contract Drawings, all significant changes and deviations from the routing of services and locations of equipment shown on the Contract Drawings and resulting from the issue of Addenda, Site Instructions, Change Orders, and job conditions. Use notes marked in red as required. Maintain the white print red line as-built set at the site for the exclusive use of recording as-built conditions, keep the set up-to-date at all times, and ensure that the set is always available for periodic review. The as-built set is also to include the following:
 - .1 the dimensioned location of all inaccessible concealed work
 - .2 the locations of control devices with identification for each
 - .3 the location of all piping system air vents and water hammer arrestors
 - .4 the location and tag identification for all tagged valves
 - .5 for underground piping, record dimensions, invert elevations, all offsets, fittings, and accessories if applicable, and locate dimensions from benchmarks that will be preserved after construction is complete
 - .6 **Digital Record "As-Built" Drawings:** When work on site is complete, transfer all the as-built red line information from the site as-built drawings to a recordable and identified CAD disc with CAD work of equal quality to the Contract Drawings. Obtain a CAD disc as described below.
 - .7 **Obtaining CAD Discs:** The mechanical drawings have been prepared on a CAD system using the latest Release of AutoCad software. For the purpose of producing final as-built drawings, discs of the Contract Drawings will be supplied free of charge by the Consultant.
 - .8 **Review and Submittal:** Prior to inspection for Substantial Performance of the work, submit for review, the red line site as-built white prints, a CAD disc of the as-built drawings, and a bound set of white prints (of equal quality to the Contract Drawings) made from the disc. The Consultant will review the drawings and, if necessary, return the disc and the marked-up white prints for corrections or further revisions, in which case complete the corrective and/or revision work and resubmit the disc and white prints until they are determined to be acceptable, all prior to issue of a Certificate of Substantial Performance.

1.17 PROGRESS PAYMENT BREAKDOWN

- .1 Submit, prior to submittal of the first progress payment draw, a breakdown of the cost of the mechanical work to assist the Consultant in reviewing and approving monthly progress payment claims.
- .2 The payment breakdown is subject to the Consultant's approval and progress payments will not be processed until an approved breakdown is in place. The breakdown is to include one-time claim items such as mobilization and demobilization, insurance, bonds (if applicable), shop drawings and product data sheets, commissioning including testing, adjusting and balancing, and project closeout submittals.
- .3 Equipment, material and labour costs are to be indicated for plumbing and drainage, HVAC piping, HVAC sheet metal, fuel systems, controls, and insulation work, etc., in the same manner as they will be indicated on the monthly progress draw.

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1.18 EQUIPMENT AND MATERIAL MANUFACTURER REQUIREMENTS

- .1 Equipment and materials scheduled or specified on the drawings or in the Specification have been selected to establish a performance and quality standard.
- .2 In most cases acceptable equipment and material manufacturers are listed for any product specified by manufacturer's name and model number. Unless otherwise stated the bid price may be based on products supplied by any of the manufacturers named as acceptable for the particular product. If acceptable manufacturers are not listed for a particular product, base the bid price on the products supplied by the specified manufacturers.
- .3 If products supplied by a manufacturer named as acceptable are used in lieu of the products specified by manufacturer's name and model number, ensure that the product is equivalent in performance and operating characteristics (including energy efficiency if applicable) to the specified product. Pay for any additional costs and changes to associated or adjacent work resulting from the use of products supplied by a manufacturer other than the specified manufacturer. In addition, in equipment spaces where products named as acceptable are used in lieu of the specified products and the dimensions of such products differ from the specified products prepare and submit for review, if requested, accurately dimensioned layouts of the rooms affected to prove that all the equipment in the room will fit properly.

1.19 SUBSTITUTED OR ALTERNATIVE PRODUCTS

- .1 Products supplied by a manufacturer/supplier other than a manufacturer specified as acceptable may be considered for acceptance by the Consultant if requested in writing a minimum of five full working days prior to the bid closing date. Requests may be made by letter, by fax, or by email. Telephone requests will not be considered.
- .2 Each request for acceptance of a proposed substitution or alternative product must be accompanied by detailed catalogue and engineering data, fabrication information, and performance characteristics to permit the Consultant to make an informed decision.
- .3 Pay for any additional costs and changes to associated or adjacent work resulting from the use of products supplied by a substituted or alternative manufacturer. In addition, in equipment spaces where substituted or alternative products are used in lieu of the specified or acceptable products and the dimensions of such products differ from the specified or acceptable products, prepare and submit for review, if requested, accurately dimensioned layouts of the rooms affected to prove that all the equipment in the room will fit properly.
- .4 The Consultant's decision regarding any proposed substitution or alternative product is final.

1.20 EQUIPMENT AND SYSTEM MANUFACTURER'S CERTIFICATION

- .1 When equipment/system installation is complete, but prior to start-up procedures, arrange and pay for the equipment/system manufacturer's authorized representative to visit the site to examine the installation, and when any required corrective measures have been made, to certify in writing to the Consultant that the equipment/system installation is complete and in accordance with the equipment/system manufacturer's instructions.

Mechanical Work General Instructions

1.21 EQUIPMENT AND SYSTEM START-UP

- .1 When installation of equipment/systems is complete but prior to commissioning, perform start-up for equipment/systems as specified in mechanical work Sections in accordance with the following requirements:
 - .1 submit a copy of each equipment/system manufacturer's start-up report sheet to the Consultant for review, and incorporate any comments
 - .2 under direct on-site supervision and involvement of the equipment/system manufacturer's representative, start-up the equipment/systems, make any required adjustments, document the procedures, leave the equipment/systems in proper operating condition, and submit a complete set of start-up documentation sheets signed by the manufacturer/supplier and the Contractor

1.22 EQUIPMENT AND SYSTEM O & M DEMONSTRATION & TRAINING

- .1 Train the Owner's designated personnel in all aspects of operation and maintenance of equipment and systems as specified in mechanical work Sections of the Specification. All demonstrations and training is to be performed by qualified technicians employed by the equipment/system manufacturer/supplier.
- .2 For each item of equipment and for each system for which training is specified, prepare training modules as specified below. Operating and Maintenance Manuals are to be used during the training sessions, and training modules are to include:
 - .1 **Operational Requirements and Criteria:** Requirements and criteria are to include but not be limited to equipment function, stopping and starting, safeties, operating standards, operating characteristics, performance curves, and limitations.
 - .2 **Troubleshooting:** Troubleshooting is to include but not be limited to diagnostic instructions, test and inspection procedures.
 - .3 **Documentation:** Documentation is to include but not be limited to equipment/system warranties, and manufacturer's/supplier's parts and service facilities, telephone numbers, email addresses, and the like.
 - .4 **Maintenance:** Maintenance requirements are to include but not be limited to inspection instructions, types of cleaning agents to be used as well as cleaning methods, preventive maintenance procedures, and use of any special tools.
 - .5 **Repairs:** Repair requirements are to include but not be limited to diagnostic instructions, disassembly, component removal and repair instructions, instructions for identifying parts and components, and review of any spare parts inventory.
- .3 Assemble the training modules into a training manual and submit a copy to the Consultant for review prior to scheduling training. Ensure that each participant in each training session has all required training material.
- .4 Schedule demonstrations and training at mutually agreed to times with a minimum of seven working days notice.

2 PRODUCTS

NOT APPLICABLE

Mechanical Work General Instructions

3 EXECUTION

NOT APPLICABLE

END OF SECTION

Basic Mechanical Materials and Methods

1 GENERAL

1.01 APPLICATION

- .1 This Section specifies products, common criteria and characteristics, and methods and execution that are common to one or more mechanical work Sections of the Specification, and is intended as a supplement to each Section and is to be read accordingly.

1.02 SUBMITTALS

- .1 Submit the following for review:
- .1 **product data sheets:** submit for:
 - .1 pressure gauges and thermometers
 - .2 Hangers
 - .3 strainers
 - .4 drain valves
 - .5 electric motors (submit with equipment they are associated with)
 - .2 **access door locations:** submit white prints of architectural reflected ceiling plan drawings and elevation drawings to indicate proposed access door locations in walls and ceilings in finished areas
 - .3 **list of equipment nameplates:** submit a list of equipment identification nameplates indicating proposed wording and sizes
 - .4 **pipe & duct identification:** submit a list of pipe and duct identification colour coding and wording
 - .5 **valve tag chart:** submit a proposed valve tag chart and a list of proposed valve tag numbering and identification wording
 - .6 **waste management and reduction plan:** submit a waste management and reduction plan prior to commencing work and as per requirements specified in this Section
 - .7 **drive belts:** as specified in Part 2 of this Section, submit a spare belt set, tagged and identified, for each belt driven piece of equipment

2 PRODUCTS

2.01 Pipe Sleeves

- .1 **Galvanized Sheet Steel:** Minimum #16 gauge galvanized steel with an integral flange at one end to secure the sleeve to formwork construction.

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- .2 **Polyethylene:** Factory fabricated, flanged, high density polyethylene sleeves with reinforced nail bosses.
- .3 **Waterproof Sleeves:** Schedule 40 mild galvanized steel pipe with a welded-on square steel anchor and water stop plate at the sleeve midpoint, or PSI-Thunderline "Century-Line" Model CS HDPE sleeves.
- .4 **Galvanized Steel or Cast Iron Pipe:** Schedule 40 mild galvanized steel, or Class 4000 cast iron.

2.02 FIRESTOPPING AND SMOKE SEAL MATERIALS

- .1 Firestopping and smoke seal system materials for mechanical penetrations through fire rated construction are specified in Division 07 and the work will be done as part of the work of Division 07.

2.03 WATERPROOFING SEAL MATERIALS

- .1 Modular, mechanical seal assemblies consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and the pipe sleeve or wall opening, assembled with stainless steel bolts and pressure plates and designed so that when the bolts are tightened the links expand to seal the opening watertight. The seal assemblies are to be selected to suit the pipe size and the sleeve size or wall opening size. Acceptable products are:
 - .1 Thunderline Corp. (Power Plant Supply Co.) "LINK SEAL" Model S-316;
 - .2 The Metraflex Co. "MetraSeal" type ES.

2.04 PIPE ESCUTCHEON PLATES

- .1 One-piece chrome plated brass or #4 finish type 302 stainless steel plates with matching screws for attachment to the building surface, each plate sized to completely cover the pipe sleeve or building surface opening, and to fit tightly around the pipe or pipe insulation.

2.05 PIPING HANGERS AND SUPPORTS

- .1 **General:** Pipe hanger and support materials, including accessories, are to be, unless otherwise specified, in accordance with the Manufacturers Standardization Society (MSS) Standard Practice Manual SP-58, Pipe hangers and Supports-Materials, Design and Manufacture, and where possible, MSS designations are indicated with each product specified below. Conform to the following requirements:
 - .1 unless otherwise specified, all ferrous hanger and support products are to be electro-galvanized
 - .2 hangers and supports for insulated piping are to be sized to fit around the insulation and the insulation jacket
- .2 **Horizontal Suspended Piping:** Hangers and supports are to be:
 - .1 adjustable steel clevis hanger – Anvil Fig. 260 – MSS Type 1

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- .2 adjustable swivel ring band type hanger – Anvil Fig. 69 – MSS Type 10
- .3 **Horizontal Pipe On Vertical Surfaces:** Epoxy coated steel pipe stays are not permitted. Supports are to be:
 - .1 steel offset pipe clamp – Anvil Fig. 103 or Myatt Fig. 170
 - .2 heavy-duty steel pipe bracket – Anvil Fig. 262 or Myatt Fig. 161 – MSS Type 26
 - .3 single steel pipe hook - Myatt Fig. 156
- .4 **Vertical Piping on Vertical Surfaces:** Epoxy coated steel pipe stays are not permitted. Supports are to be:
 - .1 steel offset pipe clamp – Anvil Fig. 103 or Myatt Fig. 170
 - .2 heavy-duty steel pipe bracket or soil pipe bracket – Anvil Fig. 262 or Myatt Fig. 161 – MSS Type 26
 - .3 extension split pipe clamp – Anvil Fig's. 138R or Myatt Fig. 129 – MSS Type 12
- .5 **Horizontal Pipe On Racks:** Unistrut or equal galvanized steel pipe racks with pipe securing hardware.
- .6 **Special Hangers and Supports:** Special hangers and supports for various applications are as follows:
 - .1 **vibration isolated riser supports** – black steel riser clamps as specified above, complete with neoprene–steel–neoprene sandwich type vibration isolation pads between the clamp and the floor
 - .2 **for groups of pipes having the same slope** – Anvil Fig. 195 welded steel brackets, Anvil Fig. 46 universal trapeze assemblies, or Unistrut or equal support assemblies, all with U-bolts, clamps, etc., to secure pipes in place
 - .3 **for sections of piping connected to vibration isolated equipment** – hangers and supports as specified above but complete with MSS Type 48 spring cushions
 - .4 **for plastic piping above ground** – generally as specified above but in accordance with the pipe manufacturer's printed recommendations
 - .5 **for bare horizontal copper piping** – generally as above but factory vinyl coated to prevent direct copper/steel contact
 - .6 **for bare copper vertical piping** – corrosion resistant ferrous clamps with flexible rubber gasket type material (not tape) to isolate the pipe from the clamp
 - .7 **insulation protection shields to & including 40 mm (1½") diameter** – equal to Anvil "Rib-Lok" Fig. 168 galvanized steel shields with ribs to keep the shield centred on the hanger.

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- .7 **Hanger Rods:** Electro-galvanized carbon steel (unless otherwise specified), round, threaded, to ASTM A36, complete with captive machine nuts with washers at hangers, sized to suit the loading in accordance with Table 3 in MSS SP-58, but in any case minimum 9.5 mm (3/8") diameter.
- .8 **Acceptable Manufacturers:** Acceptable hanger and support material manufacturers are:
 - .1 E. Myatt & Co. Inc.
 - .2 Anvil International Inc.
 - .3 Empire Tool & Mfg. Co. Inc.
 - .4 Hunt Manufacturing Ltd.
 - .5 Unistrut Canada Ltd.
 - .6 Nibco Inc. "Tolco"
 - .7 Taylor Pipe Supports

2.06 PIPING ALIGNMENT GUIDES

- .1 Prime coat painted black carbon steel pipe alignment guides sized and fabricated to suit the pipe size and the pipe insulation thickness. Acceptable products are:
 - .1 Senior Flexonics Ltd. Series PGT
 - .2 E. Myatt & Co. Ltd. Fig. 1267
 - .3 Empire Tool & Mfg. Inc. Fig 256
 - .4 The Metraflex Co. Style IV

2.07 PIPE ANCHORS

- .1 Welded structural black steel anchors of a design, size, and type to securely anchor the pipe at the point shown. Each anchor is to withstand 150% of axial thrust, and, as specified in Part 1 of this Section, is to be designed and detailed by a Professional Structural Engineer.

2.08 PIPING STRAINERS

- .1 Wye shaped strainers, bronze with sweat type or flanged connections in copper piping, cast iron with screwed, flanged, or grooved end connections in steel piping, minimum 1725 kPa (250 psi) rated and complete with a removable perforated type 304 stainless steel 20 mesh screen, and, for strainers 40 mm (1½") diameter and larger, a blow down pipe connection tapping.
- .2 Strainer for vehicle service piping systems are specified in the mechanical work Section entitled Vehicle Service Piping, Valves, and Specialties.

2.09 PIPING DRAIN VALVES

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- .1 Minimum 2070 kPa (300 psi) water rated, 20 mm ($\frac{3}{4}$ ") diameter, straight pattern full port bronze ball valves, each complete with a threaded outlet suitable for coupling connection of 20 mm ($\frac{3}{4}$ ") diameter garden hose, and a cap and chain. Acceptable products are:
 - .1 Toyo Valve Co. Fig. 5046
 - .2 Dahl Brothers Canada Ltd. Fig. No. 50 430
 - .3 Kitz Corporation Code 58CC
 - .4 Apollo Valves # 78-104-01
 - .5 Watts Industries (Canada) Inc. #B6000-CC

2.10 ACCESS DOORS

- .1 Prime coat painted steel (unless otherwise specified) flush access doors, each complete with a minimum #16 gauge frame, minimum #18 gauge door panel, heavy-duty rust-resistant concealed hinges, a positive locking screwdriver lock, and mounting and finishing features to suit the particular construction in which it is to be installed.
- .2 Access door sizes are to suit the concealed work for which they are supplied, and wherever possible they are to be of a standard size for all applications, but in any case they are to be minimum 300 mm x 300 mm (12" x 12") for hand entry and 600 mm x 600 mm (24" x 24") for body entry.
- .3 Access doors in fire rated construction are to be ULC listed and labelled and of a rating to maintain the fire separation integrity.
- .4 Where access doors are located in surfaces where special finishes are required, they are to be of a recessed door type capable of accepting the finish in which they are to be installed so as to maintain the final building surface appearance throughout, and constructed of stainless steel with a #4 finish.

2.11 PRESSURE GAUGES AND THERMOMETERS

- .1 **Pressure Gauges:** Adjustable, glycerine filled, 100 mm or 115 mm (4" or 4½") diameter, each accurate to within 1% of scale range and complete with a type 304 stainless steel case with relief valve and polished stainless steel bayonet, stainless steel rotary movement with stainless steel bushings and socket, a clear acrylic window, a dual scale white dial with a scale range such that the working pressure of the system is at the approximate mid-point of the scale, and black pointer. Acceptable products are:
 - .1 H. O. Trerice Co. No. 700 Series;
 - .2 Weiss Instruments Model LF4S-2
 - .3 Ashcroft #35-1009 SWL-26
- .2 **Pressure Gauge Accessories & Additional Requirements:** Accessories and additional requirements are as follows:
 - .1 a bronze ball type shut-off valve is to be provided in the piping to each pressure gauge

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- .2 each pressure gauge for piping and equipment with normal everyday flow is to be equipped with a brass pressure snubber
- .3 pressure gauges in fire protection piping must be ULC listed and labelled.
- .3 **Thermometers:** Round, 125 mm (5") diameter, adjustable (90°) angle bimetal dial type thermometers, each accurate to within 1% of full scale and complete with a hermetically sealed stainless steel case with stainless steel ring, dampened bimetal coil, calibration adjustment screw, white aluminum dual scale dial with black and blue markings and a range such that the working temperature of the system is the approximate mid-point of the scale, black aluminum pointer, double strength glass window, 12 mm (½") NPT connection with 6.4 mm (¼") diameter stainless steel stem, and a suitable thermowell. Acceptable products are:
 - .1 H.O. Trerice Co. B85600 Series;
 - .2 Weiss Instruments Model 5VBM25;
 - .3 Ashcroft #50EI60E-040-0/250.

2.12 MECHANICAL WORK IDENTIFICATION MATERIALS

- .1 **Equipment Nameplates:** Minimum 1.6 mm (1/16") thick 2-ply laminated coloured plastic plates, minimum 12 mm x 50 mm (½" x 2") for smaller items such as damper motors and control valves, minimum 25 mm x 65 mm (1" x 2½") for equipment, and minimum 50 mm x 100 mm (2" x 4") for control panels and similar items. Additional requirements are as follows:
 - .1 unless otherwise specified or required, each nameplate is to be white, complete with bevelled edges and black engraved capital letter wording to completely identify the equipment and its use with no abbreviations;
 - .2 wording is generally to be as per the drawings, i.e. Fan EF-1, and is to include equipment service and building area/zone served, but must be reviewed prior to engraving;
 - .3 supply stainless steel screws for securing nameplates in place;
 - .4 nameplates for equipment suspended above floor level or generally not within easy viewing from floor level are to be increased in size so as to be easily readable from floor level.
- .2 **Valve Tags:** Coloured, 40 mm (1½") square, 2-ply laminated plastic with bevelled edges, red-white, green-white, yellow-black, etc., to match the piping identification colour, each complete with a 3.2 mm (1/8") diameter by 100 mm (4") long brass plated steel bead chain, and four lines of engraved maximum size identification wording, i.e.:

VALVE V12
75 mm (3")
HTG. WATER
NORMALLY OPEN

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- .1 **Pipe Identification:** Pipe identification is to be equal to Smillie McAdams Summerlin Ltd. or Brady coiled type snap-on markers of a length to wrap completely around the pipe or pipe insulation, weather-proof type where located outdoors.
- .3 **Pipe Identification Wording and Colours:** Identification wording and colours for pipe identification materials are to be as follows:

PIPE SERVICE	IDENTIFICATION COLOUR	LEGEND
domestic cold water	green	DOM. COLD WATER
domestic hot water supply	green	DOM. HW SUPPLY
domestic hot water recirculation	green	DOM. HW RECIRC.
tempered domestic water	green	TEMP. DOM. WATER
storm drainage	green	STORM
sanitary drainage	green	SAN.
plumbing vent	green	SAN. VENT
acid sanitary drainage	yellow	ACID DRAIN
fire protection standpipe	red	F.P. STANDPIPE
fire protection sprinklers	red	F.P. SPRINKLER
natural gas	to Code	to Code, c/w pressure
natural gas vent	to Code	to Code
fuel oil supply	yellow	FUEL OIL SUPPLY
fuel oil return	yellow	FUEL OIL RETURN
fuel oil vent	yellow	FUEL OIL VENT
heating water supply	yellow	HTG. WTR. SUPPLY
heating water return	yellow	HTG. WTR. RETURN
heating water drain	yellow	HTG. WTR. DRAIN
glycol heating supply	yellow	GLY. HTG. SUPPLY
glycol heating return	yellow	GLY. HTG. RETURN
glycol heating drain	yellow	GLY. HTG. DRAIN
glycol heat reclaim return	yellow	GLY. HTG. RECLAIM R.
glycol heat reclaim supply	yellow	GLY. HTG. RECLAIM S.
refrigerant suction	yellow	REFRIG. SUCTION
refrigerant liquid	yellow	REFRIG. LIQUID

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PIPE SERVICE	IDENTIFICATION COLOUR	LEGEND
refrigerant hot gas	yellow	REFRIG. HOT GAS
diesel engine exhaust	yellow	ENGINE EXHAUST
compressed air (< 700 kPa)	greenkPa COMP. AIR
compressed air (>700 kPa)	yellowkPa COMP. AIR

- .4 **Colours For Legends & Arrows:** Colours for pipe identification legends and directional arrows are to be as follows:

IDENTIFICATION COLOUR	LEGEND & ARROW COLOUR
yellow	black
green	white
red	white

- .5 **Duct Identification:** Custom made Mylar stencils with 50 mm (2") high lettering to accurately describe the duct service, i.e. "AHU-1 SUPPLY", complete with a directional arrow, and coloured ink with ink pads and roller applicators. Ink colour is generally to be black but must contrast with the lettering background.

2.13 FLEXIBLE CONNECTORS

- .1 Double wall stainless steel flexible connectors for piping connections to vibration isolated equipment, each selected by the manufacturer to suit the application. Shop drawings or product data sheets must indicate construction and performance requirements that suit the application. Acceptable manufacturers are:
- .1 Hyspan Precision Products Inc.
 - .2 Senior Flexonics Ltd.
 - .3 The Metraflex Co.

3 EXECUTION

3.01 GENERAL PIPING AND DUCTWORK INSTALLATION REQUIREMENTS

- .1 Unless otherwise specified, locate and arrange horizontal pipes and ducts above or at the ceiling on floors on which they are shown, arranged so that under consideration of all other work in the area, the maximum ceiling height and/or usable space is maintained. If required to maintain ceiling heights, reroute and/or resize ductwork, with Consultant's approval.
- .2 Unless otherwise specified, install all work concealed in finished spaces, and concealed to the degree possible in partially finished and unfinished spaces. Refer to and examine the Architectural drawings and room finish schedules to determine finished, partially finished, and unfinished areas. Note that walls which are painted are considered finished.

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- .3 Install all pipes and ducts parallel to building lines and to each other.
- .4 Neatly group and arrange all exposed work.
- .5 **Service and Maintenance Access:** Locate all work to permit easy access for service or maintenance as required and/or applicable. Locate all valves, dampers and any other equipment which will or may need maintenance or repairs and which are installed in accessible construction so as to be easily accessible from access doors. Where valves, dampers and similar piping or ductwork accessories occur in vertical services in shafts, pipe spaces or partitions, locate the accessories at the floor level.
- .6 **Dissimilar Metal Pipe Connections:** Make all connections between pipes of different materials using proper approved adapters. Provide cast brass dielectric type adapters/unions at connections between ferrous and copper pipe.
- .7 **Manufacturer's Instructions:** Ensure that equipment and material manufacturer's installation instructions are followed unless otherwise specified herein or on the drawings, and unless such instructions contradict governing codes and regulations.
- .8 **Cleaning:** Carefully clean all ducts, pipe and fittings prior to installation. Temporarily cap or plug ends of pipe, ducts and equipment which are open and exposed during construction.
- .9 **Insulation Clearance:** Install piping and ductwork which are to be insulated so that they have sufficient clearance to permit insulation and finish to be applied continuously and unbroken around the pipe or duct, except for ductwork at fire barriers, in which case the insulation will be terminated at each side of the duct fire damper.
- .10 **Surfaces To Receive Your Work:** Inspect surfaces and structure prepared by other trades before performing your work. Verify that surfaces or the structure to receive your work have no defects or discrepancies which could result in poor application or cause latent defects in installation and workmanship. Report defects in writing. Installation of your work will constitute acceptance of such surfaces as being satisfactory.
- .11 **Piping Rust and Dirt:** Any ferrous piping that exhibits in excess of 5% surface rust, either inside or outside or both is to be wire brush cleaned to bare metal and coated with suitable primer. Steel pipe, fittings and accessories are to be free of corrosion and dirt when work is complete or prior to being concealed from view. Where dirt is evident, clean the piping prior to being concealed.
- .12 **Repair of Finished Surfaces:** For factory applied finishes, repaint or refinish all surfaces damaged during shipment and installation. The quality of the repair work is to match the original finish. This requirement also applies to galvanized finishes.
- .13 **Unions and Flanges:** Whether shown or specified on the drawings or not, provide screwed unions or flanges in all piping connections to equipment, and in regular intervals in piping runs in excess of 12 m (40') to permit removal of sections of piping.
- .14 **Elbows and Eccentric Reducers:** Unless otherwise specified and except where space limitations do not permit, all piping elbows are to be long radius. Eccentric reducers are to be installed with the straight side at the top of the piping.

3.02 PIPE JOINT REQUIREMENTS

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- .1 Do not make pipe joints in walls or slabs.
- .2 Ream all piping ends prior to making joints.
- .3 **Screwed Steel Piping:** Properly cut threads in screwed steel piping and coat male threads only with Teflon tape or paste, or an equivalent thread lubricant. After the pipe has been screwed into the fitting, valve, union, or piping accessory, not more than two pipe threads are to remain exposed.
- .4 **Welded Steel Piping:** Site bevel steel pipe to be welded or supply mill bevelled pipe. Remove all scale and oxide from the bevels and leave smooth and clean. Use factory made welding tees or welding outlet fittings for piping branches off mains. Do not use shop or site fabricated fittings unless written approval has been obtained.
- .5 **Welding Requirements:** Welding is to be TSSA registered. Welded joints are to be made by CWB certified, licensed journeyman welders qualified in accordance with CSA B51, Boiler Pressure Vessel and Pressure Piping Code, and who are in possession of a proper certificate of qualification for each procedure to be performed. Each weld is to be identified with the welder's identification symbol, and welds are not to be concealed until they have been inspected and approved. Electrodes are to be in accordance with CSA W48 Series, Electrodes, and requirements of CAN/CSA W117.2, Safety in Welding, Cutting and Allied Processes are to be followed.
- .6 **Flanged Joints:** Unless otherwise specified, make all flanged joints with EDPM gasket materials to suit the application, and bolts and nuts. Bolts are not to be longer than the length necessary to screw the nut up flush to the end of the bolt. Bolts used for flanged connections in all piping with a working pressure of 690 kPa (100 psi) and greater are to be ASTM A-193, Grade B-7, with heavy hexagon nuts to ASTM A-194, CL-2H. Provide suitable washers between each bolt head and the flange and between each nut and the flange.
- .7 **Examination of Flanged Joints:** A random check of bolted flanged connections will be made to verify that flanged connections are properly mated with no shear force acting on bolts. Supply all labour to disconnect and reconnect the selected flanged joints. If improperly mated joints are found, remove and reinstall the affected piping so that the flanges mate properly. If improperly mated joints are found, additional joints will be checked, and you will be responsible for the repair of any other improper joints discovered.
- .8 **Soldered Joints:** Unless otherwise specified make all soldered joints in copper piping using flux suitable for and compatible with the type of solder being used. Clean the outside of the pipe end and the inside of the fitting, valve, or similar accessory prior to soldering. Comply with requirements of ASTM B828, Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings.
- .9 **Mechanical Joints:** Install mechanical joint fittings and couplings in accordance with the manufacturer's instructions.
- .10 **Grooved Pipe & Coupling Joints:** Grooves are to be rolled. Make arrangements with the coupling and fitting manufacturer for shop and/or site instructions and demonstrations as required, and adhere to the manufacturer's instructions with respect to pipe grooving, support, type of gasket required, anchoring and guiding the grooved piping system.

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- .11 **Pressure Crimped Piping Joints:** If pressure crimped couplings and fittings are used, ensure that gaskets are fully compatible with the piping fluid, and that all valves and piping accessories are suitable. Use only fitting manufacturer supplied crimping equipment. Comply with the manufacturer's latest published specification, instructions, and recommendations with respect to pipe, coupling, and fitting preparation and installation, and support, anchoring and guiding of the piping system.

3.03 INSTALLATION OF PIPE SLEEVES

- .1 Where pipes pass through concrete and/or masonry surfaces provide pipe sleeves as follows:
- .1 **in poured concrete slabs:** unless otherwise specified - minimum 16 gauge flanged galvanized steel or, where permitted by governing authorities, factory fabricated plastic sleeves;
 - .2 **in concrete or masonry walls:** Schedule 40 galvanized steel pipe or Class 4000 cast iron pipe.
- .2 **Waterproof Sleeves:** Sleeves in waterproofed slabs or walls are to be lengths of Schedule 40 mild galvanized steel pipe with a mid-length water stop plate. Provide waterproof sleeves in the following locations:
- .1 in slabs over mechanical, fan, electrical and telephone equipment rooms or closets
 - .2 in the roof slab
 - .3 in waterproof walls
- .3 Size sleeves, unless otherwise specified, to leave 12 mm (½") clearance around the pipes, or where the pipe is insulated, a 12 mm (½") clearance around the pipe insulation.
- .4 Pack and seal the void between the pipe sleeves and the pipe or pipe insulation in non-fire rated construction for the length of the sleeves as follows:
- .1 **interior construction:** pack sleeves in interior construction with mineral wool and seal both ends of the sleeves with non-hardening silicone base caulking compound;
 - .2 **exterior walls above grade:** pack sleeves in exterior walls above grade with mineral wool and seal both ends of the sleeves water-tight with approved non-hardening silicone base caulking compound unless mechanical type seals have been specified;
 - .3 **exterior walls below grade:** seal sleeves in exterior walls below grade (and any other wall where water leakage may be a problem) with link type mechanical seals as specified below.
- .5 Where sleeves are required in masonry work, accurately locate and mark the sleeve location, and hand the sleeves to the mason for installation.
- .6 Terminate piping for sleeves that will be exposed so that the sleeve is flush at both ends with the building surface concerned so that the sleeve may be completely covered by an escutcheon plate, except for sleeves in waterproof floors which are to terminate 100 mm (4") above the finished floor.

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- .7 "Gang" type sleeving will not be permitted.

3.04 INSTALLATION OF WATERPROOF MECHANICAL SEALS

- .1 Provide watertight link type mechanical seals in exterior wall openings where shown or specified.
- .2 Assemble and install each mechanical seal in accordance with the manufacturer's instructions.
- .3 After installation, periodically check each mechanical seal installation for leakage and, if necessary, tighten link seal bolts until the seal is completely watertight.

3.05 DUCT OPENINGS

- .1 Duct openings, air inlet and outlet openings, fire damper and similar openings will be provided in new poured concrete work, masonry, drywall and other building surfaces by the trade responsible for the particular construction in which the opening is required.
- .2 Ensure that openings for fire dampers to 600 mm (24") high are sized to suit the damper arrangement with the folding blade out of the air stream.
- .3 For all duct openings except where fire dampers are required, pack and seal the space between the duct or duct insulation and the duct opening as specified above for pipe openings in non-fire rated construction.

3.06 SLEEVE AND FORMED OPENING LOCATION DRAWINGS

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

3.07 INSTALLATION OF PIPE ESCUTCHEON PLATES

- .1 Provide escutcheon plates suitable secured over all exposed piping passing through finished building surfaces. A finished building surface is any surface with a factory finish or that receives a site applied finish.
- .2 Install the plates so that they are tight against the building surface concerned, and ensure that the plates completely cover pipe sleeves and/or openings, except where waterproof sleeves extend above floors, in which case the plate is to fit tightly around the sleeve.

3.08 INSTALLATION OF FASTENING AND SECURING HARDWARE

- .1 Provide all fastening and securing hardware required for mechanical work to maintain installations attached to the structure or to finished floors, walls and ceilings in a secure and rigid manner capable of withstanding the dead loads, live loads, superimposed dead loads, and any vibration of the installed products.

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- .2 Use fasteners compatible with structural requirements, finishes and types of products to be connected. Do not use materials subject to electrolytic action or corrosion where conditions are liable to cause such action.
- .3 Where the floor, wall or ceiling construction is not suitable to support the loads, provide additional framing or special fasteners to ensure proper securement to the structure that is to support the products. Provide reinforcing or connecting supports where required to distribute the loading to the structural components.
- .4 Obtain written consent before using explosive actuated fastening devices. If consent is obtained, comply with requirements of CSA Standards CAN3-Z166.1 and CAN3-Z166.2.
- .5 Do not attach fasteners to steel deck without written consent from the Consultant.

3.09 INSTALLATION OF PIPE HANGERS AND SUPPORTS

- .1 Provide all required pipe hangers and supports.
- .2 Provide any additional structural steel channels, angles, inserts, beam champs and similar accessories required for hanging or supporting pipe. Unless otherwise shown or specified, hang or support pipes from the structure only.
- .3 **For Insulated Pipe:** Size the hanger or support to suit the diameter of the insulated pipe and install the hanger or support on the outside of the insulation and insulation finish.
- .4 **Horizontal Above Ground Piping:** Unless otherwise shown or specified, hang and/or support horizontal pipe above ground by means of hangers and/or supports specified in Part 2 of this Section. Unless otherwise shown or specified, hangers for suspended pipe to and including 25 mm (1") diameter are to be clevis type or adjustable ring type, and hangers for suspended pipe 40 mm (1½") diameter and larger are to be adjustable clevis type. Space hangers and supports in accordance with the following:
 - .1 **cast iron pipe:** hang or support at every joint with maximum 2.4 m (8') spacing
 - .2 **plastic pipe:** conform to pipe manufacturer's recommended support spacing
 - .3 **copper and steel pipe:** hang or support at spacing in accordance with the following schedule:

PIPE DIA.	MAX. SPACING STEEL (meters)	MAX. SPACING COPPER (meters)
to 25 mm (1")	2.4 m (8')	1.8 m (6')
40 mm (1½")	2.7 m (9')	2.4 m (8')
50 mm (2")	3.0 m (10')	2.7 m (9')
65 mm (2½")	3.6 m (12')	3.0 m (10')
75 mm (3")	3.6 m (12')	3.0 m (10')
90 mm (3½")	3.6 m (12')	3.6 m (12')
100 mm (4")	4.2 m (14')	3.6 m (12')

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250 mm (10")	6.0 m (20')	
300 mm (12")	6.7 m (22')	

- .4 **flexible grooved pipe/coupling joint piping:** as above but with not less than one hanger or support between joints
- .5 **changes in direction:** where pipes change direction, either horizontally or vertically, provide a hanger or support on the horizontal pipe not more than 300 mm (12") from the elbow, and where pipes drop from tee branches, support the tees in both directions not more than 50 mm (2") on each side of the tee
- .6 **grouped piping:** when pipes with the same slope are grouped and a common hanger or support is used, space the hanger or support to suit the spacing requirement of the smallest pipe in the group and secure pipes in place on the common hanger or support
- .5 **Vertical Piping:** Unless otherwise shown or specified, support vertical piping by means of supports specified in Part 2 of this Section, spaced in accordance with the following:
 - .1 support vertical pipes at maximum 3 m intervals
 - .2 for sections of vertical piping with a length less than 3 m (10'), support the pipe at least once
 - .3 for all vertical cast iron plain end pipe (mechanical joint type), secure the riser or pipe clamp around the pipe under a flange integral with the pipe for vertical support purposes, or provide a length of hub and spigot pipe to facilitate proper support
 - .4 for vibration isolated piping risers, provide rubber-steel-rubber vibration isolation pads between the riser clamps and the floor
- .6 **Isolation for Bare Copper Tubing:** Each hanger, support or securement for horizontal bare copper tubing is to be plastic coated to prevent direct contact between the pipe and the ferrous hanger. Each wall or floor clamp for vertical bare copper piping is to be isolated from the pipe by means of strips of flexible rubber inserts. The use of painted ferrous hangers and supports, including those painted with copper coloured paint, is not acceptable. Site application of tape or other types of isolation is not acceptable.
- .7 **Insulation Protection Shields:** For insulated horizontal piping to and including 40 mm (1½") diameter, provide galvanized steel insulation protection shields between the insulation and the hanger or support. Install shields immediately after the pipe is insulated.
- .8 **Pipe Support from Steel Deck:** Do not support piping from steel deck without written consent from the Consultant.

3.10 HARDWARE FOR PIPING EXPANSION, CONTRACTION, & BUILDING SHRINKAGE

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- .1 Provide all required hardware (expansion loops, expansion compensators, pipe guides, and anchors) for piping expansion, contraction, and building shrinkage as indicated on the drawings. Install to allow freedom of piping movement in all planes without imposing undue stress on any section of main and branch piping, equipment, or the building structure.
- .2 Provide piping offsets at take-offs to equipment wherever possible.
- .3 **Expansion compensators:** The following requirements apply to selection and installation of expansion compensators:
 - .1 select expansion compensators to withstand the system test pressure as well as operating pressure, and for the calculated movement according to the following temperature ranges:
 - .1 **cold piping**, from minimum operating temperature to 38°C (100° F), plus 25% safety factor
 - .2 **warm and hot piping**, from minimum ambient temperature (but not lower than - 5° C (23° F) to maximum operating temperature plus 25% safety factor
 - .2 where the ambient temperature during installation is higher than the operating temperature, use pre-compressed expansion compensators
 - .3 install expansion compensators in accordance with the manufacturer's published instructions
 - .4 during the construction and warranty periods, accompanied by the expansion compensator manufacturer, regularly review facilities for building shrinkage and adjust the expansion compensator installation as required to ensure that the piping is free from binding and stress
- .4 **Pipe Guides:** The following requirements apply to provision of piping guides:
 - .1 provide a minimum of two piping guides at each side of expansion loops and expansion compensators to allow piping movement in the axial direction only
 - .2 ensure that guides for vertical piping maintain accurate vertical position of the piping
 - .3 prior to system start-up, clean and lubricate guides, and adjust as required for free sliding of the piping at operating conditions
 - .4 where guides are required for "cold" piping, provide a thermal break to prevent sweating
 - .5 for vertical piping risers to and including 75 mm (3") diameter, provide guides at every floor or every 3.9 m (13'), and guide vertical piping larger than 75 mm (3") diameter at every second floor or every 7.5 m (25').

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- .5 **Anchors:** Secure anchors to the structure to avoid excessive reactive forces and operating weights into the structure, all in accordance with requirements of "Reviewed" shop drawings. Where pipe mains or branches connect to anchored risers, provide a spring type hanger or support for the main or branch to permit movement of the riser. When installation of anchors is complete, arrange, and pay for the anchor design engineer to visit the site to review the anchor installation. Submit a letter from the design P. Eng. to confirm that each anchor is properly installed.

3.11 INSTALLATION OF PIPELINE STRAINERS

- .1 Provide strainers in piping systems where shown on the drawings.
- .2 Equip each strainer with a construction screen and remove after piping has been flushed and cleaned. Install permanent screens/mesh.
- .3 Provide isolating valves in piping a maximum of 3 m (10') from the strainer on each side of a strainer.
- .4 For "Y" shaped strainers 40 mm (1½") diameter and larger, provide blow-off piping complete with a shut-off valve with cap and chain, and terminate blow-off piping downward in a vertical position.
- .5 For duplex basket strainers, equip each chamber drain plug with valved drain piping.

3.12 INSTALLATION OF EQUIPMENT DRAINS AND PIPING DRAIN VALVES

- .1 Unless otherwise shown or specified, provide a minimum 40 mm (1½") diameter type DWV copper drain piping from equipment overflows, condensate drain pans, pump bases, fresh air intake plenum drains, etc., to a floor drain location. Equip the drain piping with deep seal traps located in heated areas.
- .2 Provide a drain valve at the bottom of piping risers, at all other piping low points, and wherever else shown and/or specified
- .3 Locate drain valves so that they are easily accessible.

3.13 SUPPLY OF ACCESS DOORS

- .1 Supply access doors to give access to all mechanical work which may need maintenance or repair but which is concealed in inaccessible construction, except as otherwise specified herein or on the drawings.
- .2 Locate access doors as inconspicuously as possible in walls and partitions and arrange mechanical work such that it is clearly within view and accessible for inspection and servicing, and to suit access door locations shown on the reviewed and approved white prints of reflected ceiling plan and elevation drawings submitted as per Part 1 of this Section.

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- .3 Group piping and ductwork to ensure the minimum number of access doors is required. Access doors will be installed by the trades responsible for the particular type of construction in which the doors are required.

3.14 GENERAL RE: INSTALLATION OF VALVES

- .1 Generally, valve locations are indicated or specified on drawings or specified in Sections of the Specification where the valves are specified, however, regardless of locations shown or specified, the following requirements apply:
 - .1 provide shut-off valves to isolate all systems, at the base of all vertical risers, in branch take-offs at mains and risers on all floors, to isolate all equipment, to permit work phasing as required, and wherever else required for proper system operation and maintenance
 - .2 install shut-off valves with handles upright or horizontal, not inverted, and located for easy access
 - .3 unless otherwise specified, provide a check valve in the discharge piping of each pump
 - .4 valve sizes are to be the same as the connecting pipe size
 - .5 valves are to be permanently identified with the size, manufacturer's name and figure number, and wherever possible, valves are to be the product of the same manufacturer
 - .6 the manufacturer's name, valve model or figure number, and the pressure rating are to be clearly marked on each valve
 - .7 for valves in insulated piping, the design of the valve stem, handle and operating mechanism is to be such that the insulation does not have to be cut or altered in any manner to permit valve operation

3.15 INSTALLATION OF PRESSURE GAUGES AND THERMOMETERS

- .1 **Pressure Gauges:** Provide pressure gauges in the following locations:
 - .1 in valved tubing across the suction, suction strainer (if applicable), and discharge piping of each circulating pump
 - .2 in the supply and return piping connections to main mechanical plant equipment such as boilers, heat exchangers, main coils, etc.
 - .3 in expansion tank(s) or piping immediately at the expansion tank
 - .4 in separate domestic hot water storage tank(s)
 - .5 in piping at each side of a pressure reducing valve
 - .6 in domestic water service piping downstream of the meter
 - .7 wherever else shown and/or specified on the drawings or in the Specification

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- .2 **Thermometers:** Provide thermometers in the following locations:
 - .1 in supply and return piping connections to main mechanical plant equipment such as boilers, chillers, cooling towers, liquid to liquid heat exchangers, main coils, etc., unless temperature indication is supplied with the equipment
 - .2 in all water piping connections to hot water heaters
 - .3 in the downstream side of mixing valves
 - .4 wherever else shown and/or specified herein or on the drawings
- .3 **Installation Requirements:** Conform to the following installation requirements:
 - .1 for installation of thermometers in piping wells, provide a coat of metallic base heat transfer paste or grease in the piping well
 - .2 for pressure gauges in piping at equipment locations, install the pressure gauge between the equipment and the first pipe fitting
 - .3 locate, mount and adjust all instruments so they are easily readable
 - .4 where pressure gauges and/or thermometers are located at high level or in an area where they cannot be easily seen, provide remote reading instruments

3.16 MECHANICAL WORK IDENTIFICATION

- .1 **Exposed Piping & Ductwork:** Identify new exposed piping and ductwork as per Part 2 of this Section in locations such that it can be seen from the floor or service platforms, as follows:
 - .1 at every end of every piping or duct run
 - .2 adjacent to each valve, strainer, damper and similar accessory
 - .3 at each piece of connecting equipment
 - .4 on both sides of every pipe and duct passing through a wall, or partition
 - .5 at 6 m (20') intervals on pipe and duct runs exceeding 6 m (20') in length
 - .6 at least once in each room, and at least once on pipe and duct runs less than 6 m (20') in length
- .3 **Concealed Piping & Ductwork:** Unless otherwise specified identify new concealed piping and ductwork as per Part 2 of this Section in locations as follows:
 - .7 at points where pipes or ducts enter and leave rooms, shafts, pipe chases, furred spaces, and similar areas;
 - .8 at maximum 6 m (20') intervals on piping and ductwork above suspended accessible ceilings, and at least once in each room
 - .9 at each access door location

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- .10 at each piece of connected equipment, automatic valve, etc.
- .4 **Equipment:** Provide an identification nameplate for each new piece of equipment, including items such as control valves, motorized dampers, instruments, and similar products. Secure nameplates in place, approximately at eye level if possible, with stainless steel screws unless such a practice is prohibitive, in which case use epoxy cement applied to cleaned surfaces. Locate all nameplates in the most conspicuous and readable location. Unless otherwise specified, equipment identification terminology is to be as per drawing identification.
- .5 **Natural Gas Piping:** Paint new gas piping with primer and two coats of yellow paint in accordance with Code requirements and requirements of the Painting Section in Division 09. Identify the piping at intervals as specified above.
- .6 **Valve Tagging & Chart:** Tag valves and prepare a valve tag chart in accordance with the following requirements:
 - .1 attach a valve tag to each new valve, except for valves located immediately at the equipment they control
 - .2 prepare a computer printed valve tag chart to list all tagged valves, with, for each valve, the tag number, location, valve size, piping service, and valve attitude (normally open or normally closed)
 - .4 frame and glaze one copy of the chart and, unless otherwise directed, affix to a wall in each main Mechanical and/or Equipment Room
 - .5 include a copy of the valve tag chart in each copy of the operating and maintenance instruction manuals
 - .6 hand an identified and packaged (jewel case) compact disc of the valve tag chart to the Owner at the time the O & M Manuals are submitted.

3.17 SYSTEM FLOW DIAGRAMS

- .1 Prepare AutoCAD, coloured, 1200 mm x 900 mm (48" x 36") flow diagrams of mechanical systems to identify all equipment and valves.
- .2 Install framed and glazed diagrams in equipment rooms housing the system equipment. Confirm location prior to installation.
- .3 Include reduced size copies of the diagrams in each copy of the O & M Manuals.

3.18 FINISH PAINTING OF MECHANICAL WORK

- .1 Finish painting of exposed mechanical work is specified in Division 09 and is part of the work of Division 09.

3.19 PIPE LEAKAGE TESTING

- .1 Before new piping has been insulated or concealed, and before equipment, fixtures and fittings have been connected, test all piping for leakage.

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- .2 Tests are to be witnessed by the Consultant and/or Owner's representative, and, where required, representatives of governing authorities. Give ample notice of tests in writing and verify attendance. Have completed test report sheets dated and signed by those present to confirm proper test results.
- .3 When circumstances prevent scheduled tests from taking place, give immediate and adequate notice of cancellation to all who were scheduled to attend.
- .4 **Gravity Drainage & Vent Piping:** Securely close all openings and pipe ends and fill piping with water up to the highest level, and ensure that the water stands at the same level for a minimum of two hours. After the fixtures and fittings are set and the pipes connected to the building drain or drains, turn on water into all pipe, fixtures, fittings and traps in order to detect any imperfect material or workmanship. Make a smoke test if required by the Municipality. At your option, drain and vent piping may be pressure tested with cold water at 345 kPa (50 psi) for two hours with zero leakage.
- .5 **Pumped Drainage Piping:** Test piping with cold water at a pressure of 1½ times normal working pressure and maintain the pressure for a minimum of two hours.
- .6 **Domestic Water Piping:** Test piping with cold water at a pressure of 1½ times normal working pressure and maintain the pressure for a minimum of two hours.
- .7 **Heat Transfer (HVAC) System Piping:** Test piping with cold water at a pressure of 1035 kPa (150 psi) for a minimum of two hours.
- .8 **Natural Gas Piping:** Test piping in accordance with the requirements of CAN/CSA - B149.1. After completion of the verification test, locate the required tag stating the results of the verification test at the point of entry of the gas main into the building, affixed to the pipe in a secure manner. Check all piping joints and connections for leaks with a water/soap solution while the piping is under pressure.
- .9 **General Re: All Testing:** The following requirements apply to all testing:
 - .1 ensure that all piping has been properly flushed, cleaned and is clear of foreign matter prior to pressure testing
 - .2 temporarily remove or valve off all piping system specialties or equipment which may be damaged by test pressures prior to pressure testing the systems, and flush piping to remove foreign matter
 - .3 include for temporary piping connections required to properly complete the tests
 - .4 piping under test pressure is to have zero pressure drop for the length of the test period
 - .5 make tight leaks found during tests while the piping is under pressure, and if this is impossible, remove and refit the piping and reapply the test until satisfactory results are obtained
 - .6 where leaks occur in threaded joints in steel piping, no caulking of these joints will be allowed under any conditions

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- .7 tests are to be done in reasonably sized sections so as to minimize the number of tests required
- .8 in addition to the leakage tests specified above, demonstrate proper flow throughout the systems including mains, connections and equipment, as well as proper venting and drainage, and include for any necessary system adjustments to achieve the proper conditions

3.20 ELECTRICAL WIRING WORK FOR MECHANICAL WORK

- .1 Unless otherwise specified or indicated, the following electrical wiring work for mechanical equipment will be done as part of the electrical work:
 - .1 "line" side power wiring to pre-wired power and control panels and variable frequency drives, and "load" side power wiring from the panels and VFD's to the equipment
 - .2 provision of receptacles for plug-in equipment
 - .3 provision of dedicated 120 volt, 15A-1P circuits terminated in junction boxes in mechanical equipment rooms for automatic control and building automation system wiring connections to be made as part of the automatic controls work
 - .4 120 volt power connections to electrical receptacles integral with small ceiling exhaust fans, including wiring through light switches or speed controllers;
- .2 Mechanical wiring work not listed above or specified herein or on the drawings to be done as part of the electrical work is to be installed in conduit and is to be done as part of the mechanical work in accordance with wiring requirements specified for the electrical work.

3.21 CLEANING MECHANICAL WORK

- .1 Refer to cleaning requirements specified in Division 01.
- .2 Clean all mechanical work prior to application for Substantial Performance of the work.
- .3 Include for vacuum cleaning the interior of air handling units and ductwork systems.

3.22 USE OF MECHANICAL SYSTEMS FOR TEMPORARY HEATING

- .1 Permanent mechanical systems in the building may be used for temporary heating during construction subject to the following conditions:
 - .1 each entire system is complete, pressure tested, cleaned, and flushed out
 - .2 specified water treatment system has been commissioned, and treatment is being continuously monitored

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- .3 building has been closed in and areas to be heated/ventilated are clean and will not thereafter be subjected to dust-producing processes
- .4 there is no possibility of damage from any cause
- .5 supply ventilation systems are protected by minimum MERV 7 filters, which are to be inspected every other day, and changed every 2 weeks, or more frequently as required
- .6 return air systems have approved construction filters over all openings, inlets, and outlets
- .7 all systems are operated as per the manufacturer's recommendations or instructions, and are monitored on a regular and frequent basis
- .8 warranties are not affected in any way
- .9 regular preventive and all other manufacturer's recommended maintenance routines are performed
- .10 before Substantial Performance, each entire system is to be refurbished, cleaned internally and externally, restored to "as-new" condition, and filters in air systems replaced
- .11 energy costs are to be paid by the Contractor

3.23 MAINTAINING EQUIPMENT PRIOR TO ACCEPTANCE

- .1 Maintain all equipment in accordance with the manufacturer's printed instructions prior to start-up, testing and commissioning.
- .2 Employ a qualified millwright to check and align shafts, drives, and couplings on all base mounted split coupled motor driven equipment.
- .3 Where equipment lubrication fittings are not easily accessible, extend the fittings to accessible locations using copper or aluminium tubing.
- .4 All filters are to be new upon Substantial Performance of the work. This is in addition to any spare filters specified.

3.24 CONNECTIONS TO OTHER EQUIPMENT

- .1 Carefully examine the Contract Documents during the bidding period and include for mechanical work piping and/or ductwork connections to equipment requiring such connections.

3.25 WASTE MANAGEMENT AND DISPOSAL

- .1 Separate and recycle waste materials in accordance with requirements of Canadian Construction Association Standard Document CCA 81, A Best Practices Guide to Solid Waste Reduction.
- .2 Prepare a waste management and reduction plan and submit a copy for review prior to work commencing at the site.

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- .3 Place materials defined as hazardous or toxic waste in designated containers.
- .4 Ensure emptied containers are sealed and stored safely for disposal.

3.26 INSTALLATION OF FLEXIBLE CONNECTORS

- .1 Provide flexible connectors in all piping connections to vibration isolated equipment.

END OF SECTION

Mechanical Insulation

1 GENERAL

1.01 APPLICATION

- .1 This Section specifies insulation requirements that are common to mechanical work Sections of the Specification. It is a supplement to each Section and is to be read accordingly.

1.02 SUBMITALS

- .1 Insulation System Samples: At least four weeks prior to insulation work commencing, submit a sample of each type of insulation (and insulation accessories and finish), in applied form, for approval. Mount the samples on a plywood board. Identify each product with the manufacturer's name and insulation type, and the proposed use of the insulation. When the sample board has been approved, all mechanical insulation work is to conform to the approved sample board.
- .2 **Product Data Sheets:** Submit a product data sheet for each insulation system product.

1.03 QUALITY ASSURANCE

- .1 Mechanical insulation is to be applied by a licensed journeyman insulation mechanic, or by an apprentice under direct, daily, on-site supervision of a journeyman mechanic.
- .2 Do not apply insulation unless leakage tests have been satisfactorily completed.
- .3 Ensure that all surfaces to be insulated are clean and dry.
- .4 Ensure that the ambient temperature is minimum 13° C (55° F) for at least one day prior to the application of insulation, and for the duration of insulation work, and that relative humidity is and will be at a level such that mildew will not form on insulation materials.
- .5 All insulation materials must be stored on site in a proper and dry storage area. Any wet insulation material is to be removed from the site.

1.04 DEFINITIONS

- .1 For the work of this Section:
- .1 "concealed" means mechanical services and equipment above suspended ceilings, in non-accessible chases, in accessible pipe spaces, and furred-in spaces
- .2 "exposed" means exposed to normal view during normal conditions and operations
- .3 "mineral fibre" includes glass fibre, rock wool, and slag wool
- .4 "domestic water" means all piping (cold, hot, tempered) extended from the building Municipal supply main

Mechanical Insulation

2 PRODUCTS

2.01 FIRE HAZARD RATINGS

- .1 Unless otherwise specified, all insulation system materials inside the building must have a fire hazard rating of not more than 25 for flame spread and 50 for smoke developed when tested in accordance with CAN/ULC-S102, Surface Burning Characteristics of Building Materials and Assemblies.

2.02 THERMAL PERFORMANCE

- .1 Unless otherwise specified, thermal performance, i.e. conductivity, of insulation is to meet or exceed the values given in Tables 6.8.2.A, 6.8.2.B, 6.8.3.A and 6.8.3.B of ASHRAE/IES Standard 90.1.

2.03 PIPE INSULATION MATERIALS

- .1 **Horizontal Pipe Insulation at Hangers & Supports:** Equal to Belform Insulation Ltd. "Koolphen K-Block" insulated pipe support inserts consisting of minimum 150 mm (6") long, premoulded, rigid, sectional phenolic foam insulation (of same thickness as adjoining insulation) with a reinforced foil and kraft paper vapour barrier jacket and a captive galvanized steel saddle.
- .2 **Flexible Foam Elastomeric:** Closed cell, sleeve type, longitudinally split self-seal, foamed plastic pipe insulation with a water vapour transmission rating of 0.10 in accordance with ASTM E96-90, Procedure B, and all required installation accessories. Acceptable products are:
 - .1 Armacell AP/Armaflex SS
 - .2 Nomaco K-Flex "LS" Self-Seal Pipe Insulation
- .3 **Fire Rated Premoulded Mineral Fibre:** Non-combustible, fire-rated, rigid, sectional, longitudinally split mineral wool or basalt pipe insulation with a reinforced vapour barrier jacket and compatible with CAN4-S115 and CAN/ULC-S101 firestopping. Acceptable products are:
 - .1 Roxul "Tecton 1200"
 - .2 Paroc 1200
- .4 **Premoulded Mineral Fibre:** Rigid, sectional, sleeve type insulation to ASTM Standard C 547-00, with a factory applied vapour barrier jacket. Acceptable products are:
 - .1 Johns Manville Inc. "Micro-Lok AP-T Plus"
 - .2 Knauf Fiber Glass "Pipe Insulation" with "ASJ-SSL" jacket
 - .3 Manson Insulation Inc. "ALLEY K APT"
 - .4 Owens Corning Fiberglas Pipe Insulation

Mechanical Insulation

- .5 **Blanket Mineral Fibre:** Blanket type roll insulation to CGSB 51-GP-11M, 24 kg/m³ (1½ lb./ft.³) density, with a factory applied vapour barrier facing. Acceptable products are:

- .1 Johns Manville Inc. Type 150 "Microlite"
- .2 Knauf Fiber Glass Blanket Insulation with multi-purpose "FSK" facing
- .3 Manson Insulation Inc. "ALLEY WRAP FSK"
- .4 Isofab Faced Flexible FSK Insulation

2.04 EQUIPMENT INSULATION MATERIALS

- .1 **Blanket Mineral Fibre:** Blanket type roll form insulation to ASTM Standard C553-00, 24 kg/m³ (1½ lb./ft.³) density, with a factory applied vapour barrier facing. Acceptable products are:

- .1 Knauf Fiber Glass Blanket Insulation with multi-purpose "FSK" facing
- .2 Manson Insulation Inc. "ALLEY WRAP FSK"
- .3 Johns Manville Inc. Type 150 "Microlite"
- .4 Isofab Faced Flexible FSK Insulation

2.05 REMOVABLE/REUSABLE INSULATION COVERS

- .1 **Valve, Etc., Covers:** NO SWEAT reusable insulation wraps with vapour barrier jacket and self-sealing ends and longitudinal seam, with a length to suit the application and an insulation thickness equal to the adjoining insulation.
- .2 **Equipment Covers:** Custom manufactured covers conforming to the shape of the item to be insulated, designed to be easily removable and replaceable to suit the use and maintenance procedures of the particular item, and to provide adequate personnel protection. Covers are to be complete with minimum 95 kg/m³ (6 lb./ft.³) density ceramic fibre insulation sewn between minimum 542.5 g/m² (1.8 oz./ft.²) weight silicone impregnated fibreglass fabric in a quilted pattern using double stitches made with Kelvar or Teflon coated fibreglass thread. Overlap flaps are to be secured using laces, snaps, or Velcro double stitched in place. Acceptable manufacturers are:

- .1 Cossby Dewar Inc.
- .2 Insufab Systems Inc.
- .3 ADL Insulflex Inc.
- .4 Firwin Corp.

2.06 DUCTWORK SYSTEM INSULATION MATERIALS

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- .1 **Rigid Mineral Fibre Board:** Preformed board type insulation to ASTM C612-00a, with a factory applied reinforced aluminum foil and kraft paper facing. Acceptable products are:
 - .1 Knauf Fiber Glass Insulation Board with FSK facing
 - .2 Manson Insulation Inc. "AK BOARD FSK"
 - .3 Johns Manville Inc. Type 814 "Spin-Glas"
 - .4 Owens Corning 703, 704
- .2 **Semi-Rigid Mineral Fibre Board:** Roll form insulation to ASTM Standard C1393 00a, consisting of cut strips of rigid mineral board insulation glued to an aluminium foil and kraft paper facing. Acceptable products are:
 - .1 Multi-Glass Insulation Ltd. "Multi-Flex MKF"
 - .2 Glass-Cell Fabricators Ltd. "R-FLEX"
 - .3 Owens Corning Pipe and Tank Insulation
 - .4 Johns Manville Inc. Pipe and Tank Insulation
- .3 **Blanket Mineral Fibre:** Blanket type roll form insulation to ASTM Standard C553-00, 24 kg/m³ (1½ lb./ft.³) density, 40 mm (1½") thick, with a factory applied vapour barrier facing. Acceptable products are:
 - .1 Knauf Fiber Glass Blanket Insulation with multi-purpose "FSK" facing
 - .2 Manson Insulation Inc. "ALLEY WRAP FSK"
 - .3 Johns Manville Inc. Duct Wrap Type 150 "Microlite"
 - .4 Isofab Faced Flexible FSK Insulation

2.07 INSULATION FASTENINGS

- .1 **Wire:** Minimum #15 gauge galvanized annealed wire.
- .2 **Wire Mesh:** Minimum #15 gauge galvanized annealed wire factory woven into 25 mm (1") hexagonal mesh.
- .3 **Aluminium Banding:** Equal to Childers Products Co. "FABSTRAPS" minimum 12 mm (½") wide, 0.6 mm (1/16") thick aluminium strapping.
- .4 **Stainless Steel Banding:** Equal to Childers Products Co. "FABSTAPS" 0.6 mm (1/16") thick, minimum 12 mm (½") wide type 304 stainless steel strapping.
- .5 **Duct Insulation Fasteners:** Weld-on 2 mm (3/32") diameter zinc coated steel spindles of suitable length, complete with minimum 40 mm (1½") square zinc plated steel self-locking washers.
- .6 **Tape Sealant:** Equal to MACtac Canada Ltd. self-adhesive insulation tapes, types PAF, FSK, ASJ, or SWV as required to match the surface being sealed.

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- .7 **Adhesive - Mineral Fibre Insulation:** Clear, pressure sensitive, brush consistency adhesive, suitable for a temperature range of -20°C to 82°C (-4°F to 180°F), compatible with the type of material to be secured, and WHMIS classified as non-hazardous.
- .8 **Adhesive - Flexible Elastomeric Insulation:** Armacell "Armaflex" #520 air-drying contact adhesive.
- .9 **Lagging Adhesive:** White, brush consistency, ULC listed and labelled, 25/50 fire/smoke rated lagging adhesive for canvas jacket fabric, suitable for colour tinting, complete with fungicide and washable when dry.
- .10 **Sheet Metal Screws:** No. 10 stainless steel sheet metal screws.

2.08 INSULATION JACKETS AND FINISHES

- .1 **Canvas:** ULC listed and labelled, 25/50 rated, roll form, minimum 170 g (6 oz.) canvas jacket material.
- .2 **White PVC:** Roll form sheet and fitting covers, minimum 15 mil thick white PVC, 25/50 rated, complete with installation and sealing accessories. Acceptable products are:
 - .1 Proto Corp. "LoSMOKE"
 - .2 The Sure-Fit System "SMOKE-LESS 25/50"
 - .3 Johns Manville Inc. "Zeston" 300
- .3 **Coloured PVC:** Roll form sheet and fitting covers, minimum 15 mil thick coloured PVC, 25/50 rated, complete with installation and sealing accessories. Acceptable products are:
 - .1 Proto Corp. "LoSMOKE"
 - .2 The Sure Fit System "SMOKE-LESS 25/50"
 - .3 Johns Manville Inc. "Zeston" 300
- .4 **Insulation Cement:** Heat resistant, trowel consistency thermal insulating and finishing cement to CAN/CGSB 51.12, and suitable in all respects for the application.
- .5 **Protective Coating - Flexible Foam Elastomeric Insulation:** Equal to Armacell "WB Armaflex" weatherproof, water-based latex enamel finish.

3 EXECUTION

3.01 GENERAL INSULATION APPLICATION REQUIREMENTS

- .1 Unless otherwise specified, do not insulate the following:
 - .1 factory insulated equipment and piping
 - .2 heating piping within radiation unit enclosures, including blank filler sections of enclosures
 - .3 branch potable water piping located under counters to serve counter mounted plumbing fixtures and fittings, except barrier-free lavatories

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- .4 exposed chrome plated potable water angle supplies from concealed piping to plumbing fixtures and fittings, except barrier-free lavatories
- .5 heated liquid system pump casings, valves, strainers and similar accessories
- .6 heating system expansion tanks
- .7 manufactured expansion joints and flexible connections
- .8 acoustically lined ductwork and/or equipment
- .9 flexible branch ductwork from sheet metal ducts to grilles or diffusers
- .10 piping unions, except for unions in "cold" category piping
- .2 Install insulation directly over pipes and ducts and not over hangers and supports.
- .3 Install piping insulation and jacket continuous through pipe openings and sleeves.
- .4 Install duct insulation continuous through walls, partitions, and similar surfaces except at fire dampers.
- .5 When insulating "cold" piping and equipment, extend insulation up valve bodies and other such projections as far as possible, and protect the insulation jacketing from the action of condensation at its junction with the metal.
- .6 Where mineral fibre rigid sleeve type insulation is terminated at valves, equipment, unions, etc., neatly cover the exposed end of the insulation with a purpose made PVC cover on "cold" piping, and with canvas jacket material on "hot" piping.
- .7 Carefully and neatly gouge out insulation for proper fit where there is interference between weld bead, mechanical joints, etc., and insulation. Bevel away from studs and nuts to permit their removal without damage to insulation, and closely and neatly trim around extending parts of pipe saddles.
- .8 Where thermometers, gauges, and similar instruments occur in insulated piping, and where access to heat transfer piping balancing valve ports and similar items are required, create a neat, properly sized hole in the insulation and provide a suitable grommet in the opening.
- .9 Where piping and/or equipment is traced with electric heating cable, ensure that the cable has been tested and accepted prior to the application of insulation, and ensure that the cable is not damaged or displaced during the application of insulation.

3.02 INSULATION FOR HORIZONTAL PIPE AT HANGERS AND SUPPORTS

- .1 At each hanger and support location for piping 50 mm (2") diameter and larger and scheduled to be insulated, except where roller hangers and/or supports are required, and unless otherwise specified, supply a factory fabricated section of phenolic foam pipe insulation with integral vapour barrier jacket and captive galvanized steel shield. Supply the insulation sections to the piping installers for installation as the pipe is erected.

3.03 PIPE INSULATION REQUIREMENTS - MINERAL FIBRE

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- .1 Insulate the following pipe inside the building and above ground with mineral fibre insulation of the thickness indicated:
 - .1 domestic hot and cold water piping - 25 mm (1") thick
 - .2 tempered domestic water piping, supply and return - 25 mm (1") thick
 - .3 storm drainage piping inside the building from roof drains to the point where mains discharge outside the buildings - 25 mm (1") thick
 - .4 condensate drainage piping from fan coil unit or any other air conditioning system/unit drain pans to main vertical drain risers or to indirect drainage point - 25 mm (1") thick
 - .5 drainage piping from refrigerated drinking fountains to nearest 75 mm (3") diameter or larger drain pipe - 25 mm (1") thick
 - .6 hot water heating piping, supply and return, up to and including 50 mm (2") diameter - 25 mm (1") thick
 - .7 hot water heating piping, supply and return, 65 mm (2½") diameter and larger - 40 mm (1½") thick
 - .8 all piping as above located inside the building in unheated areas and indicated to be traced with electric heating cable - minimum 50 mm (2") thick
 - .2 **Piping:** Ensure that the overlap flap of the sectional insulation jacket is secured tightly in place. Cover section to section butt joints with tape sealant.
 - .3 **Fittings:** Insulate fittings with sectional pipe insulation mitred to fit tightly, and cover butt joints with tape sealant, or, alternatively, wrap fittings with blanket mineral fibre insulation to a thickness and insulating value equal to the sectional insulation, secure in place with adhesive and/or wire, and cover with PVC fitting covers.
 - .4 **"Cold" Piping Unions, Valves, Strainers, Etc.:** Unless otherwise specified, insulate unions, valves, strainers, and similar piping system accessories in "cold" piping such as domestic water or chilled water piping with cut and tightly fitted segments of sectional pipe insulation with all joints covered with tape sealant, or, alternatively, wrap the piping union, valve, strainer, etc., with blanket mineral fibre and cover with PVC covers as for "Fittings" above.
 - .5 **Flanges and Mechanical Couplings:** Terminate sectional insulation approximately 50 mm (2") from the flange or coupling on each side of the flange or coupling. Cover the flange or coupling with a minimum 50 mm (2") thickness of blanket mineral fibre insulation wide enough to butt tightly to the ends of the adjacent sectional insulation. Secure the blanket insulation in place and cover with a purpose made purpose made PVC coupling cover.
 - .6 **Concealed Rough-In Piping at Plumbing Fixtures:** Take special care at concealed water rough-in piping at plumbing fixtures to ensure that the piping is properly insulated. If necessary due to space limitations, use 12 mm (½") thick sectional pipe insulation in lieu of 25 mm (1") thick insulation.

3.04 PIPE INSULATION REQUIREMENTS – FLEXIBLE FOAM ELASTOMERIC

Mechanical Insulation

- .1 Install flexible elastomeric pipe insulation in strict accordance with the manufacturer's published instructions to suit the application, and using adhesive, joint sealants and finish to produce a water-tight installation. Insulate the following pipe with flexible elastomeric pipe insulation of the thickness indicated.
 - .1 refrigerant piping outside the building – 25 mm (1") thick

3.05 PIPE INSULATION REQUIREMENTS – FIRE RATED INSULATION

- .1 Where pipe (inside the building and above ground) which is to be insulated as specified above penetrates fire rated construction, provide fire-rated, non-combustible sectional insulation on the portion of pipe in the fire barrier and for a distance of 50 mm (2") on either side of the fire barrier. Insulation thickness is to be as specified, but in any case minimum 25 mm (1").

3.06 EQUIPMENT INSULATION REQUIREMENTS - BLANKET TYPE MINERAL FIBRE

- .1 Insulate the following equipment with mineral fibre blanket type insulation of the thickness indicated:
 - .1 roof drain sumps where inside the building – 25 mm (1") thick
 - .2 the top of radiant ceiling panels – 50 mm (2") thick
- .2 Unless otherwise noted, wrap the equipment to a thickness and insulating value equal to an equivalent thickness of rigid sectional pipe insulation. Laminate the insulation in place with a full coverage of adhesive and secure with wire. Apply a jacket of the insulation vapour barrier material secured in place with adhesive or sealant tape.
- .3 Cover roof drain sumps with purpose made PVC fitting covers.
- .4 Lay the fibreglass blanket on radiant ceiling panels or active chilled water beams after testing is complete.

3.07 EQUIPMENT INSULATION REQUIREMENTS – REMOVABLE/REUSABLE TYPE

- .1 Provide "wrap type" removable and reusable insulation covers for "cold" circuit backflow preventers, and similar items.

3.08 DUCTWORK INSULATION REQUIREMENTS - MINERAL FIBRE

- .1 Insulate the following ductwork systems inside the building and above ground with mineral fibre insulation of the thickness indicated:

Mechanical Insulation

-
- .1 all outside air intake ductwork, casings and plenums from fresh air intakes to and including mixing plenums or sections, or, if mixing plenums or sections are not provided, to the first heating coil, or if both mixing plenums or sections and heating coil sections are not provided, and the fresh air is not tempered, then the fresh air ductwork system complete – 40 mm (1½") thick
 - .2 mixed supply air or preheated supply air casings, plenums and sections to and including the fan section where not factory insulated – 25 mm (1") thick rigid board or 40 mm (1½") thick flexible blanket as required
 - .3 supply air ductwork outward from fans, except for supply ductwork exposed in the area it serves – 25 mm (1") thick rigid board or 40 mm (1½") thick flexible blanket as required
 - .4 exhaust discharge ductwork for a distance of 3 m (10') downstream (back) from exhaust openings to atmosphere, including any exhaust plenums within the 3 m (10') distance – 25 mm (1") thick rigid board or 40 mm (1½") thick flexible blanket as required
 - .5 all heat recovery ductwork, and any other ductwork, casings, plenums or sections specified or detailed on the drawings to be insulated – thickness as specified
- .2 Insulation for casings, plenums, and exposed rectangular ductwork is to be rigid board type. Insulation for round ductwork and concealed rectangular ductwork is to be blanket type.
- .3 **Exposed Rectangular Ducts and/or Casings:** Liberally apply adhesive to all surfaces of the duct and/or casing. Accurately and neatly press the insulation into the adhesive with tightly fitted butt joints. Provide pin and washer insulation fasteners at 300 mm (12") centres on bottom and side surfaces. Secure and seal all joints with 75 mm (3") wide tape sealant. Additional installation requirements are as follows:
- .1 at trapeze hanger locations install insulation between the duct and the hanger
 - .2 provide drywall type metal corner beads on edges of ductwork, casings and plenums in equipment rooms, service corridors, and any other area where the insulation is subject to accidental damage, and secure in place with tape sealant
- .4 **Concealed Rectangular or Oval Ductwork:** Liberally apply adhesive to all surfaces of the duct, and wrap the insulation around the duct with a top butt joint and tight section to section butt joints. Provide pin and washer insulation fasteners at 300 mm (12") centres on bottom surfaces. Secure and seal all joints with 75 mm (3") tape sealant. Additional installation requirements are as follows:
- .1 at each trapeze type duct hanger provide a 100 mm (4") wide full length piece of rigid mineral fibre board insulation between the duct and the hanger
- .5 **Exposed & Concealed Round or Oval Ductwork:** Accurately cut sections of insulation to fit tightly and completely around the duct. Liberally apply adhesive to all surfaces of the duct, and wrap the insulation around the duct with a top butt joint and tight section to section butt joints. Seal all joints with tape sealant. At duct hanger locations install the insulation between the duct and hanger. At each hanger location for concealed ductwork where flexible blanket insulation is used, provide a 100 mm (4") wide full circumference strip of semi-rigid board type duct insulation between the duct and the hanger.

Mechanical Insulation

- .6 **Common Duct Insulation Requirements:** Insulation application requirements common to all types of rigid ductwork are as follows:
- .1 at duct connection flanges insulate the flanges with neatly cut strips of the rigid insulation material secured with adhesive to side surfaces of the flange with a top strip to cover the exposed edges of the side strips, then butt the flat surface duct insulation up tight to the flange insulation, or, alternatively, increase the insulation thickness to the depth of the flange and cover the top of the flanges with tape sealant
 - .2 the installation of fastener pins and washers is to be concurrent with the duct insulation application
 - .3 cut insulation fastener pins almost flush to the washer and cover with neatly cut pieces of tape sealant
 - .4 accurately and neatly cut and fit insulation at duct accessories such as damper operators (with standoff mounting) and pitot tube access covers
 - .5 prior to concealment of insulation by either construction finishes or canvas jacket material, patch all vapour barrier damage by means of tape sealant

3.09 INSULATION FINISH REQUIREMENTS

- .1 **Canvas:** Unless otherwise shown and/or specified, jacket all exposed mineral fibre insulation work inside the building with canvas secured in place with a full 100% covering coat of lagging adhesive. Accurately cut canvas with scissors or a knife. Do not rip or tear canvas to size. Remove lagging adhesive splatter from adjacent uninsulated surfaces.
- .2 **White PVC:** Jacket exposed pipe and duct insulation work inside the building in "wet" vehicle wash areas with white sheet PVC and fitting covers. Install sheet PVC and fitting covers tightly in place with overlapped circumferential and longitudinal joints arranged to shed water. Seal all joints to produce a neat water-tight installation. Provide slip-type expansion joints where required by manufacturer's instructions.
- .3 **Protective Coating – Flexible Elastomeric Insulation:** Apply 2 coats (with 24 hours between coats) of the specified coating to all insulation outside the building.

END OF SECTION

VARIABLE FREQUENCY DRIVES

1 GENERAL

1.01 APPLICATION

- .1 This Section specifies variable frequency drive requirements that are common to mechanical work Sections of the Specification and it is a supplement to each Section and is to be read accordingly.

1.02 SUBMITTALS

- .1 **Product Data:** Submit product data sheets for variable frequency drives. Include all construction and performance details with the submission, as well as wiring and control schematics, and dimensions.
- .2 **Certification Letter:** Submit a start-up and installation certification letter from the supplier of the variable frequency drives as specified in Part 3 of this Section.
- .3 **CD of Parameters:** Submit a compact disk of parameters for uploading for future use as specified in Part 3 of this Section.
- .4 **Extended Warranty:** See Article #1.03 below. Include a copy of the VFD extended warranty in each Operating and Maintenance Manual, and, prior to Substantial Performance of the work, submit a copy of the warranty to the Owner.

1.03 EXTENDED WARRANTY

- .1 Each variable frequency drive is to be covered by a one year extended warranty by the manufacturer direct to the Owner. The extended warranty terms and conditions are to be identical to the one year Contract warranty, and the extended warranty period is to commence the day the Contract warranty expires.

2 PRODUCTS

2.01 VARIABLE FREQUENCY DRIVES

- .1 Factory assembled and tested, CSA or ETL certified, fully digital, pulse width modulated type VFD's, each matched to the motor it is associated with and each suitable for operation in an ambient temperature range of between 15° F and 105° F with a maximum humidity of 95% non-condensing, and a maximum altitude of 3300' for rated output. No transformers are to be used in either the input or output of the VFD.
- .2 **Operation:** Each VFD is to operate as follows:
 - .1 if the "Manual" mode is selected the VFD/motor is to start when the run key is depressed and the speed is to be controlled by depressing the Accelerate or Decelerate keys on the keypad, or by the direct speed set mode
 - .2 if the "Auto" mode is selected the VFD/motor is to start when a contact closure run command is received from the building control system, and the speed is to be controlled by a speed reference signal from the building control system

VARIABLE FREQUENCY DRIVES

- .3 in the event of a power outage the VFD is to automatically restart when the power returns provided the run command is maintained
- .4 in the event of an inverter fault trip, the VFD is to attempt to restart automatically up to maximum of five attempts and, if after five attempts, restart does not occur, the VFD is to lock out
- .3 **Performance:** Each VFD is to have performance characteristics as follows:
 - .1 minimum efficiency of 97% at maximum load and speed
 - .2 minimum line side displacement power factor of 0.96 at all speeds and loads
 - .3 adjustable minimum and maximum motor frequency of 0 to 120 Hz
 - .4 separately adjustable acceleration and deceleration ramps from 0.1 to 3,600 seconds with damping and smoothing parameters for 0% to 100% speed
 - .5 DC injection braking
 - .6 automatic restart after an inverter fault trip, and the VFD is to attempt to restart automatically five times with lock-out after the fifth attempt if a restart has not occurred
 - .7 the VFD is to restart the motor at the speed at which it is rotating and then re-accelerate to the speed called for by the speed reference signal;
 - .8 capable of running for setup and testing without a motor connected
 - .9 capable of accepting the opening of a remote motor disconnect while running without causing damage to the VFD
 - .10 auto restart after power outage
 - .11 skip frequency reject point to prevent the motorized equipment from operating at a resonant speed, and adjustable centre frequency with a band width of 0-10 Hz
 - .12 automatic/manual signal follower for 4-20 mA, 0-20mA, 0-10 VDC or 2-10 VDC reference
 - .13 capable of accepting AC line voltage variations of +10% to -15%
- .4 **Design and Construction Features:** Each VFD, as a minimum, is to be complete with:
 - .1 input line reactors to reduce the total harmonic distortion, and, for 575 volt motors, output reactors to limit the dv/dt to 1000 volts / 0.5 microseconds at motor terminals
 - .2 soft switching insulated gate bipolar transistors in the inverter section
 - .3 an EEMAC 2, sprinkler-proof, dead front, enamelled steel surface mounting enclosure with lockable door
 - .4 a horsepower rated, door interlocked, pad-lockable open main disconnect switch

VARIABLE FREQUENCY DRIVES

- .5 input line fuses coordinated with electronic protection circuits so as not to blow under normal output faults such as overcurrent, short circuit, and ground fault, and three spare fuses in a holder on the back of the enclosure door
- .6 protective devices consisting of, as a minimum:
 - .1 line over voltage and line under voltage protection
 - .2 phase loss and unbalance protection
 - .3 short circuit protection for line to line and line to ground faults
 - .4 electronic instantaneous overcurrent protection
 - .5 current limit, adjustable between 25% and 120%
 - .6 a continuous duty service factor of 100% rated output current with 1st overload protection rating of 120% for 1 minute
 - .7 internal over temperature protection
 - .8 electronic motor stall protection to trip the VFD off should a motor overload or stall occur
- .7 operate interface facilities consisting of a door mounted keypad with a 32 character Alpha-numeric high resolution display to allow personnel to set up and monitor the VFD parameters, observe output speed, load or other programmable values, and monitor status and fault information, complete with tactile keys and backlit display, and the following:
 - .1 maintenance monitoring to display the time since starting, total elapsed run time, and total KWH, and maintenance target alarm to alert the operator with a displayed message
 - .2 the following control functions on the door mounted keypad, as follows:
 - .1 Run (Hand and Auto Mode)
 - .2 Stop (Hand and Auto Mode)
 - .3 Parameterization button (to toggle between parameters)
 - .3 a selectable display to observe the following parameters:
 - .1 frequency
 - .2 frequency set-point
 - .3 motor current
 - .4 DC-link voltage
 - .5 motor torque (% nominal)

VARIABLE FREQUENCY DRIVES

- .6 motor RPM
- .4 fault diagnostics to simplify troubleshooting, and, in the event of a fault condition, the display it so indicate the nature of the fault, including:
 - .1 overvoltage
 - .2 undervoltage
 - .3 overcurrent
 - .4 overload
 - .5 overheating of motor (monitoring with PTC)
 - .6 inverter over temperature
 - .7 main phase missing (for 3 phase units)
- .8 control system interface facilities, consisting of:
 - .1 dry contact closure from the control system for run command (Auto Mode)
 - .2 4-20 mA (0-20 mA, 0-10 VDC, 2-10 VDC) signal from the control system for speed control (Auto Mode)
 - .3 dry contact (N.O.) output to the control system to indicate:
 - .1 inverter fault
 - .2 inverter running
 - .4 0-20 mA or 4-20 mA analog output to the control system, proportional to 0-100% speed or load
 - .5 terminal for interlocking of up to 5 external interlocks, e.g. firestat, freezestat, etc.
- .9 control system serial communications interface and software to permit remote monitoring and modification of all VFD parameters, with interface via RS-485 communications standards, and a process controller with the following features as a minimum:
 - .1 input: field process signal (temperature, pressure, etc.)
 - .2 output: 4-20 mA or 0-10 V speed reference to the VFD
 - .3 programmable proportional, integral and derivative gains
 - .4 operator adjustable process set-point.
- .10 communications protocol as required to allow direct interface with the building automation system.

VARIABLE FREQUENCY DRIVES

- .11 modular components and circuitry necessary to safely bypass the motor from the VFD to line, or from the line to the VFD at zero speed, and consisting of:
 - .1 a door interlocked input circuit breaker to ensure positive shutdown of all input power to both the VFD and bypass, with motor protection provided in both modes of operation by a common thermal motor overload relay
 - .2 mechanically interlocked contactors on the output of the VFD and in the bypass circuit
 - .3 an inverter/bypass selector switch with indicator lights for each mode of operation, located in the enclosure door
- .12 for motors greater than 25 HP, harmonic filters to limit total harmonics distortion (voltage) to 5% and total demand distortion (current) to 10%, measured at the input side of the VFD
- .5 **Acceptable Manufactures:** Acceptable manufactures are:
 - .1 A.C. Technology Corp.
 - .2 Siemens Electric
 - .3 Toshiba Canada
 - .4 Eaton Corp. Allen-Bradley
 - .5 Danfoss Graham
 - .6 ABB

3 EXECUTION

3.01 SUPPLY OF VARIABLE FREQUENCY DRIVES

- .1 Supply variable frequency drives for motorized mechanical equipment in accordance with drawing requirements.
- .2 Ensure that all variable speed drives are the products of the same manufacturer.
- .3 Where VFD's are required for custom made air handling units the VFD's will be supplied (By Div. 25) loose, field mounted and "load" side connected to fan motors by the air handling unit manufacturer. "Line" side power wiring to these VFD's will be done as part of the electrical work.
- .4 Where VFD's are required for pumps, mount each VFD generally where shown but with exact location to ensure that the VFD is accessible in accordance with Electrical Code requirements. "Line" and "load" side power wiring to these VFD's will be done as part of the electrical work.
- .5 When installation of the VFD's is complete, arrange for the VFD manufacturer/supplier to:

VARIABLE FREQUENCY DRIVES

- .1 supply a factory authorized technician at the site for a minimum of 4 hours per system to examine installation and connection of each VFD, and to perform start-up and set-up procedures in conjunction with equipment start-up and testing procedures;
- .2 supply a factory authorized technician at the site for a minimum of one 8 hour day to train the Owner's personnel on VFD operating and maintenance procedures;
- .3 prepare and submit a letter to certify that all VFD's have been properly installed, tested and adjusted, and are in proper operating condition;
- .4 submit a CD of parameters for uploading for future use by the Owner.
- .6 Coordinate all procedures specified above to the performed by the VFD manufacturer/supplier representative with the system commissioning work.

END OF SECTION

MOTOR STARTERS AND WIRING

1 GENERAL

1.01 APPLICATION

- .1 This Section specifies requirements for motor starters and mechanical wiring for mechanical work that are common to mechanical work Sections of the Specification and it is a supplement to each Section and is to be read accordingly.

1.02 SUBMITTALS

- .1 **Product Data:** Submit product data sheets for all products specified in this Section except conduit, wiring and accessories. Include all construction and performance details with the submission, as well as wiring and control schematics.

1.03 QUALITY ASSURANCE

- .1 Motor starters are to be in accordance with the following standards:
 - .1 CSA-C22.2 N0. 14, Industrial Control Equipment
 - .2 Tri-National Standard CAN/CSA-60947-4-1/UL 60947-1A/NMX-J-Z90-ANCE, Low Voltage Switchgear and Controlgear-Part 4-1: Contactors and Motor Starters-Electromechanical Contactors and Motor Starters
- .3 Acceptable manufacturers are:
 - .1 Rockwell Automation Inc. - Allen-Bradley
 - .2 Eaton Corp. – Cutler-Hammer
 - .3 Eaton Corp. – Moeller Electric
 - .4 Siemens Canada
 - .5 Schneider Electric

2 PRODUCTS

2.01 MOTOR STARTERS

- .1 **General:** General requirements for motor starters are as follows:
 - .1 all motor starters must be capable of starting the associated motors under the imposed loads
 - .2 confirm that starter voltage matches the motor prior to ordering
 - .3 unless otherwise specified, all motor starters (and disconnect switches) are to have a 50,000 symmetrical SCIA (short circuit interrupting ampacity)
 - .4 equip starters with accessories and modifications as per the drawing Motor Starter Schedule

MOTOR STARTERS AND WIRING

- .5 equip every starter associated with a building fire alarm system fan shutdown with a double voltage relay with suitable coil voltage
- .2 **Single Phase Motor Starters:** Unless otherwise specified or scheduled single phase motor starters are to be manual motor starting switches, each suitable in all respects for the motor it controls and complete with a neon "ON" pilot light, a snap action toggle operator designed to prevent the switch from being held closed under a sustained motor overload, an enclosure to suit the application, and properly sized thermal overload protection which can be reset by moving the toggle to the "OFF" position.
- .2 **Three Phase Motor Starters:** Unless otherwise specified, starters for three phase motors are to be combination "quick-make" and "quick-break" fused disconnects and full voltage non-reversing across-the-line starters, each complete with a properly sized thermal overload relay per phase, a 120 volt holding coil, and an enclosure to suit the application.
- .3 **Motor Starter Enclosures:** Unless otherwise specified, motor starter enclosures are to be in accordance with the following NEMA/EEMAC ratings:
 - .1 all enclosures located in sprinklered areas – Type 2
 - .2 all enclosures exposed to the elements – Type 3R, constructed of stainless steel
 - .3 all enclosures except as noted above – Type 1

2.02 FUSES

- .1 Fuses: Unless otherwise scheduled or specified, English Electric Ltd. HRC fuses, Form I Class "J" for constant running equipment and Form II Class "C" for equipment that cycles on and off.

2.03 MOTOR STARTER PANELS

- .1 Level #14 gauge G60 galvanized sheet steel panel sized to suit the number of starters/disconnect switches to be mounted plus 20% blank space, secured to a galvanized steel angle framework suitable for wall mounting and equipped with a suitable length of splitter trough to feed the starters/disconnects.

2.04 WARNING SIGNS

- .1 Appropriately sized white PVC warning signs with red lettering, screw holes, and stainless steel screws.

3 EXECUTION

3.01 SUPPLY OF MOTOR STARTERS AND ACCESSORIES

- .1 Unless otherwise shown or specified, supply a starter for each item of motorized equipment you provide.

MOTOR STARTERS AND WIRING

- .2 **Three Phase Motor Starters on Motor Starter Panels:** Where three phase starters are indicated and/or scheduled to be mounted on a wall or on a motor starter panel, provide the panel(s). The starters will be mounted and connected, complete with the panels and splitter trough, as part of the electrical work. Hand the starters to the electrical trade at the site when they are required.
- .3 **Disconnect Switches:** Where package type equipment with integral starters, or equipment with starters integral in loose power and control panels supplied with the equipment is fed from a motor starter panel, a disconnect switch will be provided on the motor starter panel as part of the electrical work
- .4 **Single Phase Motor Starters:** Unless otherwise specified or shown on the drawings, single phase motor starters will be mounted adjacent to the equipment they serve and connected complete as part of the electrical work. Hand the starters to the electrical trade at the site at the proper time.
- .5 **Warning Signs:** Provide warning signs at starter locations where required, i.e. "Motor is Under ECMS Control and May Start At Any Time Without Warning".

3.02 ELECTRICAL WIRING WORK FOR MECHANICAL WORK

- .1 Unless otherwise specified or indicated, the following electrical wiring work for mechanical equipment will be done as part of the electrical work:
 - .1 "line" side power wiring to motor starters or disconnects on walls or on motor starter panels, and "load" side wiring from the starters or disconnects to the equipment
 - .2 "line" side power wiring to pre-wired power and control panels and variable frequency drives, and "load" side power wiring from the panels and VFD's to the equipment
 - .3 provision of disconnect switches for all motors that are in excess of 30' from the starter location, or that cannot be seen from the starter location, and all associated power wiring
 - .4 all motor starter interlocking in excess of 24 volts
 - .5 provision of dedicated 120 volt, 15A-1P circuits terminated in junction boxes in mechanical equipment rooms for automatic control and building automation system wiring connections to be made as part of the automatic controls work
 - .6 120 volt wiring connections to lighting fixture/switch combinations integral with air handling units
 - .7 120 volt wiring connections to duplex receptacles integral with air handling unit control panels
- .2 Mechanical wiring work not listed above or specified herein or on the drawings to be done as part of the electrical work is to be installed in conduit and is to be done as part of the mechanical work in accordance with wiring requirements specified for the electrical work.

END OF SECTION

COMMISSIONING OF LIFE SAFETY AND FIRE PROTECTION SYSTEMS - MECHANICAL

1 GENERAL

1.1 Scope

- .1 Provide coordinated commissioning of life safety and fire protection systems provided under Division 20 with those provided under Division 26 and in accordance with section 01 91 11.
- .2 Coordinate and jointly prepare with the Division 26 contractor to conduct complete and thorough testing and documentation of the systems interface and integration between various LSFP systems provided under Division 26 and those provided under Division 20.
- .3 Include all labor and material as required to participate in the life safety and fire protection commissioning process, as outlined in this section, for equipment and systems provided under Division 20.

1.2 Definitions

- .1 Refer to section 01 91 11.

1.3 Related Sections

- .1 In addition to the requirements of this section, coordinate and implement the commissioning of life safety and fire protection systems in conjunction with:
 - .1 Section 01 91 13 General Commissioning Requirements
 - .2 Section 20 08 15 Commissioning - Mechanical
- .2 The commissioning requirements described in the LSFPCx program are the minimum required. Commissioning procedures under Section 20 08 15 may have greater requirements, and the greater requirements of the two govern.

2 PRODUCTS

2.1 Not Applicable

3 EXECUTION

3.1 Commissioning requirements

- .1 Participate in the development and implementation of the coordinated commissioning program for life safety and fire protection systems in compliance with section 01 91 11.

END OF SECTION

MECHANICAL COMMISSIONING

1 GENERAL

1.1 Scope

- .1 Provide commissioning of mechanical systems provided under Division 20.
- .2 Mechanical system installation, start-up, testing, balancing, preparation of O&M manuals and operator training are the responsibility of the Division 20 Contractors, with the coordination of the commissioning process the responsibility of the General Contractor/ Construction Manager.

1.2 Related work

- .1 Commission mechanical systems in conjunction with:
 - .1 Section 20 08 01, Start-up and Performance Testing
 - .2 Section 23 05 93, Testing, Adjusting and Balancing

1.3 Reference Standards

- .1 Comply with the latest edition of the following:
 - .1 ASHRAE Guideline 1-1996 The HVAC Commissioning Process, as amended herein.

1.4 Commissioning Process

- .1 The Commissioning process develops, coordinates, and documents the following:
 - .1 Equipment start-up
 - .2 Control system calibration
 - .3 Testing and balancing
 - .4 Verification and Performance Testing
 - .5 Operation documentation
 - .6 Operator training
- .2 The Commissioning Program is divided into the following parts:
 - .1 Part 1: Pre-Start and Start-Up testing
 - .2 Part 2: Installation Verification testing
 - .3 Part 3: Performance Validation testing
 - .4 Part 4: Systems Operating Manuals
 - .5 Part 5: Operator Training

1.5 Work Included

- .1 Commissioning work of Division 20 includes, but is not limited to:

MECHANICAL COMMISSIONING

- .1 Testing and start-up of equipment.
 - .2 Testing, adjusting and balancing of hydronic and air systems.
 - .3 Cooperation with the Commissioning Authority in developing and implementation of the commissioning plan.
 - .4 Providing qualified personnel for participation in implementing commissioning test procedures, including seasonal testing required after the initial testing.
 - .5 Providing equipment, materials, and labor as necessary to correct construction and/or equipment deficiencies found during the commissioning process.
 - .6 Providing operation and maintenance manuals, and as-built drawings to the Commissioning Authority for verification.
 - .7 Providing training and demonstrations for the systems specified in this Division.
- .2 Conduct complete and thorough evaluation and documentation of the operation and performance of all components, systems, and sub-systems, including the following equipment and systems:
- .1 Air handling systems
 - .2 Cooling generation systems
 - .3 Heating generation systems
 - .4 Hydronic distribution systems
 - .5 Electric heating systems
 - .6 Air distribution and exhaust systems
 - .7 Domestic hot water systems
 - .8 Domestic cold water systems
 - .9 Fire protection systems / suppression systems
 - .10 Variable frequency drives
 - .11 Building Automation Systems
 - .12 Fuel systems
 - .13 Laboratory gas and liquid systems
- .3 Commission equipment which has been pre-tendered, pre-purchased, or pre-ordered by the Owner or their Agent, and the value of which has been assigned to the Mechanical Contractor or their sub-trades and is included in the value of the Work.
- .4 Commission services to equipment, but not the equipment itself, where the supply of the equipment does not form part of the mechanical Work.
- .5 Provide the following commissioning documentation:
- .1 recording completed Pre-start and Start-up procedures test results,

MECHANICAL COMMISSIONING

- .2 recording completed Installation Verification and Performance Validation test results,
- .3 As-built records.
- .4 Operation and maintenance manuals
- .6 The final commissioning report will be prepared by the Commissioning Authority.

1.6 Excluded Work

- .1 Unless otherwise specified, commissioning of equipment which is marked Not in Contract (NIC) or Not in Mechanical Contract (NIMC), where the value for the supply of equipment is not included as part of the Work.

1.7 Definitions

- .1 *Major deficiency* – an item which if not corrected renders the equipment or system unsuitable or un-safe for use by the Owner. Major deficiencies must be corrected as a condition for achieving Substantial Performance.
- .2 *Minor deficiency* – an item which does not impact on the operation of the equipment or system and will allow the Owner to use the system safely. Minor deficiencies may be corrected before or after Substantial Performance, but will not prevent certification of Substantial Performance of the Work.

1.8 Commissioning Schedule

- .1 Provide a detailed commissioning schedule for consolidation into the main construction schedule.
- .2 Include:
 - .1 equipment and systems start-up predecessors
 - .2 time periods for pre-start and start up testing, verification and validation testing for each equipment and system.

1.9 Documentation Deliverables

- .1 Identify documents including test documents, binder covers, etc. using equipment ID numbers provided on equipment schedules.
- .2 Scan original signed test reports, including verification and performance test reports, manufacturers service reports, etc. in Adobe Acrobat *.pdf version 8 format. For original document chapters, provide Adobe chapter referencing.
- .3 Submit three (3) copies of each completed and accepted Verification and Functional Performance Test reports, both preliminary and final issues.
- .4 Collate final, accepted and signed test results in separate binders as follows:

MECHANICAL COMMISSIONING

- .1 Fire Protection
- .2 Plumbing and Drainage
- .3 HVAC Systems
- .4 Building Management Systems
- .5 Provide three (3) CD-R or DVD-R copies of commissioning documentation.

1.10 Substantial Performance

- .1 Substantial Performance
- .2 Application for Substantial Performance of the Work is precedent on the Work being ready for Owner's use which includes completion of the following commissioning elements:
 - .1 Start-Up and testing, including TAB reports,
 - .2 Commissioning Verification testing including submission of completed records,
 - .3 Commissioning Performance Validation testing including submission of completed records, except for alternate season tests,
 - .4 Commissioning Controls Validation testing,
 - .5 Training of Owner's operations personnel,
 - .6 As-built documentation issued for Consultant's review,
 - .7 Operations and Maintenance manuals which have been reviewed by the Consultant and accepted by the Owner.

1.11 Test Equipment

- .1 Furnish tools and equipment required during the commissioning process.
- .2 Utilities (water, gas, fuel oil, electrical power) are provided by the Owner
- .3 Provide any proprietary test equipment and software required by equipment manufacturer for programming and / or start-up, whether specified or not.
- .4 Manufacturer provides test equipment, demonstrate its use, and assists in the commissioning process as needed.
- .5 Turn-over proprietary test equipment to the Owner upon completion of the commissioning process, where such requirement is specified in the relevant equipment specification sections.

MECHANICAL COMMISSIONING

2 ORGANIZATION

2.1 General

- .1 Complete all phases of work so that the systems can be started, tested, balanced, and owner's acceptance procedures be undertaken in a timely manner such that only one acceptance test is conducted at any one time.
- .2 Participate and assist in the development of the Commissioning Plan and schedule by the General Contractor, by providing necessary information pertaining to the equipment and installation. Provide commissioning schedule information to be incorporated into the overall Construction Plan schedule.
- .3 Acceptance procedures may begin prior to completion of a system and/or sub-system. Start of acceptance procedures before system completion does not relieve the Contractor from completing those systems in accordance with the commissioning and construction schedule.

2.2 Participants

- .1 Commissioning Team consists of multiple parties with separate responsibilities.
- .2 Owner:
 - .1 establishes acceptance criteria,
 - .2 provides operations staff to receive training, and to witness any or all tests at their discretion,
 - .3 final acceptance of commissioning results.
- .3 Design Consultant:
 - .1 responsible for the construction review activities in accordance with local building code requirements,
 - .2 may participate in development and / or review of commissioning procedures,
 - .3 reviews commissioning test results,
- .4 Commissioning Authority:
 - .1 develops commissioning plan and procedures,
 - .2 coordinates Owner's commissioning team members who witnesses tests,
 - .3 selectively witnesses commissioning tests on an audit basis to confirm compliance by the Contractor to the Commissioning Plan,
 - .4 reviews commissioning test results and makes recommendations to the Owner for acceptance.
- .5 General Contractor / Construction Manager:
 - .1 coordinates and manages commissioning activities,

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- .2 develops and integrates commissioning activities into the construction schedule,
 - .3 ensures commissioning procedures are completed and documented, and commissioning records including any required attachments are submitted.
- .6 Mechanical trades Contractors:
- .1 Provide the services of qualified technician(s) who are familiar with the construction and operation of the system, to start-up and debug equipment and systems within the Division 20 scope of Work. Include for labour, materials, and subsistence costs for these same technicians to assist the Commissioning Authority in completing the commissioning program.
 - .2 Provide access to the contract plans, shop drawings, and equipment cut sheets of all installed equipment.
 - .3 Ensure the qualified technician(s) are available and present during commissioning testing to complete the tests, make adjustments and to assist in problem resolutions.
 - .4 Should any equipment or system experience performance problems and/or reconstruction or replacement of components is required, include for additional technician time for subsequent retesting of systems until required system performance is achieved.
 - .5 The Commissioning Authority reserves the right to approve proposed technicians with regard to the technical skill level required for each type of equipment and/or system, and a willingness by the individual(s) to work within the Commissioning Group.
- .7 Controls Contractor, in addition to the requirements described above:
- .1 Provide test reports using own documentation formats, for wiring tests, loop testing, loop tuning, and sequence functional tests.
 - .2 Provide details of the control system, schematics, and a narrative description of control sequences of operation.
- .8 Electrical Contractor:
- .1 provide a foreman electrician familiar with the electrical interlocks, interfaces with emergency power supply, and interfaces with alarm and life-safety systems. Provide access to the contract plans, and all as-built schematics of sub-systems, interfaces and interlocks.
- .9 Equipment suppliers:
- .1 provide the services of manufacturers' service personnel to provide assistance with pre-start and initial start-up of the equipment, as required.

MECHANICAL COMMISSIONING

3 EXECUTION

3.1 Commissioning Meetings

- .1 Participate in periodic commissioning team meetings, and trade commissioning meetings.
- .2 Pre-construction:
 - .1 participate in a pre-construction meeting of commissioning team members, to familiarize parties with the commissioning process, and to ensure that the responsibilities of each party are clearly understood.
- .3 Construction and Post-Construction:
 - .1 participate in commissioning meetings as scheduled by the General Contractor.
 - .2 participate in trade commissioning meetings as required, in addition to the regular commissioning team meetings,
 - .3 identify to the commissioning group problems relating to the commissioning schedule, identification of start-up issues, etc., and participate in the resolution of these problems.

3.2 Commissioning Procedures

- .1 The Owner's designated Commissioning Authority provides the commissioning procedures (checklists, etc.) for use by the contractor.
- .2 Each commissioning procedure tests the equipment and systems, and consists of the following elements:
 - .1 Document sign-off
 - .2 Pre-start and Initial test
 - .3 Installation Verification - Equipment
 - .4 Installation Verification - Systems
 - .5 Performance Validation
 - .6 Controls Validation
 - .7 Appendices.
- .3 Document Sign-Off:
 - .1 each completed procedure is signed off by the following parties:
 - (a) Contractor, for testing,
 - (b) Commissioning Consultant, for review and witnessing,
 - (c) Owner, for test acceptance.
- .4 Pre-Start and Initial Test:

MECHANICAL COMMISSIONING

- .1 Checklists included: confirmation of authorities inspections, pre-start safety checks (where applicable), system cleaning and pressure testing, and confirmation of availability of supporting systems.
- .5 Installation Verification - Equipment
 - .1 Checklists to verify the installation of equipment, including: design specification requirements, drawing requirements, manufacturer installation requirements, and other experience-related items.
 - .2 Use of pre-printed manufacturer installation and start-up checklists are permitted and encouraged; however, the commissioning procedure checklists may contain supplemental items.
- .6 Installation Verification - System:
 - .1 Checklists to verify the installation of the system associated with the equipment.
- .7 Performance Validation:
 - .1 Specific test procedures and record documentation requirements for performance measurements of the various systems.
- .8 Controls Validation:
 - .1 Step-by-step testing methodologies to prove the functional operation of control systems, for normal and abnormal operating conditions, and alarm conditions.
- .9 Appendices:
 - .1 Collate test reports from authorities having jurisdiction, manufacturer start-up and test reports, balancing reports, etc.

3.3 Commissioning test methodology

- .1 Step 1: complete the pre-start, start-up and testing, and adjusting and balancing tests. On completion of this phase, complete the related documentation and submit to the Commissioning Authority and Consultant.
- .2 Steps 2 and 3: on completion of Step 1, conduct the Verification and Validation testing of the operating systems. Identify deficiencies and correct. After the deficiencies have been corrected, notify the Commissioning Authority and agree on dates to demonstrate the commissioned systems.
- .3 Step 4: where the Commissioning Authority identifies systems which require witness demonstration, repeat Steps 2 and 3. These demonstrations may be coordinated with training demonstrations of Owner's operations staff.
- .4 On completion of systems which do not require witness demonstration, finalize the report and submit to the Commissioning Authority and the Consultant for review.

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- .5 On completion of systems which have been witness demonstrated, the Commissioning Authority is to sign-off the completed document, before they are issued for review.

3.4 Commissioning implementation

- .1 Conduct operating tests and checks to verify that all components, equipment, systems, and interfaces between systems, operate in accordance with contract documents.
- .2 Demonstrate and verify operating modes, interlocks, specified control sequences, specific responses to abnormal or emergency conditions, and verification of the proper response of the Building Automation System.
- .3 Validate the results of the TAB report.
- .4 Roles and Responsibilities:

Organized by:	General Contractor
Test sheets provided by:	Commissioning Authority
Testing Conducted by:	Div 20 Contractors
Testing recorded by:	Div 20 Contractors
Tests witnessed by:	Commissioning Authority (selected tests) Design Consultant (selected tests)
Reports reviewed by:	General Contractor Commissioning Authority Design Consultant Owner
Reports Accepted by:	Owner

3.5 Operating checks

- .1 The Commissioning Authority witnesses selected equipment and system tests on an audit basis.
- .2 Set the system equipment into operating mode to be tested including but not limited to:
- .1 Normal shut-down
 - .2 Normal auto position
 - .3 Normal manual position

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- .4 Unoccupied cycle
- .5 Emergency power operation, including transition states.
- .6 Alarm conditions
- .3 Inspect and verify the position of each device and interlock identified on the checklist.
- .4 Repeat the above tests for each operating cycle that applies to the system being tested.
- .5 Check the operating condition of the following elements during all modes of operation of the system:
 - .1 Safety interlocks
 - .2 Alarms
 - .3 Smoke control and smoke venting interlocks
 - .4 Life safety systems
- .6 For failed test items, provide appropriate comments to the checklist data sheet and classify whether it is a "Major" or "Minor" deficiency.
 - .1 The Consultant retains the right to make the final decision regarding classifications of deficiencies.
- .7 Verify the operational control of the systems through the Building Management System as follows:
 - .1 TAB airflow rates and calibrate terminal boxes in all modes of operation
 - .2 Equipment operation in both heating and cooling modes.
 - .3 Minimum outdoor air intake positions, air-side economizer cycles, and multi-set outdoor air damper positions as required for each operating sequence and mode.
 - .4 Building pressurization and other specialty programs
- .8 Verify the proper responses of instrumentation and control devices (actuators) as follows:
 - .1 For each controller or sensor, record the indicated monitoring and control system reading, and the test instrument reading.
 - .2 If the initial test indicates that the test reading is outside of the control range of the installed device, check the calibration of the installed device and adjust as required. Re-test the deficient device and record the results on the checklist data sheets.
- .9 The Commissioning Authority witnesses the field verification of the final TAB report as follows:

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- .1 Select, at random, 10% of the report data for verification.
- .2 The TAB contractor will be provided advance notice of the date of retesting, but not the equipment to be tested.
- .3 The TAB contractor uses the same equipment and instruments used for collecting the original data.
- .10 Test failure is defined as:
 - .1 For all readings other than sound, a deviation of more than 10 percent from the TAB report results.
 - .2 For sound pressure readings, a deviation of 2 dB at any bandwidth, not including differences in background noise readings.
 - .3 A failure rate greater than 10% of the selected items (1% of all TAB test results) will result in rejection of the final TAB report.
- .11 Acceptance
 - .1 The final reports will be reviewed by the Commissioning Authority and the Consultant, to determine if verification is complete and the operating systems are functioning in accordance with the contract documents.
 - .2 The Commissioning Authority, in conjunction with the Consultant, reviews and makes final classification of all noted deficiencies. Correct deficiencies classified as "Major" before acceptance of the Verification stage.
 - .3 The Owner will make the final acceptance of test results.

3.6 Performance Validation Testing

- .1 Conduct performance tests and checks to validate that equipment and system components are providing the required heating and cooling performance (capacity), including but not limited to:
 - .1 Capability of the Chilled water system to deliver the required flow rate, and water temperature at design conditions.
 - .2 Capability of the hydronic and domestic water heating systems to deliver the required flow rate, and temperature.
 - .3 Capacity of electric heating systems at design temperatures.
 - .4 Confirm the ability of the HVAC systems to deliver the required cooling/heating services, at the design supply air temperature, required static pressure, and proper outside air ventilation rate.
- .2 Special testing requirements:
 - .1 Test water chillers in accordance with ARI 590 and 591, at design conditions for full load ratings, and IPLV ratings.

MECHANICAL COMMISSIONING

3.7 Problem Resolution

- .1 In the event that additional work is required to either correct systems, misapplied equipment, and/or deficient performance under varying load conditions, assist the Owner and Commissioning Authority in developing an acceptable resolution to the problem, including the resources of equipment suppliers.
- .2 The Owner has final approval over any additional work required to achieve the required level of performance.
- .3 Complete corrective work in a timely fashion to permit the completion of the commissioning process.

3.8 Acceptance

- .1 Any identified deficiencies will be reviewed by the Consultant in conjunction with the General Contractor/Construction Manager to determine if correction of the deficiency is as a result of a defect in the equipment or installation.
- .2 If it is determined the performance deficiency is as a result of a defect in the equipment or its installation, rectify the deficiency and repeat the performance test until the required performance levels are achieved.
- .3 If it is determined the equipment or system has been constructed in accordance with the contract documents, the Owner will decide whether to accept the performance as is, or, direct the installation contractor to make changes to the system as required to obtain performance levels which meet the design intent, and retest the system.

3.9 Seasonal Commissioning

- .1 Commence initial performance validation testing commissioning at the completion of the installation and verification testing phase. Conduct performance testing, which is weather dependent, as applicable to current seasonal conditions. Complete performance testing on non-weather dependent systems in accordance with the agreed commissioning plan schedule.
- .2 For out-of-season system performance testing, conduct initial performance tests to demonstrate off-peak load performance. Schedule peak load performance testing over the succeeding nine (9) months to ensure all equipment is tested at peak load prior to the expiry of the warranty period.
- .3 Test heating equipment/systems during winter design extremes.
- .4 Test cooling systems during summer design extremes with a fully occupied building.
- .5 Alternatively, provide temporary equipment (load banks, etc.) to simulate full load conditions. Submit proposed methodology for review by the Commissioning Authority and Consultant.

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3.10 Additional Commissioning

- .1 Additional commissioning activities may be required after completion of system performance testing. Include in the tender cost a reasonable reserve to complete this work, including assistance from manufacturers' service technicians.

3.11 Systems Operating Manuals

- .1 Provide Operating and Maintenance Manuals in accordance with the requirements of section 20 01 01.
- .2 The Systems Operating Manuals (SOM) are in addition to the Operating and Maintenance Manuals (OMM) required under Section 20 01 01.
 - .1 Provided by Commissioning Authority and/or Consultant.

3.12 Training

- .1 Equipment Training:
 - .1 Provide equipment training in accordance with Section 20 01 01. The manufacturer's representative training will emphasize operating instructions and preventative maintenance.
- .2 Systems Training:
 - .1 In addition to the equipment training described above, provide additional training to describe the operational requirements and design intent of each system.
 - .2 Include classroom instruction, delivered by competent instructors. Place emphasis on overall systems diagrams and descriptions, and design criteria and conditions.
 - .3 If required, obtain and pay for the services of the Design Consultant to provide the instructor services and to provide lecture material for inclusion in the training manual.
 - .4 Training topics to include:
 - (a) Types of installed systems
 - (b) Design intent and design criteria
 - (c) Design constraints
 - (d) Different operating modes – occupied, unoccupied, emergency conditions, etc.
 - (e) Seasonal operating modes
 - (f) IAQ
 - (g) Energy efficiency
 - (h) System operation
 - (i) Automatic controls
 - (j) Service, maintenance, diagnostics and repairs
 - (k) Use of reports and logs
 - (l) Troubleshooting

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- .5 Structure each session to start with the classroom instruction for the overall system, followed by hands-on instruction for each equipment, with the services of the manufacturers' representative as required. Demonstrate the start-up and shut-down of each system.
 - .6 Organize and schedule each training session to deliver the required instruction in an efficient and effective manner on a schedule agreed upon with the Owner. Allow for two (2) training sessions for each topic, separated by approximately one week each, to allow for shift coverage.
 - .7 Structure each training session based on type of maintenance personnel attending the training session, i.e. Plumbers, fitters, general maintenance, controls technicians, etc. Develop the proposed training plan and obtain approval from the Owner before commencing the training.
 - .8 Complete the training as close to Substantial Performance as possible, so that the Owner's operations staff are prepared to operate the system after Substantial Performance is certified.
- .3 Training Manuals
- .1 Provide training material hand-outs for each session.
 - .2 Collect training material and bind into separate binders.

END OF SECTION

General Requirements

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Read and conform to:
 - .1 The Contract CCDC2-2008, Stipulated Price Contract as amended,
 - .2 Division 1 requirements and documents referred to therein.
- .2 The technical Sections of this Division are generally divided into units of work for the purpose of ready reference. The division of the work among subcontractors is not the Consultant's responsibility and the Consultant assumes no responsibility to act as an arbiter and/or to establish subcontract limits between any Sections of the work..
- .3 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.
- .4 Wherever differences occur in the tender documents, the most onerous condition governs. Base the bid on the most costly arrangement.

1.2 DEFINITIONS

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

1.3 WORK INCLUDED

- .1 Products and methods mentioned or shown in the Contract Documents complete with incidentals necessary for a complete operating installation. Provide all tools, equipment and services required to do the work.
- .2 Cutting and patching of new or existing work.
- .3 Identification of equipment, piping, valves and controllers.
- .4 Take such measures and include in Bid Price for the proper protection of the existing building and its finishes at all times during alterations and construction of the new addition. Coordinate this protective work with all trades.
- .5 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 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

General Requirements

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 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.
- .3 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.
- .4 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 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 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

General Requirements
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 01 and to Section 22 01 01 General Requirements.
- .2 Arrange with each manufacturer/supplier to extend warranties as necessary to coincide with warranty period or those periods specified.

1.10 EXTRAS AND CREDITS

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

2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

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

General Requirements

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

General Requirements

3.1 RELATIONSHIP WITH OTHER TRADES

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

3.2 INSTALLATION REQUIREMENTS

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

3.3 CONTRACT DRAWINGS

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

General Requirements

- .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 COMMISSIONING

- .1 Refer to Section 01 91 15 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 Z320-11 Building Commissioning Standard
- .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 Brock University,
 - .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

Demolition & Renovations

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 05 05 & 22 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 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.
- .6 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 all authorities of intent to demolish and schedule for the work. Obtain required permits from authorities.
- .2 Conform to all 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 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.

1.5 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 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.

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1.6 PHASING AND SCHEDULING (NOT APPLICABLE)

- .1 Refer to Division 1 PHASING AND SCHEDULING OF THE WORK.
- .2 Coordinate with the work of all Sections of Division 15 with other trades and assist in the development of the Phasing Strategy.

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 shut downs 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, supported above floors 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 any and all damage to the building and components resulting from failure to provide sufficient protection, to the satisfaction of the Consultant.
- .3 All existing air intake and exhaust openings that may be affected by dust and/or debris from the construction work shall be fitted with appropriate filter media to protect against entry of dust and/or debris into the building and its air distribution systems. Filters shall be closely monitored and replaced when necessary. The Contractor shall replace existing filters that become contaminated with dust and/or debris from construction work with new filters.
- .4 In the event that dust and debris from construction work does penetrate the building and/or its air distribution systems, the Contractor shall be responsible for cleaning the affected areas and/or systems.
- .5 Temporary filters shall be removed on completion of the construction works.

3.4 DEMOLITION

- .1 Notify all authorities of intent to demolish and schedule for the work.
- .2 All demolition work shall conform to all 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

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mechanical services to the building including, but not limited to; sanitary sewer(s), storm sewer(s), water service, natural gas service, steam service, condensate return, water supply to standpipe and sprinkler systems, fire suppression systems hot water heating systems, steam and condensate 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 all service shut downs 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 All demolition work shall 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 Waste disposal shall conform to the requirements of Division 1, municipal By-Laws and Ministry of the Environment regulations and standards.
- .10 All existing air intake and exhaust openings that may be affected by dust and/or debris from the demolition work shall be fitted with appropriate filter media to protect against entry of dust and/or debris into the building and its air distribution systems. Filters shall be closely monitored and replaced when necessary. The Contractor shall replace existing filters that become contaminated with dust and/or debris from demolition work with new filters.
- .11 In the event that dust and debris from demolition work does penetrate the building and/or its air distribution systems, this Section shall be responsible for cleaning the affected areas and/or systems.
- .12 Disconnect remove, cap and identify all utilities within demolition areas.
- .13 Demolish in an orderly and careful manner. Protect existing supporting structural members.
- .14 Remove demolished materials from site except where specifically noted otherwise. Do not burn or bury materials on site.
- .15 Remove materials as Work progresses. Upon completion of Work, leave areas in clean condition.
- .16 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 Existing items to be relocated shall be cleaned and repaired or altered as required to suit new location. All damaged or ineffective parts shall be replaced and the item made "as new".
- .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 all surfaces and finishes in areas from which items have been removed and in which items are relocated. Cap all existing services required to be severed to effect alterations and do all other work necessary to make good such areas to satisfaction of consultant.
- .6 Openings in existing floor assemblies and vertical fire separations necessitated by installation of equipment and systems or construction in general must be temporarily sealed 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.

3.6 INSPECTION AND RE-CERTIFICATION

- .1 Where any equipment, machine or apparatus is modified, rebuilt or rewound with any change resulting

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in its performance or capacity rating and characteristics it shall be inspected and re-certified as required by authorities having jurisdiction.

- .2 A nameplate giving the name of the person or firm making the change and the resulting changes in performance or capacity shall be provided and affixed to the equipment, machine or apparatus adjacent to the original nameplate. Where the original nameplate is removed, the original manufacturer's name and original identifying data, such as serial numbers, shall be added to the nameplate.
- .3 Refer to rules 2-100 and 2-102 of the Ontario Electrical Safety Code.

END OF SECTION

Common Work Results

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 05 05 & 22 01 01.

1.2 COMMON WORK RESULTS

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

1.3 REFERENCE STANDARDS

- .1 Provide all work in accordance with requirements of Regulatory Agencies and conform to:
 - .1 Local and district by-laws, regulations and published engineering standards.
 - .2 the Ontario Building Code as amended,
 - .3 the Ontario Gas Utilization Code as amended
 - .4 Regulations for Construction Projects under The Occupational Health and Safety Act.
- .2 Conform to following CSA Standards:
 - .1 CSA B242 Groove and Shoulder Type: Mechanical Pipe Couplings.
 - .2 CAN1-B149.1 Natural gas and propane installation code.
 - .3 CSA B64.1 Manual for the Selection and Installation of Backflow Prevention Devices
 - .4 CSA B64.1 Manual for the Maintenance and Field Testing of Backflow Prevention Devices.
- .3 Conform to following National Research Council Canada publications:
 - .1 National Building Code of Canada and Supplements to National Building Code of Canada
 - .2 National Fire Code of Canada.
 - .3 Canadian Plumbing Code.
- .4 Provide work where indicated in conformance with guide Specification of the Victaulic System for Building Services, G-100.
- .5 The above documents or portions thereof are referenced within the work of Division 22 and shall be considered part of the requirements of this document as though fully repeated herein.

1.4 QUALIFICATIONS

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

1.5 SUBMITTALS

- .1 Submit shop drawings in accordance with Section 22 01 01 & 01 22 00.

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 WASTE MANAGEMENT & DISPOSAL

- .1 Separate and recycle waste materials in accordance with Division 1 Waste Management and

Common Work Results

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

1.8 WARRANTY

- .1 Provide extended coverage five year warranty for motors larger than 20 HP (15 kW).

2 PRODUCTS

2.1 PIPING SPECIALTIES

- .1 Cast brass, pressure, copper to copper unions shall be used with seamless copper tubing smaller than 3" (75 mm).
- .2 Cast brass flanges shall be used with seamless copper tubing, type L for tubing 3" (75 mm) and larger.
- .3 Dart type, 125 lb. (860 kPa) black malleable iron unions shall be used with all steel pipe for piping 2-1/2" (65 mm) and smaller.
- .4 Slip-on, 150 lb. (1000 kPa) carbon steel flanges with 1/16" (4 mm) raised face shall be used with all steel pipe for piping larger than 2-1/2" (65 mm).
- .5 Gaskets for joining flanged steel pipe shall be 1/16" (4 mm) Cranite ring type gaskets.
- .6 Piping specialties including backflow preventers, strainers, valves etc. shall be line size unless indicated otherwise on drawings.
- .7 Strainers
 - .1 Manufacturers:
 - .1 Sarco SB
 - .2 S. A. Armstrong
 - .3 Crane
 - .4 Conbraco
 - .5 Colton
 - .2 In copper tubing: Class 250, wye type, bronze, screwed connection, with blind caps, and 1/32" (0.8 mm) perforated stainless steel screen.
 - .3 In Steel Piping: 2" (50mm) and smaller
 - .1 Body and cover: screwed, line size Y type strainer, semi-steel conforming to ASTM A278-85, Class 30, complete with screwed blind cap. Primary service rating of 125 psi @ 350 F (860 kPa @ 178 C). Body shall have side drain connection.
 - .2 Screen: perforated type 304 stainless steel service:
 - .1 Steam 1/16" (0.4 mm)
 - .2 Water 1/32" (0.8 mm)
 - .3 Glycol 1/32" (0.8 mm)
 - .4 Water @ Pump Suction 1/8" (3.2 mm)
 - .5 Light Oil 1/16" (1.6 mm)
 - .6 Compressed Air 1/64" (0.4 mm)
 - .4 In Steel Piping: 2-1/2" (65mm) and larger
 - .1 Body and cover: flanged, line size Y type strainer, cast steel, class 150, complete with flanged blow down cover. Primary service rating of 150 psi @ 500 F (1 MPa @ 260 C).
 - .2 Screen: performed type 304 stainless steel service:
 - .1 Steam 1/32" (0.8 mm)
 - .2 Water 1/16" (1.6 mm)
 - .3 Glycol 1/16" (1.6 mm)
 - .4 Water @ Pump Suction 1/4" (6.4 mm)
 - .5 Light Oil 1/16" (1.6 mm)
 - .6 Compressed Air 1/32" (0.8 mm)
 - .5 In grooved piping:
 - .1 Victaulic Style 730 grooved end tee-type strainer for piping 2 1/2" (65 mm) and larger or approved equivalent.

- Common Work Results
- .2 Victaulic Style 731 suction diffuser, or approved equivalent

2.2 ADHESIVES, SEALANTS, PAINTS AND COATINGS

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

2.3 FIRESTOPPING COMPOUNDS

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

2.4 NAMEPLATES

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

2.5 TAGS

- .1 Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background colour. Tag size minimum 1-1/2" (40 mm) diameter. 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 STENCILS

- .1 Stencils: With clean cut symbols and letters of following size:
 - .1 3/4"-1-1/4" (20-30 mm) Outside Diameter of Insulation or Pipe: 8" (200 mm) long colour field, 1/2" (15 mm) high letters.
 - .2 1-1/2"-2" (40-50 mm) Outside Diameter of Insulation or Pipe: 8" (200 mm) long colour field, 3/4" (20 mm) high letters.
 - .3 2-1/2"-6" (65-150 mm) Outside Diameter of Insulation or Pipe: 12" (300 mm) long colour field, 1-1/4" (30 mm) high letters.

Common Work Results

- .4 8" - 10" (200-250 mm) Outside Diameter of Insulation or Pipe: 24" (600 mm) long colour field, 2-1/2" (65 mm) high letters.
- .5 Over 10" (250 mm) Outside Diameter of Insulation or Pipe: 32" (800 mm) long colour field, 3-1/2" (90 mm) high letters.
- .6 Ductwork and Equipment: 2-1/2" (65 mm) high letters.

2.7 PRESSURE GAUGES

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

2.8 STEM TYPE THERMOMETERS

- .1 Manufacturer: Tarrice Model BX91403-1/2.
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Weiss Model 9VS3-1/2.
 - .2 Winter
 - .3 Morrison
 - .4 Taylor
- .3 Thermometer: 9" (230mm) scale, red appearing thermal fluid with black figures on white scale, calibrated in both degrees F and degrees C, accuracy to ASTM E77 of 2%, clear glass lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device, 3/4" (20mm) NPT brass stem.
- .4 All thermometers to include a separable well.
- .5 Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.
- .6 Flange: 3" (75 mm) outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

2.9 DIAL THERMOMETERS

- .1 Manufacturer: Tarrice
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Weiss
 - .2 Winter
 - .3 Morrison
 - .4 Taylor
- .3 Thermometer: ASTM E1, stainless steel case, bimetallic helix actuated with silicone fluid damping, white with black markings and black pointer hermetically sealed lens, stainless steel stem.
 - .1 Size: 2" (50 mm) diameter dial.
 - .2 Lens: Clear glass.
 - .3 Accuracy: 1 percent.
 - .4 Calibration: Degrees C Both degrees F and degrees C.
- OR
- .4 Thermometer: ASTM E1, stainless steel case, adjustable angle with front recalibration, bimetallic helix actuated with silicone fluid damping, white with black markings and black pointer hermetically sealed

Common Work Results

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

2.10 TEST PLUGS

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

2.11 STATIC PRESSURE GAUGES

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

2.12 ACCESS DOORS

- .1 Standard:
 - .1 Minimum 12ga.
 - .2 304 stainless steel, no. 7 satin finish
 - .3 heavy duty fully concealed hinges
 - .4 screwdriver operated, cam latch
- .2 Concealed (Recessed):
 - .1 Minimum 12ga.
 - .2 304 stainless steel, no. 7 satin finish
 - .3 heavy duty fully concealed hinges
 - .4 screwdriver operated, cam latch
- .3 Fire Rated:
 - .1 Access doors in fire separations or fire rated assemblies: ULC labelled.
 - .2 Refer to architectural drawings for ratings of fire separations and assemblies.

Common Work Results

- .3 Minimum 12ga.
- .4 304 stainless steel, no. 7 satin finish
- .5 heavy duty fully concealed [frame and] hinges
- .6 screwdriver operated, cam latch
- .4 Air Seal Flush Mount:
 - .1 Minimum 16ga.
 - .2 304 stainless steel, #7 satin finish
 - .3 1/2" (13 mm) wide, heavy duty, fully concealed frame and concealed hinges
 - .4 1/8" x 3/8" (3.2 x 9.6 mm) closed-cell neoprene gasket
 - .5 screwdriver operated, stainless steel cam latch

2.13 SLEEVES

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

2.14 ESCUTCHEONS

- .1 Finish: Polished chrome

2.15 FLASHINGS AND COUNTER FLASHINGS

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

2.16 PENETRATION SEALS

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

3 EXECUTION

3.1 INSPECTION

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

3.2 PREPARATION

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

3.3 PIPING INSTALLATION - ABOVE GROUND

Common Work Results

- .1 Cooperate with other trades whose work affects or is affected by work of this Section, to ensure satisfactory installation and to avoid delays. Provide all materials to be built-in such as sleeves, anchors, etc., together with accurate dimensions or templates, promptly.
- .2 Layout all work accurately, installing piping parallel to lines of building.
- .3 Install piping, wherever possible, in partitions and above ceiling. Do not install piping in outside walls unless so shown on drawings. Wrap un-insulated piping in masonry walls with building paper.
- .4 Install concealed piping close to building structure to minimize furring dimensions.
- .5 Provide adequate space around piping to facilitate application of insulation.
- .6 Use dielectric couplings where piping of dissimilar metals connect.
- .7 Where piping passes through concrete floors, or walls, sleeves shall be sized to permit the pipe to expand freely without binding or crushing pipe insulation.
- .8 Install automatic control valves and wells supplied under other Sections.

3.4 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.

3.5 PIPING SYSTEMS TESTING AND INSPECTION

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

3.6 TESTING AND BALANCING

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

3.7 PROTECTION

Common Work Results

- .1 Protect finished and unfinished work by tarpaulins, or other covering, from damage due to execution of work under this Division.
- .2 Repair to satisfaction of Consultant, damage to building resulting from failure to provide such protection.
- .3 All existing air intake and exhaust openings that may be affected by dust and/or debris from the construction work of this Division shall be fitted with appropriate filter media to protect against entry of dust and/or debris into the building and its air distribution systems. Filters shall be closely monitored and replaced when necessary. The Contractor shall replace existing filters that become contaminated with dust and/or debris from construction work with new filters.
- .4 In the event that dust and debris from construction work does penetrate the building and/or its air distribution systems, the Contractor shall be responsible for cleaning the affected areas and/or systems.
- .5 Temporary filters shall be removed on completion of the construction works.

3.8 CUTTING AND PATCHING

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

3.9 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.

3.10 FIRESTOPPING

- .1 All openings in fire separations and fire rated assemblies for service penetrations shall be protected

Common Work Results

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

3.11 SLEEVES AND CURBS

- .1 Provide pipe sleeves at points where pipes pass through masonry or concrete.
- .2 Provide sleeves of minimum schedule 20 galvanized steel or cast iron.
- .3 Use cast iron or steel pipe sleeves with annular fin continuously welded at midpoint:
 - .1 through foundation walls, with penetration seals.
 - .2 through floors of mechanical rooms and equipment rooms.
- .4 Provide 1/4" (6 mm) clearance all around, between sleeve and pipes or between sleeve and insulation.
- .5 Where piping passes below footings, provide minimum clearance of 2" (50 mm) between sleeve and pipe. Backfill up to underside of footing with concrete of same strength as footing with concrete of same strength as footing.
- .6 Terminate sleeves flush with surface of concrete and masonry and 2" (50 mm) above floors. Not applicable to concrete floors on grade.
- .7 Provide watertight concrete curb 4" (100 mm) high around mechanical services (pipes, ducts, conduits) which rise through mechanical (service) room floors. Provide minimum 4" (100 mm) clearance between openings for services within curbs.
- .8 For pipes passing through roofs, use cast iron sleeves with caulking recess and flashing clamp device. Anchor sleeves in roof construction, caulk between sleeve recess and pipe, fasten roof flashing to clamp device, make water-tight durable joint. Co-ordinate with roofing Section.

3.12 FLASHINGS

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

3.13 ESCUTCHEONS AND PLATES

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

3.14 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.

3.15 SUPPORT AND ATTACHEMENT

- .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.

3.16 DISSIMILAR METALS

Common Work Results

- .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.

3.17 EQUIPMENT BASES AND CURBS

- .1 Supply and erect structural work required for installation of mechanical equipment.
- .2 Build 4" (100 mm) high concrete curbs around all openings through floors. Ensure joint between curb and floor is watertight and maintains integrity of floor membrane where applicable.

3.18 MOCK-UP

- .1 Refer to Division 01 for requirements for mock-up.
- .2 Each Section shall provide related components for mock-up.
- .3 Mock-up may not remain as part of the Work.

3.19 FIELD QUALITY CONTROL

- .1 Temporary and Trial Usage
 - .1 Allow the Owner the privilege of temporary and trial usage of installed equipment, as soon as work is complete, for a period of time required to conduct a thorough test.
 - .2 Do not construe such usage as evidence of acceptance of work by Owner.
 - .3 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.

3.20 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.

3.21 MECHANICAL IDENTIFICATION INSTALLATION

- .1 Degrease and clean surfaces to receive adhesive for identification materials.
- .2 Prepare surfaces for stencil painting.
- .3 Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer (VOC content not to exceed 680 g/L).
- .4 Install tags with corrosion resistant chain.
- .5 Comply with standard detail drawing plate, "Detail of Piping Identification".
- .6 Apply stencil markings on all covered piping.
- .7 Install plastic tape pipe markers complete around bare pipe to manufacturer's instructions.
- .8 Identify medical gas piping in accordance with CSA Z305.1 and CSA Z7396-1
- .9 Identify anaesthetic gas scavenging piping in accordance with CSA Z7396-1.
- .10 Label piping that is heat traced or equipped with heating cable "HEAT TRACED" in addition to other identification. Locate such labels adjacent to other identifications.

Common Work Results

- .11 Clearly identify abandoned services left in place as "ABANDONED".
- .12 Mark drain from hot lab sink with radiation warning symbols at 10 ft. (3 m) intervals.
- .13 Install underground plastic pipe markers 6"-8" (150-200 mm) below finished grade, directly above buried pipe.
- .14 Identify pumps, water heating equipment, tanks, and water treatment devices with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.
- .15 Identify control panels and major control components outside panels with plastic nameplates.
- .16 Identify valves in main and branch piping with tags. Consecutively number valves in each system.
- .17 Identify piping, concealed or exposed, with stencilled painting and plastic tape pipe markers. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 6 m on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.
- .18 For each item of equipment which may be started automatically or remotely, add a red lamacoid plate, 2-3/8" x 9" (60 x 230 mm), reading:
 "WARNING. THIS EQUIPMENT IS AUTOMATICALLY
 CONTROLLED. IT MAY START AT ANY TIME."
- .19 Provide colour coded self-adhesive dots to locate valves or dampers above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

3.22 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
Compressed Air	CA [psi]	Green	None
Dom. Hot Water Supply	DHWS	Green	None
Dom. Hot Water Recirc.	DHWR	Green	None
Sanitary Sewer	SAN	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

3.23 MANUFACTURER'S NAMEPLATES

- .1 Provide metal nameplates on each piece of equipment, mechanically fastened with raised or recessed letters.

Common Work Results

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

3.24 FLOW DIAGRAMS AND DIRECTORIES

- .1 Provide Consultant with six identification flow diagrams of approved size for each system. Include tag schedule, designating number, service, function, and location of each tagged item and normal operating position of valves.
- .2 Install where agreed with the Owner one copy of each flow diagram and valve schedule mounted in glazed frame. Provide one copy of each in Operation and Maintenance Manual.

3.25 INSTALLATION OF GAUGES AND THERMOMETERS

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

3.26 INSTALLATION OF ACCESS DOORS

- .1 Supply access doors for access to equipment requiring service, lubrication or adjustment and all concealed valves, cleanouts, trap primers, control and volume dampers, and other such equipment.
- .2 Turn over access doors to the appropriate general trade for installation under other Sections.
- .3 Refer to architectural drawings for ratings of fire separations and assemblies. install fire rated access doors in fire rated partitions, walls, and ceilings.
- .4 Access doors in ceilings shall be minimum 24" x 24" (600mm x 600mm), unless otherwise approved by the Consultant.
- .5 Provide concealed access doors in GWB ceilings and coordinate in-fill with general trades.
- .6 Provide Air Seal Flush Mount access doors in all Clean Rooms, Laboratories and Health Care Facility Class 1 rooms [e.g. operating rooms, procedure rooms, ICU, CCU, PACU, and all sterile environments].

END OF SECTION

Pipe Expansion Control

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with general requirements of section 20 05 05 & 22 01 01.

1.2 SECTION INCLUDES

- .1 Flexible pipe connectors.
- .2 Expansion joints and compensators.
- .3 Pipe loops, offsets, and swing joints.
- .4 Anchors and guides

1.3 REFERENCES

- .1 CSA B51 Boiler, Pressure Vessel and Pressure Piping Code
- .2 ASME B31.1 Code for Power Piping
- .3 ASME B31.3 Process piping
- .4 MIL-E-17814E - Expansion Joints, Pipe, Slip-Type, Packed.

1.4 PERFORMANCE REQUIREMENTS

- .1 Provide structural work and equipment required to control expansion and contraction of piping.
- .2 Verify that anchors, guides, and expansion joints provided, adequately protect system.
- .3 Arrange all 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 This Section shall analyze each section of pipe installed between constraints and shall determine the potential for expansion of the pipe based on pipe temperature at installation and pipe temperatures throughout the pipe's operating range. Where potential expansion exceeds 1" (25 mm) over the length of the pipe section, expansion compensators shall be installed. 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 Expansion Calculations:
 - .1 Safety Factory: 30 percent.
 - .2 Installation Temperature: 50°F (10°C).
 - .3 Hot Water Heating: 210°F (99°C).
 - .4 Domestic Hot Water: 140°F (60°C).

1.5 SUBMITTALS

- .1 Refer to section 01 33 00 & 22 01 01
- .2 Product Data:

Pipe Expansion Control

- .1 Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face-to-face length, live length, hose wall thickness, hose convolutions per metre and per assembly, fundamental frequency of assembly, braid structure, and total number of wires in braid.
- .2 Expansion Joints: Indicate maximum temperature and pressure rating, and maximum expansion compensation.
- .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.

1.6 QUALIFICATIONS

- .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 licensed in the Province of Ontario.

1.7 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.

1.8 WARRANTY

- .1 Warranty: 5-year replacement warranty.

1.9 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- .1 Manufacturers must be certified by the Expansion Joint Manufacturers Association (EJMA)
- .2 Flexible Pipe Connectors
 - .1 Flex-Pression Ltd.
 - .2 Sr. Flexonics
 - .3 Ontario Hose
 - .4 Colton Industries

Pipe Expansion Control

.3 Expansion Joints

- .1 Flex-Pression Ltd.
- .2 Hyspan Precision Products, Inc.
- .3 Sr. Flexonics

.4 Pipe Alignment Guides

- .1 Flex-Pression Ltd.
- .2 Hyspan Precision Products, Inc.
- .3 Sr. Flexonics

2.2 PIPE ALIGNMENT GUIDES

.1 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 axial travel shall be 3" for sizes 2" IPS and under, and 6" for sizes 2-1/2" IPS and over.
- .5 refer to piping and expansion joint schedules for specific insulation and motion requirements.
- .6 Basis of design: Hyspan Series 9500.

.2 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 axial travel shall be 3" for sizes 2-1/2" and under, or 6" for sizes 3" and 4".
- .5 refer to piping and expansion joint schedules for specific insulation and motion requirements.
- .6 Basis of design: Hyspan Series 9500.

2.3 FLEXIBLE PIPE CONNECTORS

.1 Copper Piping:

- .1 Inner Hose: Bronze
- .2 Exterior Sleeve: Braided bronze.

Pipe Expansion Control

- .3 Pressure Rating: 125 psi (862 kPa) WSP and 450°F (232°C).
- .4 Joint: As specified for pipe joints.
- .5 Size: Use pipe sized units
- .6 Maximum offset: 3/4" (20 mm) on each side of installed center line.
- .2 Steel Piping, 2" (50 mm) diameter and smaller:
 - .1 Inner Hose: braided bronze.
 - .2 Exterior Sleeve: None.
 - .3 Pressure Rating: 125 psi (862 kPa) WSP and 450°F (232°C).
 - .4 Joint: Threaded.
 - .5 Size: Use pipe sized units.
 - .6 Maximum offset: 3/4" (20 mm) on each side of installed center line.
- .3 Steel Piping, 2-1/2" to 3-1/2" (65mm to 90mm) diameter :
 - .1 Inner Hose: braided bronze.
 - .2 Exterior Sleeve: None.
 - .3 Pressure Rating: 125 psi (862 kPa) WSP and 450°F (232°C).
 - .4 Joint: Flanged.
 - .5 Size: Use pipe sized units.
 - .6 Maximum offset: 3/4" (20 mm) on each side of installed center line.
- .4 Steel Piping, 4" (100mm) diameter and larger:
 - .1 Inner Hose: braided 321 stainless steel.
 - .2 Exterior Sleeve: None.
 - .3 Pressure Rating: 125 psi (862 kPa) WSP and 450°F (232°C).
 - .4 Joint: Flanged.
 - .5 Size: Use pipe sized units.
 - .6 Maximum offset: 3/4" (20 mm) on each side of installed center line.

2.4 EXPANSION JOINTS - COPPER PIPING

- .1 Bronze Bellows Type:
 - .1 Construction: 2-ply bronze 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).

Pipe Expansion Control

- .4 Maximum Extension: 1/4" (6 mm).
- .5 Joint: Soldered.
- .6 Size: Use pipe line sized units
- .7 Application: Copper piping.

2.5 EXPANSION JOINTS - DESIGN 150 PSIG / 500°F

.1 Ratings

- .1 Design Pressure: 150 psig (1035 kPa)
- .2 Test Pressure: 225 psig (1552 kPa)
- .3 Design Temperature: 500 °F (260°C)

.2 Stainless Steel Bellows Type:

- .1 Construction multi-ply ASTM A240 type 321 stainless steel bellows, ASME A53, Gr. B carbon steel housing,
- .2 Pressure Rating: 150 psi (1035 kPa) WSP and 500°F (260°C).
- .3 Maximum Compression: 1-3/4" (45 mm).
- .4 Maximum Extension: 1/4" (6 mm).
- .5 Joint: Flanged.
- .6 Size: Use pipe line sized units
- .7 Application: Steel piping 2-1/2" (65 mm) and smaller.

.3 Externally Pressurized:

- .1 Construction: Self-equalizing type with three or four ply ASTM A240 type 321 stainless steel bellows; ASME A53, Grade B carbon steel housing and pipe nipples; ASME-A36 steel plate guide rings and flanges; ASME A105, 3000-lb thread-o-let drain port & plug.
- .2 Pressure Rating: 300 psi (2070 kPa) WOG and 500°F (260°C).
- .3 Maximum Compression: 8" (200 mm).
- .4 Maximum Extension: 2" (50 mm).
- .5 Joints: Flanged.
- .6 Size: Use pipe line sized units
- .7 Application: Steel piping 3" (75 mm) and larger.

2.6 LAMINATED, ULTRA-LOW PRESSURE FORCE SERIES 1501-1506

.1 Ratings:

- .1 Design Pressure: 150 PSIG 300 PSIG

Pipe Expansion Control

- .2 Test Pressure: 225 PSIG 450 PSIG
- .3 Maximum Temperature: 500 F.
- .2 Basis of design: Hyspan series 1501-1506.
- .3 Expansion joints shall be low area, three-ply, internally pressurized designs, single or dual configurations as scheduled.
- .4 Integral pipe attachments must have a radius where the bellows neck is received.
- .5 Expansion joints with larger effective area, welded to the pipe OD, not of three plies, or attached to a pipe without a radius will not be accepted.
- .6 Bellows shall be three ply, type 304 or 321 stainless steel, with the effective areas listed below, and attached to the pipe ID. Alloy 625 bellows shall be provided when chloride-ion, stress-corrosion cracking is a concern.

Pipe Size	Effective Area (in ²)	Pipe Size	Effective Area (in ²)
1-1/2"	2.3	6"	33.3
2"	4.1	8"	56.8
2-1/2"	5.8	10"	87.2
3"	8.8	12"	122.0
4"	15.4	14"	152.0

- .7 Internal liners of stainless steel shall remain within the joint over all dimensions under design motions.
- .8 Bellows receivers of A53 Gr. B (or A106 Gr. B) standard weight pipe, with internal radii.
- .9 Flanges shall be A36 carbon steel plate, or A105 forged, with ANSI B16.5 drilling and outside diameter. Flanges may be fixed or lap joint stub end as specified.
- .10 Butt weld ends of schedule standard A53 Gr. B (or A106 Gr. B).
- .11 Dual joints must include an intermediate anchor base.

2.7 LAMINATED, ULTRA-LOW PRESSURE FORCE, SERIES 1501-1502 HYRISER

- .1 Ratings:
 - .1 Design Pressure: 150 PSIG
 - .2 Test Pressure: 225 PSIG
 - .3 Maximum Temperature: 500 F.
- .2 Basis of design: Hyspan series 1501/1502 HYRISER.

Pipe Expansion Control

- .3 Expansion joints shall be low area, three-ply, internally pressurized designs, single configuration incorporating an internal guide liner.
- .4 Integral pipe attachments must have a radius where the bellows neck is received.
- .5 Expansion joints with larger effective area or axial spring rate welded to the pipe OD, not of three plies, or attached to a pipe without a radius will not be accepted.
- .6 Bellows shall be three ply, type 304 or 321 stainless steel, with the effective areas listed below, and attached to the pipe ID. Alloy 625 bellows shall be provided when chloride-ion, stress-corrosion cracking is a concern.

Pipe Size	Effective Area (in ²)	Axial Spring Rate (lbs/in)
4"	15.4	155
5"	23.5	190
6"	33.3	348
8"	56.8	325
10"	87.2	411
12"	122.0	614

- .7 Internal liners of stainless steel shall remain within the joint over all dimensions under design motions and self-drain.
- .8 Bellows receivers of A53 Gr. B (or A106 Gr. B) standard weight pipe, with internal radii.
- .9 Flanges shall be A36 carbon steel plate, or A105 forged, with ANSI B16.5 drilling and outside diameter. Flanges may be fixed or lap joint stub end.
- .10 Butt weld ends of schedule standard A53 Gr. B (or A106 Gr. B).
- .11 Dual joints must include an intermediate anchor base.
- .12 Warranty required: 5-Year limited.

2.8 TIED UNIVERSAL EXPANSION JOINTS, SERIES 1511R-1512R

- .1 Ratings:
 - .1 Design Pressure: 50, 150, or 300 PSIG
 - .2 Test Pressure: 75, 225, or 450 PSIG
 - .3 Lateral Motions: 2", 3", 4"
 - .4 Maximum Temperature 500 F.
- .2 Expansion Joints shall be the tied universal configuration incorporating two independent bellows. The expansion joint shall be installed perpendicular to the piping run inducing lateral motion. The expansion joint induces only spring forces to the piping when only lateral motions are absorbed.
- .3 Bellows shall be one-to-four plies as required of austenitic stainless steel.

Pipe Expansion Control

- .4 Flanges shall be A36 carbon steel plate, with ANSI B16.5 drilling and outside diameter. Flanges may be fixed, or vanstoned as indicated on the schedule. Carbon steel vanstone flanges allow slight rotation for misalignment and/or to allow *stainless steel wetted surfaces for corrosion resistance.
- .5 Butt weld-ends, shall be schedule standard A53 Gr. B, or the schedule and material grade otherwise indicated.
- .6 Tie/Limit rods are required to absorb pressure thrust forces and provide safety limits for design motions.
- .7 Internal liners shall be provided for;
 - .1 liquid flows at 10 feet per second or higher in pipes 6" IPS and over,
 - .2 flows exceeding 2 feet per second per inch of diameter in pipes under 6" diameter,
 - .3 flow rates exceeding 100 feet per second
 - .4 steam service,
 - .5 abrasive flows.
- .8 Tied Universal expansion joints shall be Hyspan series 1511R flanged or 1512R weld end.

2.9 EXTERNALLY-PRESSURIZED & LAMINATED EXPANSION JOINT SERIES 3501-3506

- .1 Ratings:
 - .1 Design Pressure 150 300 PSIG
 - .2 Test Pressure 225 450 PSIG
 - .3 Maximum Temperature 500 F.
- .2 Expansion joints shall be externally pressurized, with internal and external guides.
- .3 Bellows must be three plies with the specified effective areas and attached via independent collars.
- .4 Materials of construction are A-53 Gr.B (or A-106 Gr.B) standard weight liner and housing, carbon steel guide rings, and type 304 stainless steel bellows with the effective areas listed below. Attach the bellows to internal and external guide rings via 304 S.S. collars. Use Alloy 625 bellows when chloride-ion, stress-corrosion cracking is a concern.
- .5 Bellows welded to guide rings at the root or crest radii are not acceptable.
- .6 Vent internal guide rings to reduce the effects of sudden pressure changes.
- .7 Include a lifting lug and drain port.
- .8 Flanges shall be A36 carbon steel plate, or A105 forged, with ANSI B16.5 drilling and outside diameter. Flanges may be fixed or lap joint stub end.
- .9 Butt weld ends of schedule standard A53 Gr. B (or A106 Gr. B).
- .10 Dual joints must include an intermediate anchor base.
- .11 Design basis: Hyspan series 3500.

Pipe Expansion Control

Pipe Size	Effective Area (in ²)	Pipe Size	Effective Area (in ²)
1-1/2"	8.2	6"	50.3
2"	8.2	8"	80.5
2-1/2"	10.6	10"	115
3"	13.7	12"	164
4"	22.7	14"	206
5"	35.3	16"	258
		18"	318

2.10 EXTERNALLY-PRESSURIZED & LAMINATED SERIES 8500

- .1 Ratings:
 - .1 Design Pressure: 200 PSIG
 - .2 Test Pressure: 300 PSIG
 - .3 Maximum Temperature: 500 F.
 - .4 Axial Compression: 2" or 3"
- .2 Expansion compensators will be externally pressurized, with internal and external guides. The Expansion Joint Manufacturers Association (EJMA) must certify the manufacturer. Bellows must be two plies minimum with the specified effective areas.
- .3 Materials of construction for steel piping compensators are: Butt weld, male pipe thread and steel groove ends with integral liner are schedule standard A53 Grade B, carbon steel housing and guide rings, and *304 s/s or 321 s/s bellows with the effective areas listed below. Flanges, if specified, are provided fixed with ANSI B16.5 drilling and outside diameter. Attach bellows necks to internal and external guide rings. Bellows welded to guide rings at the convolution root or crest radii are not acceptable.
- .4 Materials of construction for copper tube compensators are: Type L copper tube ends male or female sweat, 304 s/s housing and guide rings, *304 or 321 s/s bellows with the effective areas listed below. Attach the bellows necks to internal and external guide rings. Bellows welded to guide rings at the convolution root or crest radii are not acceptable.
- .5 Expansion compensators will be Hyspan series 8500, or other engineer approved equal.

Steel Pipe Size	Effective Area (in ²)	Copper Tub Size	Effective Area (in ²)
3/4"	1.5	3/4"	1.1
1"	2.1	1"	1.7
1-1/4"	3.3	1-1/4"	2.4

Pipe Expansion Control

1-1/2"	4.3	1-1/2"	3.2
2"	6.3	2"	5.1
2-1/2"	8.8	2-1/2"	7.6
3"	13.1	3"	10.6
4"	20.8	4"	17.9

2.11 PRESSURE BALANCED, EXTERNALLY-PRESSURIZED, LAMINATED SERIES 3500PB

- .1 Ratings:
 - .1 Design Pressure 150 300 PSIG
 - .2 Test Pressure 225 450 PSIG
 - .3 Maximum Temperature 500 F.
- .2 Expansion joints pressure balanced, externally pressurized, laminated bellows type, with internal and external guides
- .3 Bellows shall be three plies with specified spring rates per Hyspan catalog 574H and attached via independent collars.
- .4 Materials of construction are A-53 Gr.B (or A-106 Gr.B) standard weight liner and housing, carbon steel guide rings, and type 304 stainless steel bellows with three plies. Attach the bellows to internal and external guide rings via 304 S.S. collars. Use Alloy 625 bellows when chloride-ion, stress-corrosion cracking is a concern.
- .5 Bellows welded to guide rings at the root or crest radii are not acceptable.
- .6 Vent internal guide rings to reduce the effects of sudden pressure changes.
- .7 Include a lifting lug and drain port.
- .8 Flanges shall be A36 carbon steel plate, or A105 forged, with ANSI B16.5 drilling and outside diameter. Flanges may be fixed or lap joint stub end.
- .9 Butt weld ends of schedule standard A53 Gr. B (or A106 Gr. B).
- .10 Dual joints must include an intermediate anchor base.
- .11 Design basis: Hyspan series 3500PB.

2.12 SLIP EXPANSION JOINT, SERIES 6500 PERMA-PAX

- .1 Expansion joints shall be packed-slip type containing injectable flaked graphite packing and graphite seals. Packing ports allowing packing under full line pressure are required. Non-injectable packing designs are not acceptable. Non-graphite packing and seals are not acceptable.
- .2 Internal and external line-bore machined guides of ASTM SB169-C614. Non-ASME rated bearing materials are not acceptable. Joint Seal Force is 850 pounds per inch of diameter or less in published catalog.
- .3 A stainless steel extension limit stop ring covering approximately 360 degrees will be included on each slip tube. Limit-stop pins are not acceptable.

Pipe Expansion Control

- .4 The slip tube will be made from A53-Gr.B pipe, schedule 80 from 1-1/4" through 16" IPS and schedule 60 from 18" through 24" IPS sizes. The slip tube will be hard-chromed-plated .002" thick according to ASTM B650.
- .5 One-piece body required.
- .6 Include a drain port on each joint.
- .7 See the expansion joint schedule for required weld end fittings of schedule standard, schedule 40 or schedule 80, or flanges.
- .8 Joint design and manufacturing in compliance with ASTM F1007 and MIL-E-17814F.
- .9 Expansion joints will be Hyspan Series 6500 Perma-Pax .

Nominal Size (NPS)	Effective Area (square inches)	Joint Seal Force (lbs)
2	4	1700
2-1/2	5.9	2125
3	8.9	2550
4	15	3400
5	23.2	4250
6	32.5	5100
8	55.9	6800
10	86.6	8500
12	123	10,200
14	148	11,900
16	195	13,600
18	247	15,300
20	306	17,000
24	443	20,400

2.13 BALL JOINTS, TYPE N, SERIES 6500

- .1 Hyspan-Barco Type N Series I Ball Joints
 - .1 Angular motion of plus and minus 7.5 degrees and torsional motion of 360 degrees
 - .2 Ball, Case and Bolting Retainer of carbon steel - stronger than schedule standard pipe of equivalent size
 - .3 Bolted Retainer Ball Joints allowing field tightening/adjustment of bearing/seals and unbolting replacement of bearing/seals via bolt removal. Cutting and rewelding of ball joint case for bearing/seal removal and replacement will not be accepted

Pipe Expansion Control

- .4 Ball hard-chromed-plated .002" thick according to ASTM B650.
 - .5 Bearing seals of composite phenolic material not requiring field lubrication
 - .6 Design basis: Hyspan series 6500
- .2 Hyspan-Barco Type N Series II Ball Joints
- .1 Angular motion of plus and minus 7.5 degrees and torsional motion of 360 degrees
 - .2 Ball, Case and Bolting Retainer of carbon steel - stronger than schedule standard pipe of equivalent size.
 - .3 Bolted Retainer Ball Joints allowing field tightening/adjustment of bearing/seals and unbolting replacement of bearing/seals via bolt removal. Cutting and rewelding of ball joint case for bearing/seal removal and replacement will not be accepted. Injectable graphite secondary seal shall be included.
 - .4 Flake graphite packing injected, plugged and tested at the factory.
 - .5 Ball hard-chromed-plated .002" thick according to ASTM B650.
 - .6 Bearing seals of ductile iron, composite phenolic, Inconel or other factory clarified material
 - .7 Design basis: Hyspan series 6500

PART 3 - EXECUTION

3.1 INSTALLATION

- .1 Install flexible pipe connectors and expansion joints to manufacturer's instructions.
- .2 Ratings and bolt patterns for flanges shall suit design pressure and design temperature of piping system and match those of installed components.
- .3 Construct spool pieces to exact size of flexible connection for future insertion.
- .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 Pipe anchors shall be installed securing the piping system to the building structure in order to control the direction and the amount of pipe movement. In addition, pipe anchors shall be installed to prevent separation of pipe due to hydraulic pressures. Pipe anchors shall be designed by the Contractor to accommodate all forces experienced. Prepare calculations for each anchor and submit to Consultant for review and approval. Provide pipe guides so movement is directed along axis of pipe only. Not less than two guides shall be provided on each side of an expansion joint. Erect piping such that strain and weight is not on cast connections or apparatus.
- .7 Provide support and equipment required to control expansion and contraction of piping. Provide pipe offsets, and swing joints, or expansion joints where required. The Contractor may elect to install expansion loops in place of expansion compensators where there is adequate space to do so; subject to the approval of the Consultant. The Contractor shall prepare and submit detailed design calculations for each expansion loop proposed to the Consultant for review and approval prior to installation.

Pipe Expansion Control

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.

END OF SECTION

Vibration Control

PART 1- GENERAL

1.1 General Requirements

- .1 Comply with General Requirements of Section 20 05 05 & 22 01 01.

1.2 Section Includes

- .1 Vibration control of piping, ductwork and equipment.
- .2 Coordination with Section for Supports and Anchors
- .3 Coordination with Section for Seismic Restraint of Piping & Equipment

1.3 References

- .1 Ontario Building Code.
- .2 SMACNA "HVAC Duct Construction Standards"

1.4 Performance Requirements

- .1 Provide vibration isolation on motor driven equipment over 1/2 HP (0.35 kW), plus connected piping and ductwork.
- .2 Provide minimum static deflection of isolators for equipment as indicated.
 - .1 Basement, Under 20 HP (15 kW)
 - .1 Under 400 rpm: RIS
 - .2 400 - 600 rpm: 1" (25 mm)
 - .3 600 - 800 rpm: 1/2" (12 mm)
 - .4 800 - 900 rpm: 1/4" (5 mm)
 - .5 1100 - 1500 rpm: 1/8" (4 mm)
 - .6 Over 1500 rpm: 1/8" (3 mm)
 - .2 Upper Floors, Normal
 - .1 Under 400 rpm: 1-1/2" (40 mm)
 - .2 400 - 600 rpm: 3-1/2" (90 mm)
 - .3 600 - 800 rpm: 2" (50 mm)
 - .4 800 - 900 rpm: 1" (25 mm)
 - .5 1100 - 1500 rpm: 1/2" (12 mm)
 - .6 Over 1500 rpm: 1/4" (5 mm)
 - .3 Upper Floors, Critical
 - .1 Under 400 rpm: 1-1/2" (40 mm)

Vibration Control

- .2 400 - 600 rpm: 2" (50 mm)
- .3 600 - 800 rpm: 3-1/2" (90 mm)
- .4 800 - 900 rpm: 2" (50 mm)
- .5 1100 - 1500 rpm: 1" (25 mm)
- .6 Over 1500 rpm: 1/2" (12 mm)
- .4 Consider upper floor locations critical unless otherwise indicated.
- .5 Provide seismic restraints in accordance with Ontario Building Code requirements for Post Disaster Buildings. Seismic restraints shall be designed, installed and reviewed under the direct supervision of a professional engineer licensed in the Province of Ontario.

1.5 Submittals

- .1 Shop Drawings: Locate vibration isolators, with static and dynamic load on each.
- .2 Product Data: Provide schedule of vibration isolator type with location and load on each.
- .3 Manufacturer's Installation Instructions: Indicate special procedures and setting dimensions.
- .4 Manufacturer's Certificate: Certify that isolators are properly installed and adjusted to meet or exceed specified requirements.

PART 2 - PRODUCTS

2.1 Manufacturers

- .1 Manufacturer shall be a member of VISCMA.
- .2 Acceptable manufacturers;
 - .1 Kinetics [Vibron]
 - .2 Vibroacoustics
 - .3 VAW Systems.
 - .4 Korfund
 - .5 Masdom

2.2 Vibration Isolators

- .1 Isolators and bases shall be as tabulated on the equipment schedule.
- .2 Type 2 Floor Isolators: Model FDS Free-Standing, Unhoused, Laterally Stable Steel Springs incorporating levelling bolts and 1/4 in. (6 mm) thick ribbed noise isolation pads to assure stability, the spring shall have a lateral spring stiffness greater than 1.0 times the rated vertical stiffness, and shall be designed to provide 50% overload capacity. In capacities up to 5,000 lbs. (2268 kg), springs shall be replaceable. In capacities over 5,000 lbs. (2268 kg), springs shall be welded to the top and bottom load plate assemblies.
- .3 Type 2 Hangers: Model SFH Combination Spring and Fiberglass Hangers, incorporating pre-

Vibration Control

compressed moulded fiberglass noise and vibration isolation pads, coated with a moisture impervious elastomeric membrane in series with springs, all encased in welded steel brackets. Springs shall be as specified above. Isolators shall be designed to accommodate rod misalignment over a 30 degree arc. Brackets shall be designed to carry 500% overload without failure.

- .4 Piping: All piping 1 in. (25 mm) diameter and over in the mechanical equipment room, and all piping three supports away from other mechanical equipment shall be isolated from the structure by means of vibration and noise control isolators. Suspended piping shall be isolated with Type 2 Hangers as described above. Floor-mounted piping shall be isolated with Type 2 Spring Isolators as described above.
- .5 Flexible members shall be incorporated in the ductwork adjacent to all reciprocating equipment, and shall be approved construction.
- .6 Flexible connections shall be incorporated in the ductwork adjacent to all air-moving units. The connections shall be neoprene or canvas of approved construction. High pressure ductwork, for a distance of 50 feet (1270 mm) from high pressure fans shall be isolated from the ductwork by means of Type 2 Hangers as described above.

PART 3 - EXECUTION

3.1 Installation

- .1 Install to manufacturer's instructions.
- .2 Install isolation for motor driven equipment.
- .3 Install spring hangers without binding.
- .4 On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.
- .5 Support piping connections to isolated equipment resiliently as follows:
 - .1 Up to 4" (100 mm) Diameter: First three points of support.
 - .2 5" to 8" (125 to 200 mm) Diameter: First four points of support.
 - .3 10" (250 mm) Diameter and Over: First six points of support.
 - .4 Select three hangers closest to vibration source for minimum 1" (25 mm) static deflection or static deflection of isolated equipment. Select remaining isolators for minimum 1" (25 mm) static deflection or 1/2 static deflection of isolated equipment.
- .6 Connect wiring to isolated equipment with flexible hanging loop.

3.2 Manufacturer's Field Services

- .1 Inspect isolated equipment after installation and submit report. Include static deflections.

3.3 Vibration Isolator Selections

- .1 Based on Kinetics Selection Guide. Copied with permission.
- .2 Notes to Selection Guide
 - .1 Isolator natural frequency to be 40% of the lowest equipment operating speed.

Vibration Control

- .2 Extreme care must be taken for equipment located on spans of over 20ft, especially if construction is open web joints or thin, lightweight slabs. The recommended procedure is to determine the additional deflection caused by equipment in the roof. If additional roof deflection is 0.25 in. or less, the isolator should be selected for 10 times the additional roof deflection. If additional roof deflection is over 0.25 in., supplemental roof stiffening should be installed to bring the roof deflection down below 0.25 in., or the unit should be relocated to a stiffer roof position
 - * Reference notes do not apply.
 - + Reference note #1 does not apply.
- .3 Kinetics Products Meeting Selection Guide
 - .1 Type 2
 - .1 Free-standing Steel Spring, Model FDS
 - .2 Isolation Hanger, Model SH
 - .3 Isolation Hanger, Model SFH
 - .4 Isolation Hanger, Model SRH

END OF SECTION

Vibration Control

Piping Insulation

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 05 05 & 22 01 01.

1.2 SECTION INCLUDES

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

1.3 REFERENCES

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

1.4 SUBMITTALS

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

1.5 QUALITY ASSURANCE

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

1.6 QUALIFICATIONS

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

Piping Insulation

1.7 DELIVERY, STORAGE, AND HANDLING

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

1.8 ENVIRONMENTAL REQUIREMENTS

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

2 PRODUCTS

2.1 GLASS FIBRE

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

2.2 PHENOLIC INSULATION

- .1 .1 Manufacturers:

Piping Insulation

- .1 .1 Manufacturer: Resolco International by "Insul-Phen"
- .2 .2 Other Manufacturers: in accordance with 15010.2.3
- .2 .2 Insulation: ASTM C-1126 Phenolic Foam Thermal Insulation, CFC and HCFC free, rigid moulded, noncombustible insulation fabricated in required shapes by Resolco International approved fabricators to ASTM C-450 and C-585.
 - .1 .1 Density: 2.5-lb/ft³ (40-kg/m³)
 - .2 .2 Temperature range: -290°F to +250°F (-129°C to +107°C)
 - .3 .3 Closed cell content: 92%
 - .4 .4 Compressive strength: 29 psi (2 bar)
 - .5 .5 Thermal conductivity: 0.13 BTU-in/hr-ft²-°F (18.72 W-mm/m²-°C)
 - .6 .6 Fire resistance rating: 25/50 to ASTM E84 on plain and faced product up to 3" (75mm) thick
- .3 .3 Joint Sealer:
 - .1 .1 vapour barrier type, moisture and water resistant, 97% solids by weight, non-hardening, flexible in temperature range from -5°F to +200°F (-20.5°C to +93.3°C), Daxcel 161D, Fosters 30-45, Childers CP-76.

2.3 ELASTOMERIC INSULATION

- .1 Acceptable Manufacturers:
 - .1 Armacell APArmaflex, APArmaflex W, APArmaflex SS, or APArmaflex SA.
- .2 Insulation material shall be a flexible, closed-cell elastomeric insulation in tubular or sheet form to ASTM C 534, "Specification for preformed elastomeric cellular thermal insulation in sheet and tubular form."
- .3 Insulation materials shall have a closed-cell structure to prevent moisture from wicking.
- .4 Insulation material shall be manufactured without the use of CFC's, HFC's or HCFC's, formaldehyde free, low VOC's, fiber free, dust free and shall resist mold and mildew.
- .5 Materials shall have a flame spread index of less than 25 and a smoke-developed index of less than 50 when tested in accordance with ULC S102, ASTM E 84, latest revision. In addition, the product, when tested, shall not melt or drip flaming particles, the flame shall not be progressive and all materials shall pass simulated end-use fire tests.
- .6 Materials shall have a maximum thermal conductivity of 0.27 Btu-in./h-ft²- °F at a 75°F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518, latest revisions.
- .7 Materials shall have a maximum water vapor transmission of 0.08 perm-inches when tested in accordance with ASTM E 96, Procedure A, latest revision.
- .8 The material shall be manufactured under an independent third party supervision testing program covering the properties of fire performance, thermal conductivity and water vapor transmission.
- .9 Adhesives and finishes shall be as recommended by the insulation manufacturer and shall comply with Section 15100.2.2. Accessories such as adhesives, mastics and cements shall have the same properties as listed above and shall not detract from any of the system ratings specified.

2.4 HYDROUS CALCIUM SILICATE

- .1 Manufacturers:
 - .1 Industrial Insulation Group Model Thermo-12
- .2 Insulation: ASTM C533, Type 1; rigid, moulded, white, asbestos free, corrosion inhibiting.
 - .1 Thermal conductivity (k) value: ASTM C177, C335 and C518;

Mean Temperature (°F)	200	300	400	500	600	700
BTU-in/(Hr-Ft ² -F°)	0.41	0.45	0.5	0.55	0.6	0.65
Mean Temperature (°C)	93	149	204	260	316	371
W/(m-C°)	0.059	0.065	0.072	0.079	0.086	0.094

- .2 Maximum Service Temperature: 1200°F (649°C).
- .3 Density: 14.5 lb/ft³ (232 kg/m³) to ASTM C302
- .4 Flexural strength: 65 psi (448 kPa)

Piping Insulation

- .5 Compressive strength: >100 psi (690 kPa), 5% compression, to ASTM C165
- .6 Mould Growth: Does not support (ASTM C1338)
- .7 Surface burning characteristics: Flame spread:0, Smoke developed: 0. (ULC S102)
- .3 Tie Wire: stainless steel with twisted ends on 12" (300mm) centres maximum.
- .4 Insulating Cement: to ASTM C449.

2.5 JACKETS

- .1 PVC Plastic
 - .1 Jacket: ASTM C921, One piece moulded type fitting covers and sheet material.
 - .1 Minimum Service Temperature: -31°F (-35°C).
 - .2 Maximum Service Temperature: 151°F (66°C).
 - .3 Moisture Vapour Transmission: ASTM E96; 0.03 perm inches.
 - .4 Maximum Flame Spread: ASTM E84; 25 or less.
 - .5 Maximum Smoke Developed: ASTM E84; 50 or less.
 - .6 Thickness: 20 mil (0.4 mm) minimum.
 - .2 Colour: standard off-white **OR** coloured to suit pipe identification.
 - .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.

2.6 REMOVABLE / REUSABLE INSULATION COVERS

- .1 Material: Teflon coated, woven fibreglass fabric
- .2 Weight: 16.5 oz/sq.yd. (± 10%)
- .3 Thickness: 0.015" (± 10%)
- .4 Colour: Gray
- .5 Tensile Strength: 400 x 330 lb. (W x F)
- .6 Tarp Tear strength: 60 x 40 lb. (W x F)
- .7 Mullen Burst Pressure: 650 psi
- .8 Insulation thickness: Match connecting piping
- .9 Temperature Range: -67°F to 500°F
- .10 Lacing Hooks: Stainless Steel
- .11 Tie Wire: 16-ga stainless steel

2.7 ACCESSORIES

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

Piping Insulation

3 EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

- .1 Install piping insulations to TIAC National Installation Standards.
- .2 Apply insulation materials, accessories, jackets and finishes in accordance with manufacturer's written instructions and as specified.
- .3 On exposed piping locate insulation and cover seams in least visible locations.
- .4 Insulate dual temperature pipes or cold pipes conveying fluids below ambient temperature:
 - .1 Provide vapour barrier jackets, factory applied or field applied.
 - .2 Insulate fittings, joints, and valves with moulded insulation of like material and thickness as adjacent pipe.
 - .3 Finish with glass cloth and vapour barrier adhesive.
 - .4 PVC fitting covers may be used.
 - .5 Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations.
 - .6 Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
- .5 For insulated pipes conveying fluids above ambient temperature:
 - .1 Provide standard jackets, with or without vapour barrier, factory applied or field applied.
 - .2 Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe.
 - .3 Finish with glass cloth and adhesive.
 - .4 PVC fitting covers may be used.
 - .5 For hot piping conveying fluids 140°F (60°C) or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
 - .6 For hot piping conveying fluids over 140°F (60°C), insulate flanges and unions at equipment.
- .6 Inserts and Shields:
 - .1 Application: Piping 1-1/2" (40 mm) diameter or larger.
 - .2 Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
 - .3 Insert Location: Between support shield and piping and under the finish jacket.
 - .4 Insert Configuration: Minimum 6" (150 mm) long, of same thickness and contour as adjoining insulation; may be factory fabricated.
 - .5 Insert Material: hydrous calcium silicate insulation.
- .7 Finish insulation at supports, protrusions, and interruptions.
- .8 Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapour barrier cement.
- .9 Provide integral vapour barrier jacket on insulation on pipe and fittings for exterior applications.
- .10 Provide PVC jacket and fitting covers for pipe in mechanical equipment rooms and where exposed in finished spaces.
- .11 Provide aluminum jacket and fitting covers with seams located on bottom side of horizontal piping for exterior applications, in boiler rooms and where subject to temperatures > 200°F (93°C).
- .12 For buried piping, provide factory fabricated assembly with inner all-purpose service jacket with self sealing lap, and asphalt impregnated open mesh glass fabric, with one mil (0.025 mm) thick aluminum foil sandwiched between three layers of bituminous compound; outer surface faced with a polyester film.
- .13 For heat traced piping, insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size large enough to enclose pipe and heat tracer. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

3.3 PIPE INSULATION

Piping 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.
Cold water make-up (outside building)	0 to 850	All sizes	2
Domestic cold water	0 to 850	All sizes	1
Domestic hot water & hot water recirculation	105 to higher	2 and smaller	1
		2-1/2 and larger	1-1/2
Chilled Water	40 to 55	All sizes	1-1/2
Hydronic heating (hot water & glycol/water)	105 to 140	4 and smaller	1
		5 and larger	1-1/2
	141 to 200	All sizes	1-1/2
Sanitary drainage	40 to 55	All sizes	1
Storm drainage	40 to 55	All sizes	1
FLEXIBLE INSULATION			
Service			Insulation Thickness
Horizontal storm and sanitary drainage			1"

RIGID PIPE INSULATION (SI)			
Service	Operating Temperature Range °C	Pipe Diameter (mm)	Insulation Thickness (mm)
Cold water make-up (outside building)	-18 to 454	All sizes	50
Domestic cold water	-18 to 454	All sizes	25
Domestic hot water & hot water recirculation	41 and higher	50 and smaller	25
		65 and larger	40
Chilled Water	4 to 13	All sizes	40
Hydronic heating (hot water & glycol/water)	41 to 60	100 and smaller	25
		125 and larger	40
	61 to 93	All sizes	40
		200 and larger	90
Sanitary drainage	4 to 13	All sizes	25
Storm drainage	4 to 13	All sizes	25

Piping Insulation

FLEXIBLE INSULATION	
Service	Insulation Thickness
Horizontal storm and sanitary drainage	25mm

- .2 Phenolic insulation may be used in place of rigid fiberglass pipe insulation, thickness to provide equivalent thermal resistance.
- .3 Insulate valves, flanges and pipe connections with removable / reusable insulation covers.
- .4 Wrap butt joints with a 4" (100 mm) strip of fire resistant vapour barrier jacket cemented with lagging adhesive.
- .5 Where the pipe hanger is around the insulation, provide an insulation protection shield within the pipe saddle. Coordinate with installation of hangers.
- .6 Insulate all fittings, flanges and valves on pipes to provide equivalent insulation to that on adjoining pipe.
- .7 Continue insulation through sleeves including specified finish.
- .8 Cut back covering on strainers and finish off to expose removable head insulation.
- .9 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.
- .10 Protect insulation with protection saddles where insulated pipe is supported by rollers.
- .11 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.
- .12 Extend pipe insulation and covering through walls, floors, ceilings, and concrete beams, unless indicated otherwise on drawings. protect exposed insulation extending through floors with 4" (100 mm) wide strip of 18 gauge (1.3 mm) galvanized iron.
- .13 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.
- .14 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.
- .15 Insulate and cover exposed surfaces of waste connections, traps, hot and cold supply risers 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.
- .16 Provide aluminum metal cladding over the insulation on the following services;
 - .1 All exposed piping located outdoors.
- .17 Oversize insulation of Domestic hot water piping complete with heating cable for pipe sizes 1-1/4" (35 mm) dia. and smaller by 1/4" (6 mm) in inside diameter to allow for installation over heating cable.

END OF SECTION

Plumbing Piping

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 05 05 & 22 01 01.

1.2 SECTION INCLUDES

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

1.3 REFERENCES

- .1 ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
.2 ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
.3 ASME B16.23 - Cast Copper Alloy Solder Joint Drainage Fittings - DWV.
.4 ASME B16.26 - Copper Alloy Bronze Fittings for Flared Copper Tubes.
.5 ASME B16.29 - Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV.
.6 ASME B16.32 - Cast Copper Alloy Solder Joint Fittings for Solvent Drainage Systems.
.7 ASTM A74 - Cast Iron Soil Pipe and Fittings.
.8 ASTM B32 - Solder Metal.
.9 ASTM B42 - Seamless Copper Pipe, Standard Sizes.
.10 ASTM B68 - Seamless Copper Tube, Bright Annealed.
.11 ASTM B75 - Seamless Copper Tube.
.12 ASTM B88 - Seamless Copper Water Tube.
.13 ASTM B251 - General Requirements for Wrought Seamless Copper and Copper-Alloy Tube.
.14 ASTM B302 - Threadless Copper Pipe, Standard Sizes.
.15 ASTM B306 - Copper Drainage Tube (DWV).
.16 ASTM C1053 - Borosilicate Glass Pipe and Fittings for Drain, Waste, and Vent (DWV) Applications.
.17 ASTM D2235 - Solvent Cement for Acrylonitrile - Butadiene - Styrene (ABS) Plastic Pipe and Fittings.
.18 ASTM D2239 - Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Controlled Inside Diameter.
.19 ASTM D2241 - Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
.20 ASTM D2447 - Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter.
.21 ASTM D2466 - Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
.22 ASTM D2564 - Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
.23 ASTM D2661 - Acrylonitrile-Butadiene-Styrene (ABS) Schedule 40 Plastic Drain, Waste, and Vent Pipe and Fittings.
.24 ASTM D2665 - Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
.25 ASTM D2729 - Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
.26 ASTM D2751 - Acrylonitrile-Butadiene-Styrene (ABS) Sewer, Pipe, and Fittings.
.27 ASTM D2846 - Chlorinated Polyvinyl Chloride (CPVC) Pipe, Fittings, Solvent Cements and Adhesives for Potable Hot Water Systems.
.28 ASTM D2855 - Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.
.29 ASTM D3034 - Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
.30 ASTM E814 - Fire Tests of Through-Penetration Fire Stops.
.31 ASTM F679 - Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
.32 ASTM F708 - Design and Installation of Rigid Pipe Hangers.
.33 AWWA C110 - Ductile - Iron and Gray - Iron Fittings, 3" - 48" (76 mm - 1219 mm), for Water.
.34 AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

Plumbing Piping

- .35 AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast, for Water.
- .36 AWWA C651 - Disinfecting Water Mains.
- .37 AWWA C900 - Polyvinyl Chloride (PVC) Pressure Pipe (and Fabricated Fittings), 4" - 12" (100 mm - 300 mm), for Water Distribution.
- .38 AWWA C901 - Polyethylene (PE) Pressure Pipe and Tubing, 1/2" - 3" (13 mm - 76 mm) for Water Service.
- .39 AWWA C902 - Polybutylene (PB) Pressure Pipe and Tubing, 1/2" - 3" (13 mm - 76 mm) for Water.
- .40 AWWA C905 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14" - 48" (350 mm - 1200mm).
- .41 CISPI 301 - Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste and Vent Piping Applications.
- .42 CISPI 310 - Joints with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
- .43 MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
- .44 MSS SP69 - Pipe Hangers and Supports - Selection and Application.
- .45 MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices.

1.4 SUBMITTALS FOR REVIEW

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

1.5 SUBMITTALS AT PROJECT CLOSEOUT

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

1.6 QUALITY ASSURANCE

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

1.7 REGULATORY REQUIREMENTS

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

1.8 DELIVERY, STORAGE, AND PROTECTION

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

1.9 ENVIRONMENTAL REQUIREMENTS

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

1.10 EXTRA MATERIALS

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

2 PRODUCTS

2.1 SANITARY SEWER PIPING, ABOVE GRADE

Plumbing Piping

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

2.2 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 Copper Tubing: ASTM B88M, Type L, hard drawn.
- .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.

2.3 STORM WATER PIPING, ABOVE GRADE

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

2.4 COMPRESSED AIR PIPING, ABOVE GRADE

- .1 Steel Pipe: ASTM A53, Schedule 40 black.
 - .1 Fittings: ASME B16.3, malleable iron, or ASTM A234/A234M, forged steel welding type.
 - .2 Joints: Threaded or welded to ANSI B31.1.
- .2 Copper Tubing: ASTM B88M, Type M, L, K drawn.
 - .1 Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.
 - .2 Joints: ASTM B32, solder, Grade 95TA.
- .3 Copper Tubing: ASTM B88M, Type K, L annealed.
 - .1 Fittings: ASME B16.26, cast bronze.
 - .2 Joints: Flared.
- .4 Polyethylene Pipe: ASTM D2513, SDR 11.5.
 - .1 Fittings: ASTM D2683 or ASTM D2513 socket type.
 - .2 Joints: Fusion welded.
- .5 Polyethylene/Aluminum Composition Tubing: ASTM F1281 or ASTM 1282.
 - .1 Fittings and Joints: Brass compression type.

2.5 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.

Plumbing Piping

- .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.
- .5 Flexible Connector: Neoprene with brass threaded connectors.

2.6 PIPE HANGERS AND SUPPORTS

- .1 Plumbing Piping - Drain, Waste, and Vent:
 - .1 Conform to ASME B31.9.
 - .2 Hangers for Pipe Sizes 1/2" to 1-1/2" (15 to 40 mm): Malleable iron, adjustable swivel, split ring.
 - .3 Hangers for Pipe Sizes 2" (50 mm) and Over: Carbon steel, adjustable, clevis.
 - .4 Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
 - .5 Wall Support for Pipe Sizes to 3-1/4" (80 mm): Cast iron hook.
 - .6 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.
 - .9 Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
- .2 Plumbing Piping - Water:
 - .1 Conform to ASME B31.9.
 - .2 Hangers for Pipe Sizes 1/2" to 1-1/2" (15 to 40 mm): Malleable iron, adjustable swivel, split ring.
 - .3 Hangers for Cold Pipe Sizes 2" (50 mm) and Over: Carbon steel, adjustable, clevis.
 - .4 Hangers for Hot Pipe Sizes 2" to 4" (50 to 100 mm): Carbon steel, adjustable, clevis.
 - .5 Hangers for Hot Pipe Sizes 6" (150 mm) and Over: Adjustable steel yoke, cast iron pipe roll, double hanger.
 - .6 Multiple or Trapeze Hangers: Steel channels with welded supports or spacers and hanger rods.
 - .7 Multiple or Trapeze Hangers for Hot Pipe Sizes 6" (150 mm) and Over: Steel channels with welded supports or spacers and hanger rods, cast iron roll.
 - .8 Wall Support for Pipe Sizes to 3-1/4" (80 mm): Cast iron hook.
 - .9 Wall Support for Pipe Sizes 4" (100 mm) and Over: Welded steel bracket and wrought steel clamp.
 - .10 Wall Support for Hot Pipe Sizes 6" (150 mm) and Over: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron pipe roll.
 - .11 Vertical Support: Steel riser clamp.
 - .12 Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 - .13 Floor Support for Hot Pipe Sizes to 4" (100 mm): Cast iron adjustable pipe saddle, locknut, nipple, floor flange, and concrete pier or steel support.
 - .14 Floor Support for Hot Pipe Sizes 6" (150 mm) and Over: Adjustable cast iron pipe roll and stand, steel screws, and concrete pier or steel support.
 - .15 Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

2.7 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:

Plumbing Piping

.1	Bronze:	ASTM B62 or B61 as applicable
.2	Brass:	ASTM B283 C3770
.3	Cast Iron:	ASTM A126 Class B
.6	End Connections:	
.1	Flanged ends:	ANSI B16.1 (Class 125), ANSI B16.5
.2	Face-to-face dimensions:	ANSI B16.10
.7	Design and Testing:	
.1	Bronze Gate & Check valves:	MSS-SP-80
.2	Ball Valves:	MSS-SP-110
.3	Cast Iron Gate Valves:	MSS-SP-70
.4	Cast Iron Globe Valves:	MSS-SP-85
.5	Cast Iron Check:	MSS-SP-71
.6	Butterfly Valves:	MSS-SP-67
.8	First named product as indicated in paragraphs below; other acceptable manufacturers, subject to equivalent products listed on spread sheet attached.	

2.8 ISOLATION VALVES

- .1 Up To and including 2" (50mm) - Ball type
 - .1 Manufacturer: Kitz #69AMLL
 - .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 2-1/2" (65 mm) and Larger - Butterfly type:
 - .1 Manufacturer: Kitz 6122EL
 - .2 Construction: MSS-SP-67, MSS-SP-25 and API-609; lug type having bi-directional "Dead End Service" pressure rating of 1380 kPa (200 psi) with the downstream flange removed; stainless steel stem with top and bottom bushings of dissimilar materials and with positive stem retention mechanism, aluminum bronze disc and molded or bonded style EPDM seat; suitable for both chilled water and hot water operation; supplied with 10 position locking lever handle 2" extended neck to allow for insulation. Provide gear operators for valves 150 mm and larger, and chain-wheel operators for valves mounted over 8-Ft (2400 mm) above floor.

2.9 THROTTLING VALVES

- .1 Up To and including 2" (50 mm) - Globe type:
 - .1 Manufacturer: Kitz 10.
 - .2 Construction: MSS SP-80, 860 kPa (125psig) 200 WOG, bronze body to ASTM B62, rising stem, union bonnet, inside screw, PTFE disk, solder ends.
- .2 2-1/2" (65 mm) and Larger - Globe type: (NOT READY)
 - .1 Manufacturer: Kitz 76 (Globe)
 - .2 Construction: Cast iron body globe
- .3 2-1/2" (65 mm) and Larger - Butterfly type
 - .1 Manufacturer: Kitz 6122EL
 - .2 Construction: MSS-SP-67, MSS-SP-25 and API-609; lug type having bi-directional "Dead End Service" pressure rating of 1380 kPa (200 psi) with the downstream flange removed; stainless steel stem with top and bottom bushings of dissimilar materials and with positive stem retention mechanism, aluminum bronze disc and molded or bonded style EPDM seat; suitable for both chilled water and hot water operation; supplied with 10 position locking lever handle 2" extended neck to allow for insulation. Provide gear operators for valves 150 mm and larger, and chain-wheel operators for valves mounted over 8-Ft (2400 mm) above floor.

2.10 CHECK VALVES

- .1 Up To and Including 3" (75 mm):
 - .1 Manufacturers: Kitz 23

Plumbing Piping

- .2 Construction: MSS SP-80, 860 kPa (125psig) 200 WOG, bronze body to ASTM B62, bronze trim, solder ends
- .2 4" (100mm) and Larger:
 - .1 Manufacturers: Kitz 78
 - .2 Construction: MSS SP-71, 1380 kPa Class 125 / 200 WOG, Cast iron body to ASTM A126 Class B, Bronze trim, Bolted Bonnet, flanged ends.

2.11 DRAIN VALVES

- .1 Up to 150 psig - Ball type:
 - .1 Manufacturers: Kitz 68C
 - .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 Up to 250 psig
 - .1 Manufacturers: Kitz 11M
 - .2 Construction: 250 psig (1725 kPa), 600 WOG, cast iron body to ASTM C37700, two piece body, full port, PTFE seats and stem packing or double "O" ring, blow-out proof stem, Chrome Plated ball, lever handle with cap and chain, (3/4") 20 mm hose connection.

2.12 WATER PRESSURE REDUCING VALVES

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

2.13 RELIEF VALVES

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

2.14 STRAINERS

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

Plumbing Piping

- ends, A167 304 stainless steel screen with 1/32" perforations.
- .2 Size 2-1/2" (65 mm) and larger:
 - .1 Manufacturers: Mueller Steam 758
 - .2 Construction : 300 psig non-shock WOG, cast iron, Y-pattern, bolted cover, blow-out plug, A167 304 stainless steel screen with 1/32" perforations, flanged ends.

2.15 DISINFECTION CHEMICALS

- .1 Chemicals: AWWA B300, Hypochlorite,

3 EXECUTION

3.1 EXAMINATION

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

3.2 PREPARATION

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

3.3 INSTALLATION

- .1 Install to manufacturer's instructions.
- .2 Provide non-conducting dielectric connections wherever jointing dissimilar metals.
- .3 Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.
- .4 Install piping to maintain headroom, conserve space, and not interfere with use of space.
- .5 Group piping whenever practical at common elevations.
- .6 Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- .7 Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
- .8 Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with general trades.
- .9 Establish elevations of buried piping outside the building to ensure not less than 5'6" (1.6 m) of cover.
- .10 Install vent piping penetrating roofed areas to maintain integrity of roof assembly; coordinate with Division 07.
- .11 Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer (maximum VOC content of 80 g/L) to welding.
- .12 Provide support for utility meters to requirements of utility companies.
- .13 Prepare exposed, unfinished pipe, fittings, supports, and accessories ready for finish painting where required. Coordinate with general trades.
- .14 Excavate and backfill as required for work of this Section.
- .15 Install bell and spigot pipe with bell end upstream.
- .16 Install valves with stems upright or horizontal, not inverted.
- .17 Pipe vents from gas pressure reducing valves to outdoors and terminate in weather proof hood.
- .18 Sleeve pipes passing through partitions, walls and floors.
- .19 Inserts:
 - .1 Provide inserts for placement in concrete formwork.
 - .2 Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - .3 Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4" (100 mm).
 - .4 Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
 - .5 Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.

Plumbing Piping

- | | |
|-----|--|
| .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 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 spring loaded check valves on discharge of water pumps.
- .8 Provide plug valves in natural gas systems for shut-off service.
- .9 Provide flow controls in water recirculating systems where indicated.

3.5 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.

3.6 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

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

3.7 SCHEDULES

Plumbing Piping

- .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).
 - .4 Pipe size: 4" to 6" (100 to 150 mm):
 - .1 Maximum hanger spacing: 10' (3 m).
 - .2 Hanger rod diameter: 1/2" (15 mm).
 - .5 Pipe size: 8" to 12" (200 to 300 mm):
 - .1 Maximum hanger spacing: 14' (4.25 m).
 - .2 Hanger rod diameter: 3/4" (22 mm).
 - .6 Pipe size: 14" (350 mm) and Over:
 - .1 Maximum hanger spacing: 20' (6 m).
 - .2 Hanger rod diameter: 1" (25 mm).

END OF SECTION

Compressed Air System

1 GENERAL

1.1 GENERAL REQUIREMENTS

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

1.2 SECTION INCLUDES

- .1 Pipe and Pipe Fittings.
- .2 Pressure reducing station.
- .3 Compressed Air Fixtures.

1.3 RELATED SECTIONS

- .1 Section 01 33 00 - Administrative Requirements.
- .2 Section 01 61 00 - Common Product Requirements.
- .3 Section 01 78 10 - Execution Requirements.
- .4 Section 03 30 00 - Cast-in-place Concrete.
- .5 Section 23 05 29 - Supports And Anchors.
- .6 Section 23 05 53 - Mechanical Identification: Identification of piping system.
- .7 Section 23 05 48 - Vibration Isolation.
- .8 Section 26 05 80 - Equipment Wiring: Electrical characteristics and wiring connections.

1.4 REFERENCES

- .1 ASME - Boiler and Pressure Vessel Code.
- .2 ASME B16.3 - Malleable Iron Threaded Fittings.
- .3 ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
- .4 ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
- .5 ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes.
- .6 ASME B31.1 - Power Piping.
- .7 ASME B31.9 - Building Services Piping.
- .8 ASTM A53/A53M - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
- .9 ASTM A234/A234M - Piping Fittings of Wrought-Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
- .10 ASTM B32 - Solder Metal.
- .11 ASTM B88 - Seamless Copper Water Tube.
- .12 ASTM D2513 - Thermoplastic Gas Pressure Pipe, Tubing, and Fittings.
- .13 ASTM D2683 - Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
- .14 MSS SP-80 - Bronze Gate, Globe, Angle and Check Valves.
- .15 MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.
- .16 NFPA 70 - National Electrical Code.

1.5 SUBMITTALS FOR REVIEW

- .1 Section 01 33 00: Procedures for submittals.

Compressed Air System

- .2 Product Data: Provide manufacturers catalogue literature with capacity, weight, and electrical characteristics and connection requirements.
- .3 Shop Drawings: Indicate piping system schematic with electrical characteristics and connection requirements.

1.6 SUBMITTALS FOR INFORMATION

- .1 Section 01 33 00: Procedures for submittals.
- .2 Test Reports: Submit inspector's certificate for air receiver for inclusion in Operating and Maintenance Manuals.
- .3 Certificates: Provide certificate of compliance from authority having jurisdiction indicating approval of air receiver.
- .4 Manufacturer's Instructions: Indicate manufacturer's installation instructions, hoisting and setting requirements, starting procedures.

1.7 SUBMITTALS AT PROJECT CLOSEOUT

- .1 Section 01 78 10: Procedures for submittals.
- .2 Project Record Documents: Record actual locations of equipment and components. Modify shop drawings to indicate final locations.
- .3 Operation Data: Submit for air compressor, air receiver and accessories, after cooler, refrigerated air dryer, and pressure reducing station.
- .4 Maintenance Data: Submit for air compressor, air receiver and accessories, after cooler, refrigerated air dryer, and pressure reducing station.
- .5 Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.8 QUALITY ASSURANCE

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

1.9 REGULATORY REQUIREMENTS

- .1 Conform to applicable code for installation of pressure vessels.
- .2 Products Requiring Electrical Connection: Listed and classified by CSA, ULC, cUL or Special Inspection as suitable for the purpose specified and indicated.

1.10 DELIVERY, STORAGE, AND PROTECTION

- .1 Section 01 61 00: Transport, handle, store, and protect products.
- .2 Accept air compressors, refrigerated air dryer on site in factory fabricated containers with shipping skids and plastic pipe end protectors in place. Inspect for damage.
- .3 Protect piping and equipment from weather and construction traffic.

1.11 WARRANTY

- .1 Section 01 78 10.
- .2 Provide five year manufacturer warranty for reciprocating air compressors.

Compressed Air System

1.12 MAINTENANCE PRODUCTS

- .1 Section 01 78 10.
- .2 Provide two litre containers of compressor oil.

2 PRODUCTS

2.1 PIPE AND PIPE FITTINGS

- .1 Steel Pipe: ASTM A53, Schedule 40 black.
 - .1 Fittings: ASME B16.3, malleable iron, or ASTM A234/A234M, forged steel welding type.
 - .2 Joints: Threaded or welded to ANSI B31.1.
- .2 Copper Tubing: ASTM B88M, Type M, L, K drawn.
 - .1 Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.
 - .2 Joints: ASTM B32, solder, Grade 95TA.
- .3 Copper Tubing: ASTM B88M, Type K, L annealed.
 - .1 Fittings: ASME B16.26, cast bronze.
 - .2 Joints: Flared.
- .4 Polyethylene Pipe: ASTM D2513, SDR 11.5.
 - .1 Fittings: ASTM D2683 or ASTM D2513 socket type.
 - .2 Joints: Fusion welded.
- .5 Polyethylene/Aluminum Composition Tubing: ASTM F1281 or ASTM 1282.
 - .1 Fittings and Joints: Brass compression type.

2.2 VALVES

- .1 Gate Valves
 - .1 MSS SP-80, Class 125, bronze body, bronze trim, rising stem, handwheel, inside screw, solid wedge disc, solder ends.
- .2 Ball Valves
 - .1 MSS SP-110, Class 150, 2760 kPa CWP, bronze, two piece body, chrome plated brass ball, regular port, teflon seats and stuffing box ring, blow-out proof stem, lever handle with balancing stops, solder ends with union.
- .3 Swing Check Valves
 - .1 MSS SP-80, Class 125, bronze body and cap, bronze swing disc with rubber seat, solder ends.
- .4 Air Outlets
 - .1 Quick Connector: h> brass, snap on connector with self closing valve, Style A.

2.3 UNIONS AND COUPLINGS

- .1 Unions
 - .1 Ferrous Pipe: 1034 kPa malleable iron threaded unions.
 - .2 Copper Tube and Pipe: 1034 kPa bronze unions with soldered joints.
- .2 Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.
- .3 Flexible Connector: Neoprene with brass threaded connectors.

Compressed Air System

2.4 PRESSURE REDUCING VALVE

- .1 Pressure Reducing Station: Consisting of automatic reducing valve and bypass, and low pressure side relief valve and gauge. Provide oil separator where indicated.
- .2 Valve Capacity: Reduce pressure from 1379 kPa to 207 kPa, adjustable upwards from reduced pressure.

2.5 COMPRESSED AIR FIXTURES

- .1 **WaterSaver Faucet Co., Model: L4200-132AWSA**, compressed air laboratory ball valve, deck mounted, turret base with double outlet, valve body forged brass, quarter turn open/close with chrome plated brass ball and molded PTFE seals, forged brass lever handle with colour coded index disc. Furnished with 3/8" IPS mounting shank (assembled), locknut and washer. 3/8" NPT male inlet. 3/8" NPT female outlet with removable ten serration hose end. Fixture is fully assembled and factory tested prior to shipment.

3 EXECUTION

3.1 INSTALLATION

- .1 Install valved drip connections at low points of piping system.
- .2 Install take offs to outlets from top of main, with shut off valve after take off. Slope take off piping to outlets.
- .3 Install compressed air couplings, female quick connectors, and pressure gauges where outlets are indicated.
- .4 Install tees instead of elbows at changes in direction of piping. Fit open end of each tee with plug.
- .5 Identify piping system and components. Refer to Section 23 05 53.

3.2 FIELD QUALITY CONTROL

- .1 Compressed Air Piping Leak Test: Prior to initial operation, clean and test compressed air piping to ANSI B31.1.
- .2 Repair or replace compressed air piping as required to eliminate leaks, and retest to demonstrate compliance.
- .3 Cap and seal ends of piping when not connected to mechanical equipment.

END OF SECTION

General Requirements

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Read and conform to:
 - .1 The Contract CCDC2-2008, Stipulated Price Contract as amended,
 - .2 Division 1 requirements and documents referred to therein.
- .2 Section 23 01 01 applies to and governs the work of all Sections of Division 23.
- .3 The technical Sections of this Division are generally divided into units of work for the purpose of ready reference. The division of the work among subcontractors is not the Consultant's responsibility and the Consultant assumes no responsibility to act as an arbiter and/or to establish subcontract limits between any Sections of the work..
- .4 The specifications are integral with the drawings which accompany them. Neither is to be used alone. Any item or subject omitted from one but implied in the other is fully and properly required.
- .5 Wherever differences occur in the tender documents, the most onerous condition governs. Base the bid on the most costly arrangement.

1.2 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, piping, ductwork, and valves and controllers
- .4 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.
- .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.

1.3 RELATED WORK

- .1 Painting of exposed piping and ductwork other than for identification will be supplied under Division 9.

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) 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

General Requirements

- 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 Sleeving Drawings: Prepare and submit 4 copies of sleeving drawings to clearly and accurately indicate the exact location, elevation and size of any and all formed holes, recesses and sleeving required in the work of Division 23. Obtain Consultant's approval in writing prior to sleeving, forming or cutting any such opening. Provide a copy of approved sleeving drawings to the reinforcement detailer well in advance of planned pours.
- .4 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.
- .5 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.
- .6 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.
- .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 name of project]
[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:

General Requirements

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

1.6 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.

General Requirements

- .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 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.

1.9 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.

1.10 INTERRUPTIONS

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

1.11 PHASING AND SCHEDULING

- .1 Refer to Section 01120 PHASING AND SCHEDULING OF THE WORK.
- .2 Coordinate work of all Sections of Division 23 with other trades and assist in the development of the Phasing Strategy.
- .3 Refer to O.B.C. Division C, Part 1, Subsection 1.3.3 Occupancy of Unfinished Building
- .4 Refer to Article 8.0 of Section 01120.

General Requirements

- .5 Where occupancy of a part of the work is required prior to completion of the entire project, ensure that equipment, systems and services that serve the areas to be occupied are completed, tested and fully operational 2-weeks prior to scheduled turn over and ensure that reports, certificates and documentation are submitted at that time.

2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

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

2.2 ACCEPTABLE PRODUCTS

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

2.3 EQUIVALENTS AND ALTERNATIVES

- .1 Suppliers wishing approval for additional equipment items 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

General Requirements

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 power activated tools without written permission of the Consultant. Use them in accordance with the Owner's health and safety policies.

General Requirements

- .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 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.
- .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.

General Requirements

3.6 USE OF EQUIPMENT

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

3.7 SPECIAL TOOLS AND SPARE PARTS

- .1 Within 30 days of award of contract, prepare a complete itemized list of special tools and spare parts and submit to Consultant for review. List will be used as a checklist and should include provision for sign off by the Owner on receipt.
- .2 On completion of the project furnish spare parts to the Owner as follows:
 - .1 One set of mechanical seals for each pump.
 - .2 One casing joint gasket for each pump.
 - .3 One head gasket for each heat exchanger.
 - .4 One glass for each gauge glass installed.
 - .5 One set of v-belts for each piece of machinery.
 - .6 One set of new filters for each filter bank installed.
- .3 Identify spare parts containers as to contents and replacement parts number.
- .4 Provide one set of special tools required to service equipment as recommended by manufacturers.
- .5 Furnish one grease gun and adaptors to suit different types of grease and fittings.

3.8 EXTRAS AND CREDITS

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

3.9 INSTRUCTION

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

General Requirements

satisfactorily to the Consultant prior to substantial completion of the project.

3.10 COMMISSIONING

- .1 Refer to Section 01 80 50 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 Z320-11 Building Commissioning Standard
- .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 Brock University,
 - .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

Demolition & Renovation

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 05 05 & 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 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.
- .6 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 all authorities of intent to demolish and schedule for the work. Obtain required permits from authorities.
- .2 Conform to all 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 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.

1.5 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 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

Demolition & Renovation

- .1 Refer to Division 1 PHASING AND SCHEDULING OF THE WORK.
- .2 Coordinate with the work of all Sections of Division 23 with other trades and assist in the development of the Phasing Strategy.

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 all service shut downs 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, supported above floors 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 any and all damage to the building and components resulting from failure to provide sufficient protection, to the satisfaction of the Consultant.
- .3 All existing air intake and exhaust openings that may be affected by dust and/or debris from the construction work shall be fitted with appropriate filter media to protect against entry of dust and/or debris into the building and its air distribution systems. Filters shall be closely monitored and replaced when necessary. The Contractor shall replace existing filters that become contaminated with dust and/or debris from construction work with new filters.
- .4 In the event that dust and debris from construction work does penetrate the building and/or its air distribution systems, the Contractor shall be responsible for cleaning the affected areas and/or systems.
- .5 Temporary filters shall be removed on completion of the construction works.

3.4 DEMOLITION

- .1 Notify all authorities of intent to demolish and schedule for the work.
- .2 All demolition work shall conform to all 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),

Demolition & Renovation

- water service, natural gas service, steam service, condensate return, water supply to standpipe and sprinkler systems, fire suppression systems hot water heating systems, steam and condensate 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 all service shut downs 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 All demolition work shall 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 Waste disposal shall conform to the requirements of Division 1, municipal By-Laws and Ministry of the Environment regulations and standards.
 - .10 All existing air intake and exhaust openings that may be affected by dust and/or debris from the demolition work shall be fitted with appropriate filter media to protect against entry of dust and/or debris into the building and its air distribution systems. Filters shall be closely monitored and replaced when necessary. The Contractor shall replace existing filters that become contaminated with dust and/or debris from demolition work with new filters.
 - .11 In the event that dust and debris from demolition work does penetrate the building and/or its air distribution systems, this Section shall be responsible for cleaning the affected areas and/or systems.
 - .12 Disconnect remove, cap and identify all utilities within demolition areas.
 - .13 Demolish in an orderly and careful manner. Protect existing supporting structural members.
 - .14 Remove demolished materials from site except where specifically noted otherwise. Do not burn or bury materials on site.
 - .15 Remove materials as work progresses. Upon completion of work, leave areas in clean condition.
 - .16 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 Existing items to be relocated shall be cleaned and repaired or altered as required to suit new location. All damaged or ineffective parts shall be replaced and the item made "as new".
- .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 all surfaces and finishes in areas from which items have been removed and in which items are relocated. Cap all existing services required to be severed to effect alterations and do all other work necessary to make good such areas to satisfaction of consultant.
- .6 Openings in existing floor assemblies and vertical fire separations necessitated by installation of equipment and systems or construction in general must be temporarily sealed 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 Existing refrigerant indicated to be removed shall not be discharged to the atmosphere, but shall be salvaged and reclaimed or disposed of following the guidelines of the authority having jurisdiction.
- .9 All existing air intake and exhaust openings that may be affected by dust and/or debris from the renovation work shall be fitted with appropriate filter media to protect against entry of dust and/or debris into the building and its air distribution systems. Filters shall be closely monitored and replaced

Demolition & Renovation

- when necessary. The Contractor shall replace existing filters that become contaminated with dust and/or debris from renovation work with new filters.
- .10 In the event that dust and debris from renovation work does penetrate the building and/or its air distribution systems, the Contractor shall be responsible for cleaning the affected areas and/or systems.
- .11 Temporary filters shall be removed on completion of the renovation work.

3.6 INSPECTION AND RE-CERTIFICATION

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

3.7 REFRIGERANT RECOVERY / RECYCLING

- .1 Removal, relocation and/or refilling of refrigeration piping and/or equipment that contains ozone depleting substances and other halocarbons including the following items shall conform to regulations under the Environmental Protection Act, including O. Reg. 463/10.
- .1 Solvents and sterilants
 - .2 Fire extinguishing equipment
 - .3 Refrigerants
- .2 Ozone depleting substances (ODS) and other halocarbons shall be recovered using equipment and processes that are designed and approved specifically for the task.
- .3 Disposal of ODS and other halocarbons and associated equipment and containers shall comply with requirements under the Environmental Protection Act, including O. Reg. 463/10.
- .4 Persons servicing, testing and/or performing tasks associated with the removal, relocation and/or refilling of refrigeration piping and/or equipment that contains ozone depleting substances and other halocarbons shall be certified under Section 34 of O. Reg. 463/10.
- .5 Prepare and submit all records and notices required by authorities having jurisdiction.

END OF SECTION

Common Work Results

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 05 05 & 23 01 01.

1.2 COMMON WORK RESULTS

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

1.3 REFERENCE STANDARDS

- .1 Provide all work in accordance with requirements of Regulatory Agencies and conform to:
 - .1 Local and district by-laws, regulations and published engineering standards.
 - .2 the Ontario Building Code as amended,
 - .3 the Ontario Gas Utilization Code as amended
 - .4 Regulations for Construction Projects under The Occupational Health and Safety Act.
 - .5 Fire Code made under the Fire Marshal's Act.
- .2 Conform to following CSA Standards:
 - .1 CSA B242 Groove and Shoulder Type: Mechanical Pipe Couplings.
 - .2 CSA W48 series Electrodes.
 - .3 CSA B51, Boiler, Pressure Vessel and Pressure Piping Code.
 - .4 CAN/CSA-W117.2, Safety in Welding, Cutting and Allied Processes
- .3 Conform to following National Research Council Canada publications:
 - .1 National Building Code of Canada and Supplements to National Building Code of Canada
 - .2 National Fire Code of Canada.
 - .3 Canadian Plumbing Code.
 - .4 Model National Energy Code for Buildings
- .4 Conform to following American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME) Standards:
 - .1 ANSI/ASME B31.1 Power Piping.
 - .2 ANSI/ASME B31.3, Process Piping.
 - .3 ANSI/ASME Boiler and Pressure Vessel Code:
 - .1 Section 1: Power Boilers.
 - .2 Section V: Nondestructive Examination.
 - .3 Section IX: Welding and Brazing Qualifications.
 - .4 ASME A13.1 - Scheme for the Identification of Piping Systems.
 - .5 ASME B40.100 - Pressure Gauges and Gauge Attachments.
- .5 Conform to following American Welding Society (AWS) Standards:
 - .1 AWS C1.1, Recommended Practices for Resistance Welding.
 - .2 AWS Z49.1, Safety Welding, Cutting and Allied Process.
 - .3 AWS W1, Welding Inspection.
- .6 Conform to following American Society for Testing and Materials (ASTM) Standards:
 - .1 ASTM E1 - Specification for ASTM Thermometers.
 - .2 ASTM E77 - Inspection and Verification of Thermometers.
- .7 Conform to following Underwriters Laboratories (UL) Standards:
 - .1 UL 393 - Indicating Pressure Gauges for Fire-Protection Services.
 - .2 UL 404 - Gauges, Indicating Pressure, for Compressed Gas Service.
 - .3 AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
- .8 Conform to AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
- .9 Conform to IEEE 112 - Test Procedure for Polyphase Induction Motors and Generators.
- .10 Conform to NEMA MG 1 - Motors and Generators.
- .11 Provide work where indicated in conformance with guide Specification of the Victaulic System for Building Services, G-100.
- .12 The above documents or portions thereof are referenced within the work of Division 23 and shall be considered part of the requirements of this document as though fully repeated herein.

Common Work Results

1.4 1.4 QUALIFICATIONS

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

1.5 SUBMITTALS

- .1 Submit shop drawings in accordance with refer to section 01 33 00 & 23 01 01

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 WASTE MANAGEMENT & DISPOSAL

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

1.8 WARRANTY

- .1 Provide extended coverage five year warranty for motors larger than 20 HP (15 kW).

2 PRODUCTS

2.1 PIPING SPECIALTIES

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

2.2 ADHESIVES, SEALANTS, PAINTS AND COATINGS

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

Common Work Results

- | | |
|-----|--|
| .6 | Sealants for Firestopping: max. VOC emission of 650g/L clear and 350 g/L pigmented |
| .7 | Acrylic Sealant for supports and anchors: maximum VOC emission of 250g/L |
| .8 | Insulation Vapour Barrier Lap Adhesive: maximum VOC emission of 80g/L |
| .9 | Insulation Joint Sealer: maximum VOC emission of 250g/L |
| .10 | Insulation Vapour Barrier Mastic: maximum VOC emission of 400g/L |
| .11 | Flame Retardent Adhesive: maximum VOC emission of 650g/L clear and 350 g/L pigmented |

2.3 WELDING ELECTRODES

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

2.4 NAMEPLATES

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

2.5 TAGS

- .1 Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background colour. Tag size minimum 1-1/2" (40 mm) diameter. **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 STENCILS

- .1 Stencils: With clean cut symbols and letters of following size:
 - .1 3/4"-1-1/4" (20-30 mm) Outside Diameter of Insulation or Pipe: 8" (200 mm) long colour field, 1/2" (15 mm) high letters.
 - .2 1-1/2"-2" (40-50 mm) Outside Diameter of Insulation or Pipe: 8" (200 mm) long colour field, 3/4" (20 mm) high letters.
 - .3 2-1/2"-6" (65-150 mm) Outside Diameter of Insulation or Pipe: 12" (300 mm) long colour field, 1-1/4" (30 mm) high letters.
 - .4 8" - 10" (200-250 mm) Outside Diameter of Insulation or Pipe: 24" (600 mm) long colour field, 2-1/2" (65 mm) high letters.
 - .5 Over 10" (250 mm) Outside Diameter of Insulation or Pipe: 32" (800 mm) long colour field, 3-1/2" (90 mm) high letters.
 - .6 Ductwork and Equipment: 2-1/2" (65 mm) high letters.

2.7 PRESSURE GAUGES

- .1 Manufacturer: Trerice Model 600C.
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Weiss
 - .2 Winter
 - .3 Morrisson
 - .4 Taylor
- .3 Gauge: 4-1/2" (115mm) diameter black cast aluminum, phosphor bronze bourdon tube, rotary brass movement, brass socket, with front recalibration adjustment, black scale on white background, mid-scale accuracy: 1%, scale: psi and kPa.
- .4 Gauge Cock: Tee or lever handle, brass for maximum 150 psi (1034 kPa0).

Common Work Results

- .5 Needle Valve: Brass, 1/4" (6 mm) NPT for minimum 150 psi (1034 kPa).
- .6 Pulsation Damper: Pressure snubber, brass with 1/4" (6 mm) connections.
- .7 Syphon: Steel, Schedule 40, 1/4" (6 mm) angle or straight pattern.

2.8 STEM TYPE THERMOMETERS

- .1 Manufacturer: Trerice Model BX91403-1/2.
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Weiss Model 9VS3-1/2.
 - .2 Winter
 - .3 Morrison
 - .4 Taylor
- .3 Thermometer: 9" (230mm) scale, red appearing thermal fluid with black figures on white scale, calibrated in both degrees F and degrees C, accuracy to ASTM E77 of 2%, clear glass lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device, 3/4" (20mm) NPT brass stem.
- .4 All thermometers to include a separable well.
- .5 Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.
- .6 Flange: 3" (75 mm) outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

2.9 DIAL THERMOMETERS

- .1 Manufacturer: Trerice
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Weiss.
 - .2 Winter.
 - .3 Morrisson.
 - .4 Taylor
- .3 Thermometer: ASTM E1, stainless steel case, bimetallic helix actuated with silicone fluid damping, white with black markings and black pointer hermetically sealed lens, stainless steel stem.
 - .1 Size: 2" (50 mm) diameter dial.
 - .2 Lens: Clear glass.
 - .3 Accuracy: 1 percent.
 - .4 Calibration: Degrees C Both degrees F and degrees C.

OR
- .4 Thermometer: ASTM E1, stainless steel case, adjustable angle with front recalibration, bimetallic helix actuated with silicone fluid damping, white with black markings and black pointer hermetically sealed lens, stainless steel stem.
 - .1 Size: 3" (75 mm) diameter dial.
 - .2 Lens: Clear glass.
 - .3 Accuracy: 1 percent.
 - .4 Calibration: Degrees F.

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

Common Work Results

2.10 THERMOMETER SUPPORTS

2.11 TEST PLUGS

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

2.12 STATIC PRESSURE GAUGES

- .1 Manufacturer: Trerice
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Weiss.
 - .2 Winter.
 - .3 Taylor.
 - .4 Substitutions: Refer to Section 01 62 00.
- .3 3-1/2" (90 mm) diameter dial in metal case, diaphragm actuated, black figures on white background, front recalibration adjustment, 2 percent of full scale accuracy.
- .4 Inclined manometer, red liquid on white background with black figures, front recalibration adjustment, 3 percent of full scale accuracy.
- .5 Accessories: Static pressure tips with compression fittings for bulkhead mounting, 1/4" (6 mm) diameter tubing.

2.13 ACCESS DOORS

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

Common Work Results

- .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

2.14 ADHESIVES, SEALANTS, PAINTS & COATINGS

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

2.15 FIRESTOPPING COMPOUNDS

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

2.16 SLEEVES

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

2.17 ESCUTCHEONS

- .1 Finish: Polished chrome

2.18 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.

2.19 PENETRATION SEALS

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

3 EXECUTION

3.1 INSPECTION

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

3.2 PREPARATION

Common Work Results

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

3.3 PIPING INSTALLATION - ABOVE GROUND

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

3.4 PIPING JOINTS

- .1 Make joints in piping installed under this Division using persons familiar with the particular materials being used and in accordance with CSA B51 and CSA B52, manufacturer's instructions, and as specified herein.
- .2 Use only welder and/or brazer operators, with a valid identification card, as issued under The Boiler and Pressure Vessels Act, to make joints in Registered Piping Systems, as indicated under Section 23 01 01, and 23 05 00.
- .3 Use silver solder or Silfos for joining 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 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.
- .6 Install unions or welding flanges at connections to valves, etc. to facilitate removal.
- .7 Use butt welding and/or schedule 40 carbon steel welding fittings to join sections of steel piping with welding ends.

Common Work Results

3.5 WELDING

- .1 Welder's Qualifications
 - .1 Welding qualifications to be in accordance with CSA B51.
 - .2 Use qualified and licensed welders possessing certificate for each procedure to be performed from authority having jurisdiction.
 - .3 Furnish welder's qualifications to Consultant and Owner.
 - .4 Each welder to possess identification symbol issued by authority having jurisdiction.
- .2 Inspector's Qualifications: qualified to CSA W178.2
- .3 Welding Procedures
 - .1 Registration of welding procedures in Procedures accordance with CSA B51.
 - .2 Copy of welding procedures to be available for inspection at all times.
 - .3 Safety in welding, cutting and allied processes to be in accordance with CAN/CSA-W117.2.
- .4 Workmanship: Welding to be in accordance with ANSI/ASME B31.1 and B31.3, ANSI/ASME Boiler and Pressure Vessel Code, Sections I and IX and ANSI/AWWA C206, using procedures conforming to AWS B3.0, AWS C1.1, special procedures specified elsewhere in Division 15 applicable requirements of provincial authority having jurisdiction.
- .5 Installation Requirements:
 - .1 Identify each weld with welder's identification symbol.
 - .2 Backing rings:
 - .1 Where used, fit to minimize gaps between ring and pipe bore.
 - .2 Do not install at orifice flanges.
 - .3 Fittings:
 - .1 NPS 2 and smaller: install welding type sockets.
 - .2 Branch connections: install welding tees or forged branch outlet fittings.
- .6 Inspection and Testing:
 - .1 Hydrostatically test all welds to requirements of ANSI/ASME B31.1.
 - .2 Review all weld quality requirements and defect limits of applicable codes and standards with Consultant before any work is started.
 - .3 Formulate "Inspection and Test Plan" in co-operation with Consultant.
 - .4 Do not conceal welds until they have been inspected, tested and approved by inspector.
 - .5 Perform examinations and tests by specialist qualified in accordance with CSA W178.1 and CSA W178.2 and approved by Consultant, to ANSI/ASME Boiler and Pressure Vessels Code, Section V, CSA B51 and requirements of authority having jurisdiction.
 - .6 Visual examinations: include entire circumference of weld externally and wherever possible internally.
 - .7 Failure of visual examinations: on failure of any weld by visual examination, perform additional testing as directed by Consultant of a total of up to 25% of all welds, selected at random by Consultant, by particle tests.
 - .8 Inspect and test all welds in high pressure steam and high pressure condensate piping in accordance with "Inspection and Test Plan" by magnetic particle (hereinafter referred to as "particle") tests.
- .7 Defects Causing Rejection: as described in ANSI/ASME B31.1 and ANSI/ASME Boiler and Pressure Vessels Code, plus;
 - .1 Undercutting greater than 1/32" (0.8 mm) adjacent to cover bead on outside of pipe.
 - .2 Undercutting greater than 1/32" (0.8 mm) adjacent to root bead on inside of pipe.
 - .3 Undercutting greater than 1/32" (0.8 mm) at combination of internal surface and external surface.
 - .4 Incomplete penetration and incomplete fusion greater than total length of 1-1/2" (38 mm) 97% in any 6" (150 mm) length of weld depth of such defects being greater than 1/32" (0.8mm).
 - .5 Repair all cracks and defects in excess of 1/32" (0.8mm) in depth.
 - .6 Repair defects whose depth cannot be determined accurately on the basis of visual examination or particle tests.
- .8 Re-inspect and re-test repaired or re-worked welds at Contractor's expense.

3.6 FLUSHING AND CLEANING

Common Work Results

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

3.7 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 Commissioning Agent
 - .3 The Owner's Representative
 - .4 The Consultant
- .5 Notification must be given at least 48 hours in advance of tests being conducted, to all persons required to be present.
- .6 Repair all leaks exposed during testing and retest. If defects in pipe or fittings are discovered in the system, they shall be removed and replaced.
- .7 Certify tests not required by authorities having jurisdiction.

3.8 EQUIPMENT TESTING AND INSPECTION

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

3.9 TESTING AND BALANCING

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

3.10 ELECTRICAL COMPONENTS AND WIRING

- .1 Conform to requirements of Division 26 for all wiring included in Division 23. Includes pre-wired

Common Work Results

- .2 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 the field wiring for equipment shall be included under Division 23, unless specifically called for under Division 25.

3.11 PROTECTION

- .1 Protect finished and unfinished work by tarpaulins, or other covering, from damage due to execution of work under this Division.
- .2 Repair to satisfaction of Consultant, damage to building resulting from failure to provide such protection.
- .3 All existing air intake and exhaust openings that may be affected by dust and/or debris from the construction work shall be fitted with appropriate filter media to protect against entry of dust and/or debris into the building and its air distribution systems. Filters shall be closely monitored and replaced when necessary. The Contractor shall replace existing filters that become contaminated with dust and/or debris from construction work with new filters.
- .4 In the event that dust and debris from construction work does penetrate the building and/or its air distribution systems, the Contractor shall be responsible for cleaning the affected areas and/or systems.
- .5 Temporary filters shall be removed on completion of the construction works.

3.12 CUTTING AND PATCHING

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

3.13 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

Common Work Results

- 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.

3.14 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.

3.15 FIRESTOPPING

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

Common Work Results

- 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.

3.16 SLEEVES AND CURBS

- .1 Provide pipe sleeves at points where pipes pass through masonry or concrete.
- .2 Provide sleeves of minimum schedule 20 galvanized steel or cast iron.
- .3 Use cast iron or steel pipe sleeves with annular fin continuously welded at midpoint:
- .1 through foundation walls, with penetration seals.
- .2 through floors of mechanical rooms and equipment rooms.
- .4 Provide 1/4" (6 mm) clearance all around, between sleeve and pipes or between sleeve and insulation.
- .5 Where piping passes below footings, provide minimum clearance of 2" (50 mm) between sleeve and pipe. Backfill up to underside of footing with concrete of same strength as footing with concrete of same strength as footing.
- .6 Terminate sleeves flush with surface of concrete and masonry and 2" (50 mm) above floors. Not applicable to concrete floors on grade.
- .7 Provide watertight concrete curb 4" (100 mm) high around mechanical services (pipes, ducts, conduits) which rise through mechanical (service) room floors. Provide minimum 4" (100 mm) clearance between openings for services within curbs.
- .8 For pipes passing through roofs, use cast iron sleeves with caulking recess and flashing clamp device. Anchor sleeves in roof construction, caulk between sleeve recess and pipe, fasten roof flashing to clamp device, make water-tight durable joint. Co-ordinate with roofing Section.

3.17 FLASHINGS

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

3.18 ESCUTCHEONS AND PLATES

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

3.19 SUPPORT AND ATTACHMENT

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

3.20 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.

3.21 DISSIMILAR METALS

- .1 Separate dissimilar metals in order to prevent galvanic corrosion.
- .2 Provide gaskets or shims of approved materials to avoid electrolytic action.

Common Work Results

- .3 Use dielectric unions and/or flanges where piping of dissimilar metals are connected.

3.22 EQUIPMENT BASES AND CURBS

- .1 Build 4" (100 mm) high concrete curbs around all openings through floors for ductwork. Make allowances for installation of ductwork and fire dampers where required. Ensure joint between curb and floor is watertight and maintains integrity of floor membrane where applicable.

3.23 MOCK-UP

- .1 Refer to Division 01 for requirements for mock-up.
- .2 Each Section shall provide related components for mock-up.
- .3 Mock-up may not remain as part of the Work.

3.24 FIELD QUALITY CONTROL

- .1 Temporary and Trial Usage
 - .1 Allow the Owner the privilege of temporary and trial usage of installed equipment, as soon as work is complete, for a period of time required to conduct a thorough test.
 - .2 Do not construe such usage as evidence of acceptance of work by Owner.
 - .3 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.

3.25 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.

3.26 MECHANICAL IDENTIFICATION INSTALLATION

- .1 Degrease and clean surfaces to receive adhesive for identification materials.
- .2 Prepare surfaces for stencil painting.
- .3 Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer (VOC content not to exceed 680 g/L).
- .4 Install tags with corrosion resistant chain.
- .5 Comply with standard detail drawing plate, "Detail of Piping Identification".
- .6 Apply stencil markings on all covered piping.
- .7 Install plastic tape pipe markers complete around bare pipe to manufacturer's instructions.
- .8 Identify medical gas piping in accordance with CSA Z305.1 and CSA Z7396-1
- .9 Identify anaesthetic gas scavenging piping in accordance with CSA Z7396-1.

Common Work Results

- .10 Label piping that is heat traced or equipped with heating cable "HEAT TRACED" in addition to other identification. Locate such labels adjacent to other identifications.
- .11 Clearly identify abandoned services left in place as "ABANDONED".
- .12 Mark drain from hot lab sink with radiation warning symbols at 10 ft. (3 m) intervals.
- .13 Install underground plastic pipe markers 6"-8" (150-200 mm) below finished grade, directly above buried pipe.
- .14 Identify pumps, water heating equipment, tanks, and water treatment devices with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.
- .15 Identify control panels and major control components outside panels with plastic nameplates.
- .16 Identify valves in main and branch piping with tags. Consecutively number valves in each system.
- .17 Identify piping, concealed or exposed, with stencilled painting and plastic tape pipe markers . Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 6 m on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.
- .18 For each item of equipment which may be started automatically or remotely, add a red lamacoid plate, 2-3/8" x 9" (60 x 230 mm), reading: **"WARNING. THIS EQUIPMENT IS AUTOMATICALLY CONTROLLED. IT MAY START AT ANY TIME."**
- .19 Provide colour coded self-adhesive dots to locate valves or dampers above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

3.27 MECHANICAL IDENTIFICATION SCHEDULES

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

SERVICE	COLOURS		LEGEND
	BACKGROUND	LETTERS	
City water	Green	Black	CITY WATER
Condenser water supply	Green	Black	COND. WTR. SUPPLY
Condenser water return	Green	Black	COND. WTR. RETURN
Chilled water supply	Green	Black	CH. WTR. SUPPLY
Chilled water return	Green	Black	CH. WTR. RETURN
Hot water heating supply	Yellow	Black	HEATING SUPPLY
Hot water heating return	Yellow	Black	HEATING RETURN
Make-up water	Yellow	Black	MAKE-UP WTR
Boiler feed water	Yellow	Black	BLR. FEED WTR
Steam [] kPa	Yellow	Black	[] kPa STEAM
Steam condensate (gravity)	Yellow	Black	ST.COND.RET (GRAVITY)
Steam condensate (pumped)	Yellow	Black	ST.COND.RET (PUMPED)
Safety valve vent	Yellow	Black	STEAM VENT
Intermittent blow-off	Yellow	Black	INT. BLOW-OFF
Continuous blow-off	Yellow	Black	CONT. BLOW-OFF
Plumbing vent	Green	Black	SAN. VENT
Refrigeration suction	Yellow	Black	REF. SUCTION

Common Work Results

Refrigeration liquid	Yellow	Black	REF. LIQUID
Refrigeration hot gas	Yellow	Black	REF. HOT GAS
Gas regulator vents	to Code		

3.28 MANUFACTURER'S NAMEPLATES

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

3.29 FLOW DIAGRAMS AND DIRECTORIES

- .1 Provide Consultant with six identification flow diagrams of approved size for each system. Include tag schedule, designating number, service, function, and location of each tagged item and normal operating position of valves.
- .2 Install where agreed with the Owner one copy of each flow diagram and valve schedule mounted in glazed frame. Provide one copy of each in Operation and Maintenance Manual.

3.30 INSTALLATION OF GAUGES AND THERMOMETERS

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

3.31 INSTALLATION OF ACCESS DOORS

- .1 Supply access doors for access to equipment requiring service, lubrication or adjustment and all concealed valves, cleanouts, trap primers, control and volume dampers, and other such equipment.
- .2 Turn over access doors to the appropriate general trade for installation under other Sections.
- .3 Refer to architectural drawings for ratings of fire separations and assemblies. install fire rated access doors in fire rated partitions, walls, and ceilings.
- .4 Access doors in ceilings shall be minimum 24" x 24" (600mm x 600mm), unless otherwise approved by the Consultant.
- .5 Provide concealed access doors in GWB ceilings and coordinate in-fill with general trades.
- .6 Provide Air Seal Flush Mount access doors in all Clean Rooms, Laboratories and Health Care Facility Class 1 rooms [e.g. operating rooms, procedure rooms, ICU, CCU, PACU, and all sterile environments].

END OF SECTION

Supports & Anchors

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 05 05 & 23 01 01.

1.2 SECTION INCLUDES

- .1 Pipe and equipment hangers and supports.
- .2 Equipment bases and supports.
- .3 Sleeves and seals.

1.3 REFERENCES

- .1 ASME B31.1 - Power Piping.
- .2 ASME B31.2 - Fuel Gas Piping.
- .3 ASME B31.5 - Refrigeration Piping and Heat Transfer Components.
- .4 ASTM F708 - Design and Installation of Rigid Pipe Hangers.
- .5 MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
- .6 MSS SP69 - Pipe Hangers and Supports - Selection and Application.
- .7 MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices.
- .8 NFPA 13 - Installation of Sprinkler Systems.
- .9 NFPA 14 - Installation of Standpipe, Private Hydrants, and Hose Systems.
- .10 UL 203 - Pipe Hanger Equipment for Fire protection Service.

1.4 SUBMITTALS

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

1.5 REGULATORY REQUIREMENTS

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

2 PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

- .1 Manufacturers:
 - .1 Anvil
 - .2 Myat
 - .3 Hunt
- .2 Hydronic Piping:
 - .1 Conform to CSA B-51 and ASME B31.9.
 - .2 Hangers for Pipe Sizes 1/2" to 1-1/2" (13 to 38 mm): Carbon steel, adjustable swivel, split ring.
 - .3 Hangers for Cold Pipe Sizes 2" (50 mm) and Over: Carbon steel, adjustable, clevis.
 - .4 Hangers for Hot Pipe Sizes 2" to 4" (50 to 100 mm): Carbon steel, adjustable, clevis.
 - .5 Hangers for Hot Pipe Sizes 6" (150 mm) and Over: Adjustable steel yoke, cast iron roll, double hanger.
 - .6 Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
 - .7 Multiple or Trapeze Hangers for Hot Pipe Sizes 6" (150 mm) and Over: Steel channels with welded spacers and hanger rods, cast iron roll.
 - .8 Wall Support for Pipe Sizes to 3" (76 mm): Cast iron hook.
 - .9 Wall Support for Pipe Sizes 4" (100 mm) and Over: Welded steel bracket and wrought steel

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- clamp.
- .10 Wall Support for Hot Pipe Sizes 6" (150 mm) and Over: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.
- .11 Vertical Support: Steel riser clamp.
- .12 Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- .13 Floor Support for Hot Pipe Sizes to 4" (100 mm): Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- .14 Floor Support for Hot Pipe Sizes 6" (150 mm) and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
- .15 Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

2.2 ACCESSORIES

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

3 EXECUTION

3.1 INSTALLATION

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

3.2 INSERTS

- .1 Provide inserts for placement in concrete formwork.
- .2 Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- .3 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.

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 Support vertical piping at every other floor. Support vertical cast iron pipe at each floor at hub.
- .7 Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- .8 Support riser piping independently of connected horizontal piping.
- .9 Provide copper plated hangers and supports for copper piping.
- .10 Design hangers for pipe movement without disengagement of supported pipe.
- .11 Prime coat exposed steel hangers and supports. Refer to Section 09 91 10. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

3.4 SLEEVES

- .1 Set sleeves in position in formwork. Provide reinforcing around sleeves.
- .2 Size sleeves large enough to allow for movement due to expansion and contraction. Provide for

Supports & Anchors

- continuous insulation wrapping.
- .3 Extend sleeves through floors 1" (25 mm) above finished floor level. Caulk sleeves.
 - .4 Where piping or ductwork penetrates floor, ceiling, or wall, close off space between pipe or duct and adjacent work with stuffing insulation and caulk. Air tight. Provide close fitting metal collar or escutcheon covers at both sides of penetration.
 - .5 Install chrome plated steel escutcheons at finished surfaces.

3.5 SCHEDULES

- .1 Imperial Measure (IP)

Pipe Size (in)	Rod Diameter (in)	Support Spacing (Ft)	
		Steel Pipe	Copper Tube
1/2	3/8	7	6
3/4	3/8	7	6
1	3/8	7	6
1-1/4	3/8	7	6
1-1/2	3/8	9	8
2	3/8	10	9
2-1/2	3/8	12	10
3	3/8	12	10
4	5/8	14	12
6	7/8	17	
8	7/8	19	
10	7/8	21	
12	7/8	23	
14	1	25	
16	1	27	
18	1	28	

- .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

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65	10	3.6	3
75	10	3.6	3
100	16	4.2	3.6
150	22	17	
200	22	5.7	
250	22	6.4	
300	22	7	

END OF SECTION

Heat Tracing

1 GENERAL

1.1 GENERAL REQUIREMENTS

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

1.2 SYSTEM DESCRIPTION

- .1 This Section includes a heat tracing system for freeze protection of aboveground water lines with Proportional Ambient Sensing Control (PASC), monitoring, integrated ground-fault circuit protection.
- .2 The freeze protection system shall have a design, installation and operating manual specific to aboveground water lines.

1.3 REFERENCES

- .1 CSA C22.2 No.130-03 Requirements for Electrical Resistance Heating Cables and Heating Device Sets

1.4 SUBMITTALS

- .1 Heating cable data sheet
- .2 ULC, CSA, certificates for freeze protection for aboveground water lines
- .3 Pipe freeze protection design guide
- .4 Manufacturer's installation and operation manual
- .5 Manufacturer's installation details
- .6 Manufacturer's maintenance instructions.
- .7 Connection kits and accessories data sheet
- .8 Controller data sheet
- .9 Controller wiring diagram

1.5 QUALIFICATIONS

- .1 Manufacturers Qualifications
 - .1 Minimum of ten (10) years experience in manufacturing electric self-regulating heating cables.
 - .2 ISO-9001 registered.
 - .3 Manufacturer to provide products consistent with UL 515, CSA 22.2 No 130-03 and IEEE 515.1 requirements.
- .2 Installer Qualifications
 - .1 System installer shall have complete understanding of product and product literature from manufacturer or authorized representative prior to installation.
 - .2 Electrical connections shall be executed by a licensed electrician.

1.6 DELIVERY, STORAGE AND HANDLING

- .1 General Requirements: Deliver, store and handle products to prevent their deterioration or damage due to moisture, temperature changes, contaminates or other causes.
- .2 Delivery and Acceptance Requirements: Deliver products to site in original,

Heat Tracing

unopened containers or packages with intact and legible manufacturers' labels identifying the following:

- .1 Product and Manufacturer
- .2 Length/Quantity
- .3 Lot Number
- .4 Installation and Operation Manual
- .5 MSDS (if applicable)
- .3 Storage and Handling Requirements
 - .1 Store the heating cable in a clean, dry location with a temperature range 0°F (-18°C) to 140°F (60°C).
 - .2 Protect the heating cable from mechanical damage.

1.7 WARRANTY

- .1 Extended Warranty
 - .1 Manufacturer shall provide ten (10) year warranty for all heating cables and components. Provide one (1) year warranty for all heat trace controllers.
 - .2 Contractor shall submit to owner results of installation tests required by the manufacturer.

2 PRODUCTS

2.1 MANUFACTURERS AND PRODUCTS

- .1 Manufacturer shall be Tyco Thermal Controls, LLC, located at, 307 Constitution Drive, Menlo Park, CA 94025 Tel: (800) 545-6258 www.tycothermal.com
- .2 Pipe Freeze Protection System
 - .1 Raychem® XL-Trace® self-regulating heating cable with polyolefin (-CR) or fluoropolymer (-CT) outer jacket
 - .2 Raychem RayClic® and accessories
 - .3 DigiTrace® ACS-30 digital controller and EC-TS
- .3 Furnish heat tracing system for the freeze protection of aboveground water lines from a single manufacturer to ensure a single source responsibility.
- .4 The system (heating cable, connection kits, and controller) shall be ULC Listed, CSA Certified for freeze protection of aboveground water lines. No parts of the system may be substituted or exchanged.

2.2 SELF-REGULATING HEATING CABLE

- .1 Heating cable shall be Raychem XL-Trace self-regulating heating cable manufactured by Tyco Thermal Controls.
 - .1 Model Numbers
 - .1 8XL2-CT
 - .2 5XL2-CR
 - .2 The heating cable shall consist of a continuous core of conductive polymer that is radiation cross-linked, extruded between two (2) 16 AWG nickel-plated copper bus wires that varies its power output in response to pipe temperature changes.
 - .3 The heating cable shall have a modified polyolefin inner jacket and a tinned-

Heat Tracing

- copper braid to provide a ground path and enhance the cables ruggedness.
- .4 The heating cable shall have a fluoropolymer or polyolefin outer jacket depending on application.
- .5 The heating cable shall have a self-regulating factor of at least 90 percent for 5/8XL or at least 70 percent for 12XL. The self-regulating factor is defined as the percent reduction of the heating cable power output going from a 40°F pipe temperature to 150°F pipe temperature.
- .6 The heating cable shall operate on line voltages of 208 volts without the use of transformers.
- .7 The heating cable shall be part of a ULC Listed, CSA Certified.
- .8 The outer jacket of the heating cable shall have the following markings:
 - .1 Heating cable model number
 - .2 Agency listings
 - .3 Meter mark
 - .4 Lot/Batch ID

2.3 HEATING CABLE CONNECTION KITS

- .1 Heating cable connection kits shall be Raychem RayClic.
- .2 Manufacturer shall provide power connection, splice/tee and end seal kits compatible with selected heating cable.
- .3 Installation shall not require the installing contractor to cut into the heating-cable core to expose the bus wires. [for RayClic connection kits only]
- .4 Connection kits shall be rated NEMA 4X to prevent water ingress and corrosion. All components shall be UV stabilized.
- .5 Connection kits shall be UL Listed, CSA Certified.

2.4 HEATING CABLE INSTALLATION ACCESSORIES

- .1 High temperature, glass filament tape for attachment of heating cable to water lines. Cable ties are not permitted. (TTC Catalog Number: GT-66)
- .2 Plastic Piping - provide an aluminium self-adhesive tape over the heating cable on all plastic piping if required. (TTC Catalog Number: AT-180)
- .3 Labels - Provide warning labels every 10 feet on exterior of insulation, opposite sides of pipe. (TTC Catalog Number: ETL)

2.5 ELECTRONIC THERMOSTAT

- .1 Electronic thermostat for ambient sensing thermostat for pipe pipe freeze protection shall be EC-TS. For control of single heat-tracing circuit. Temperature set point can be visually checked through clear lid.

2.6 MULTIPLE DIGITAL TEMPERATURE CONTROLLER

- .1 Multiple Circuit Distributed Digital Control System
 - .1 Distributed digital control system shall be DigiTrace ACS-30 heat-trace control system.
 - .2 Heating cable manufacturer shall provide a distributed digital control system with pre-programmed parameters to provide concurrent control for heating

Heat Tracing

- cables used for pipe freeze protection, flow maintenance, hot water temperature maintenance, surface snow melting, roof and gutter de-icing, freezer frost heave prevention and floor heating applications.
- .3 All programming shall be done through the central User Interface Terminal (ACS-UIT2).
 - .4 The ACS-UIT2 shall be a color LCD touch-screen display with password protection to prevent unauthorized access to the system.
 - .5 The ACS-UIT2 shall communicate with up to fifty-two (52) ACS Power Control Panels (ACS-PCM2-5) where each panel can control up to five (5) circuits and accept up to five (5) temperature inputs. The DigiTrace C910-485 digital controller may be added to the ACS-30 Network for single circuit extensions.
 - .6 Digital control system shall be capable of assigning up to four (4) RTD temperature inputs per heat-tracing circuit.
 - .7 The ACS-UIT2 shall communicate with up to sixteen (16) Remote Monitoring Modules (RMM2), where each module can accept up to 8 temperature inputs.
 - .8 The ACS-UIT2 shall have a USB port to allow for quick and easy software update.
 - .9 The ACS-UIT2 shall have three (3) programmable alarm contacts including an alarm light on the enclosure cover.
 - .10 A separate offline software tool shall be made available to allow users to pre-program the digital control system and transfer program via a USB drive or Ethernet.
 - .11 The ACS-UIT2 enclosure shall be NEMA 4 for indoor or outdoor locations.
 - .12 The ACS-PCM2-5 panel shall be in a NEMA 4/12 enclosure approved for nonhazardous indoor and outdoor locations.
 - .13 The ACS-PCM2-5 panel shall provide ground-fault and line current sensing, alarming, switching and temperature inputs for five (5) heat tracing circuits.
 - .14 Each ACS-PCM2-5 panel shall have five (5) 3-pole, 30 A contactors (EMR type).
 - .15 The ACS-PCM2-5 panel shall be capable of operating at 120 V to 277 V.
 - .16 The ACS-PCM2-5 shall have an alarm contact including an alarm light on the panel cover
 - .17 Digital controller shall have an integrated adjustable GFPD (10 - 200 mA).
 - .18 Digital control system will have a built-in self-test feature to verify proper functionality of heating cable system.

2.7 THERMAL PIPE INSULATION

- .1 Pipes must be thermally insulated in accordance with the XL-Trace design guide requirements.

3 EXECUTION

3.1 INSTALLATION

- .1 Installers shall be familiar with installing heat-trace cable and equipment.
- .2 The installer shall be responsible for providing a complete functional system, installed

Heat Tracing

- in accordance with applicable national and local requirements.
- .3 Install heating cables in accordance with the contract documents and the manufacturer's recommendations.
- .4 Apply the heating cable linearly on the pipe after piping has successfully completed any pressure tests. Secure the heating cable to piping with fiberglass tape at maximum spacing 0.5 m.
- .5 On plastic piping, the heating cable shall be applied using aluminum tape (AT-180)
- .6 Ensure that heating cables do not touch or cross each other at any point.
- .7 Run only cold leads in conduit and ensure sensing bulb does not touch cable.
- .8 Loop additional cable at fittings, valves, and flanges.
- .9 Ground shield to building ground.
- .10 Grounding of controller shall conform to requirements in Division 26.
- .11 Make power and control connections. Connection of all electrical wiring shall conform to requirements in Division 26.
- .12 Power connection, end seal, splice and tee kit components shall be applied in the field.
- .13 Heating cable circuit shall be protected by a ground-fault device for equipment protection.
- .14 Coordinate cable installation with insulation application.
- .15 Apply "Electric Traced" labels to outside of thermal insulation.

3.2 THERMAL PIPE INSULATION

- .1 Pipes must be thermally insulated in accordance with the XL-Trace design guide requirements.
- .2 Thermal insulation must be a type that is flame retardant (closed-cell or fiberglass) with waterproof covering.

3.3 FIELD QUALITY CONTROL

- .1 Start-up of system shall be performed by a factory technician or a qualified factory representative.
- .2 Field Testing and Inspections
 - .1 The system shall be commissioned in accordance the manufacturer's installation and operating instructions.
 - .2 The heating cable circuit integrity shall be tested using a 2500 Vdc megohmmeter at the following intervals below. Minimum acceptable insulation resistance shall be 1000 megohms or greater.
 - .1 Before installing the heating cable
 - .2 After heating cable has been installed onto the pipe
 - .3 After installing connection kits
 - .4 After the thermal insulation is installed onto the pipe
 - .5 Prior to initial start-up (commissioning)
 - .6 As part of the regular system maintenance
 - .3 The technician shall verify that the C910-485 control parameters are set to the application requirements.
 - .4 The technician shall verify that the C910-485 alarm contacts are corrected connected to the BMS.

Heat Tracing

- .5 The technician shall verify that the C910-485 and ProtoNode-RER are configured correctly with the BMS.
- .6 All commissioning results will be recorded and presented to the owner.

END OF SECTION

Testing, Adjusting & Balancing

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 05 05 & 23 01 01.

1.2 SECTION INCLUDES

- .1 Testing, adjustment, and balancing of air systems.
- .2 Testing, adjustment, and balancing of piping systems.
- .3 Testing, adjustment, and balancing of equipment.
- .4 Testing, adjustment and balancing of room relative pressures in health care facilities.
- .5 Testing, adjustment, and balancing of smoke management systems.
- .6 Measurement of final operating condition of HVAC systems.
- .7 Sound measurement of equipment operating conditions.
- .8 Vibration measurement of equipment operating conditions.

1.3 REFERENCES

- .1 Ontario Building Code.
- .2 Ontario Fire Code.
- .3 AABC - National Standards for Total System Balance.
- .4 ACG - AABC Commissioning Guideline.
- .5 ADC - Test Code for Grilles, Registers, and Diffusers.
- .6 ASHRAE 111 - Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-conditioning, and Refrigeration Systems.
- .7 ASHRAE Guideline 0 The Commissioning Process,
- .8 ASHRAE Guideline 1 The HVAC Commissioning Process,
- .9 ASHRAE Guideline 1.1 HVAC&R Technical Requirements for the Commissioning Process,
- .10 ASHRAE Guideline 5 Commissioning Smoke Management Systems
- .11 ASTM E779 Determining Air Leakage Rate by Fan Pressurization.
- .12 NEBB - Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.
- .13 SMACNA - HVAC Systems Testing, Adjusting, and Balancing.
- .14 SMACNA HVAC Systems Commissioning Manual,
- .15 CAN/CSA Z318.0 Commissioning of Health Care Facilities,

1.4 SUBMITTALS

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

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1.5 PROJECT RECORD DOCUMENTS

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

1.6 QUALITY ASSURANCE

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

1.7 INDEPENDENT AGENCY

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

1.8 QUALIFICATIONS

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

1.9 PRE-BALANCING CONFERENCE

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

1.10 SEQUENCING

- .1 Sequence work to commence after completion of systems and schedule completion of work before Substantial Completion of Project.

1.11 SCHEDULING

- .1 Schedule and provide assistance in final adjustment and test of life safety system with Fire Authority.

1.12 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 Coordinate verification of smoke control and automatic sprinkler systems with verification of fire alarm system under Division 26.

2 PRODUCTS

2.1 REFERENCE STANDARDS

- .1 All equipment required for the verification of equipment and systems shall be furnished by the agency

Testing, Adjusting & Balancing

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

3 EXECUTION

3.1 EXAMINATION

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

3.2 PREPARATION

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

3.3 INSTALLATION TOLERANCES

- .1 Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 5 percent of design for return and exhaust systems.
- .2 Air Outlets and Inlets: Adjust total to within plus 5 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 5 percent of design.
- .3 Hydronic Systems: Adjust to within plus or minus 10 percent of design.
- .4 Room Pressurization: Adjust to within plus 20 percent and minus 0 percent of design for rooms under positive pressure and within plus 0 percent and minus 20 percent of design for rooms under negative pressure.

3.4 ADJUSTING

- .1 Ensure recorded data represents actual measured or observed conditions.
- .2 Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

Testing, Adjusting & Balancing

- .3 After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- .4 Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
- .5 At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.
- .6 Check and adjust systems approximately six months after final acceptance and submit report.

3.5 AIR SYSTEM PROCEDURE

- .1 Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.
- .2 Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.
- .3 Measure air quantities at air inlets and outlets.
- .4 Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.
- .5 Use branch volume control dampers and splitters to regulate air quantities. Devices at air outlets may be used only to the extent that adjustments do not create objectionable air motion or sound levels.
- .6 Provide system schematic with required and actual air quantities recorded at each outlet or inlet.
- .7 Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan.
- .8 Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
- .9 Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
- .10 Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.
- .11 Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 in.wg. (12.5 Pa) positive static pressure near the building entries.
- .12 Check multi-zone units for motorized damper leakage. Adjust air quantities with mixing dampers set first for cooling, then heating, then modulating.
- .13 For variable air volume system powered units set volume controller to air flow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable air volume temperature control.

3.6 WATER SYSTEM PROCEDURE

- .1 Adjust water systems to provide required or design quantities.
- .2 Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.
- .3 Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
- .4 Effect system balance with automatic control valves fully open to heat transfer elements.
- .5 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.
- .6 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.

3.7 SCHEDULES

- .1 Equipment requiring testing, adjusting and balancing:
 - .1 Plumbing Pumps
 - .2 HVAC Pumps
 - .3 Air Coils

Testing, Adjusting & Balancing

-
- .4 Terminal Heat Transfer Units
 - .5 Air Handling Units
 - .6 Fans
 - .7 Air Filters
 - .8 Air Terminal Units
 - .9 Air Inlets and Outlets
 - .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 Summary of outdoor and exhaust flows to indicate amount of building pressurization
 - .5 Nomenclature used throughout report
 - .6 Test conditions
 - .3 Instrument List:
 - .1 Instrument
 - .2 Manufacturer
 - .3 Model number
 - .4 Serial number
 - .5 Range
 - .6 Calibration date
 - .4 Electric Motors:
 - .1 Manufacturer
 - .2 Model/Frame
 - .3 HP/BHP
 - .4 Phase, voltage, amperage; nameplate, actual, no load
 - .5 RPM
 - .6 Service factor
 - .7 Starter size, rating, heater elements
 - .8 Sheave Make/Size/Bore
 - .5 V-Belt Drive:
 - .1 Identification/location
 - .2 Required driven RPM
 - .3 Driven sheave, diameter and RPM
 - .4 Belt, size and quantity
 - .5 Motor sheave diameter and RPM
 - .6 Centre to centre distance, maximum, minimum, and actual
 - .6 Pump Data:
 - .1 Identification/number
 - .2 Manufacturer
 - .3 Size/model
 - .4 Impeller
 - .5 Service
 - .6 Design flow rate, pressure drop, BHP
 - .7 Actual flow rate, pressure drop, BHP

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- | | | |
|-----|------------------------------|--|
| | .8 | Discharge pressure |
| | .9 | Suction pressure |
| | .10 | Total operating head pressure |
| | .11 | Shut off, discharge and suction pressures |
| | .12 | Shut off, total head pressure |
| .7 | Heating Coil Data: | |
| | .1 | Identification/number |
| | .2 | Location |
| | .3 | Service |
| | .4 | Manufacturer |
| | .5 | Air flow, design and actual |
| | .6 | Water flow, design and actual |
| | .7 | Water pressure drop, design and actual |
| | .8 | Entering water temperature, design and actual |
| | .9 | Leaving water temperature, design and actual |
| | .10 | Entering air temperature, design and actual |
| | .11 | Leaving air temperature, design and actual |
| | .12 | Air pressure drop, design and actual |
| .8 | Air Moving Equipment | |
| | .1 | Location |
| | .2 | Manufacturer |
| | .3 | Model number |
| | .4 | Serial number |
| | .5 | Arrangement/Class/Discharge |
| | .6 | Air flow, specified and actual |
| | .7 | Return air flow, specified and actual |
| | .8 | Outside air flow, specified and actual |
| | .9 | Total static pressure (total external), specified and actual |
| | .10 | Inlet pressure |
| | .11 | Discharge pressure |
| | .12 | Sheave Make/Size/Bore |
| | .13 | Number of Belts/Make/Size |
| | .14 | Fan RPM |
| .9 | Return Air/Outside Air Data: | |
| | .1 | Identification/location |
| | .2 | Design air flow |
| | .3 | Actual air flow |
| | .4 | Design return air flow |
| | .5 | Actual return air flow |
| | .6 | Design outside air flow |
| | .7 | Actual outside air flow |
| | .8 | Return air temperature |
| | .9 | Outside air temperature |
| | .10 | Required mixed air temperature |
| | .11 | Actual mixed air temperature |
| | .12 | Design outside/return air ratio |
| | .13 | Actual outside/return air ratio |
| .10 | Exhaust Fan Data: | |
| | .1 | Location |
| | .2 | Manufacturer |
| | .3 | Model number |
| | .4 | Serial number |
| | .5 | Air flow, specified and actual |
| | .6 | Total static pressure (total external), specified and actual |
| | .7 | Inlet pressure |
| | .8 | Discharge pressure |

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- .9 Sheave Make/Size/Bore
- .10 Number of Belts/Make/Size
- .11 Fan RPM
- .11 Duct Traverse:
 - .1 System zone/branch
 - .2 Duct size
 - .3 Area
 - .4 Design velocity
 - .5 Design air flow
 - .6 Test velocity
 - .7 Test air flow
 - .8 Duct static pressure
 - .9 Air temperature
 - .10 Air correction factor
- .12 Duct Leak Test:
 - .1 Description of ductwork under test
 - .2 Duct design operating pressure
 - .3 Duct design test static pressure
 - .4 Duct capacity, air flow
 - .5 Maximum allowable leakage duct capacity times leak factor
 - .6 Test apparatus
 - .1 Blower
 - .2 Orifice, tube size
 - .3 Orifice size
 - .4 Calibrated
 - .7 Test static pressure
 - .8 Test orifice differential pressure
 - .9 Leakage
- .13 Terminal Unit Data:
 - .1 Manufacturer
 - .2 Type, constant, variable, single, dual duct
 - .3 Identification/number
 - .4 Location
 - .5 Model number
 - .6 Size
 - .7 Minimum static pressure
 - .8 Minimum design air flow
 - .9 Maximum design air flow
 - .10 Maximum actual air flow
 - .11 Inlet static pressure
- .14 Air Distribution Test Sheet:
 - .1 Air terminal number
 - .2 Room number/location
 - .3 Terminal type
 - .4 Terminal size
 - .5 Area factor
 - .6 Design velocity
 - .7 Design air flow
 - .8 Test (final) velocity
 - .9 Test (final) air flow
 - .10 Percent of design air flow
- .15 Sound Level Report:
 - .1 Location
 - .2 Octave bands - equipment off
 - .3 Octave bands - equipment on
- .16 Vibration Test:

Testing, Adjusting & Balancing

-
- .1 Location of points:
 - .1 Fan bearing, drive end
 - .2 Fan bearing, opposite end
 - .3 Motor bearing, centre (if applicable)
 - .4 Motor bearing, drive end
 - .5 Motor bearing, opposite end
 - .6 Casing (bottom or top)
 - .7 Casing (side)
 - .8 Duct after flexible connection (discharge)
 - .9 Duct after flexible connection (suction)
 - .2 Test readings:
 - .1 Horizontal, velocity and displacement
 - .2 Vertical, velocity and displacement
 - .3 Axial, velocity and displacement
 - .3 Normally acceptable readings, velocity and acceleration
 - .4 Unusual conditions at time of test
 - .5 Vibration source (if non-complying)

3.8 VERIFICATION CHECKLIST

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

3.9 EQUIPMENT VERIFICATION

- .1 Test the operation of all equipment installed under Division 23 according to instructions in appropriate articles of this Division. Advise installing contractor of any required adjustments or replacements to ensure that equipment is operating as intended. Retest equipment after adjustment or replacement.
- .2 Ensure that the Contractor has given proper advance notification to all persons required to be present as tests are conducted.
- .3 Instrumentation: verify installation of air filter gauges, pumps, thermometers, thermometer wells, pitot traverse stations, and flow-measuring devices ensuring that:
 - .1 Location of points for readings is appropriate to measure what it is intended to measure;
 - .2 The scale range is appropriate to place the normal reading near mid-range of the scale;
 - .3 Proper positioning of instrumentation to allow reading from a convenient location, and for easy access.
- .4 Filters Inspection: visually inspect each filter installation. Verify adjustment of latching devices, installation of end spacers in filter boxes, and proper latching and sealing of access doors. Verify the installation of new (clean) filter media after Contractor's start-up procedures.
- .5 Pre-start-up Inspection:
 - .1 Verify proper equipment mounting and setting.
 - .2 Verify that control, interlock, and power wiring are complete.
 - .3 Verify proper alignment of motors and drives.
 - .4 Verify proper piping connections and accessories.
 - .5 Verify that lubrication is complete.
- .6 First Run Observation:
 - .1 Verify direction of rotation.
 - .2 Verify setting of safety controls.
 - .3 Monitor heat build-up in bearings.
 - .4 Check motor loads against nameplate ratings.

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- .7 Equipment Checkout:
 - .1 Verify the proper overload heater sizes.
 - .2 Verify function of safety and operating controls.
 - .3 Verify proper operation of equipment.
 - .4 Report on inspection, observation, and checkout procedures.
 - .8 Stuffing Boxes and Packing Glands: verify adjustment of boxes on pump shafts and packing glands on valve stems.
 - .9 Motor Rotation: visually inspect and verify the direction of motor rotation. It is possible for motor rotation to have been checked by the electrician when power connections were made on temporary electric power, then when final connections were made to the permanent transformer bank, crossed phasing may reverse the rotation of all three-phase motors on the system.
 - .10 Overload Heaters: verify supply voltage to each equipment. If the applied voltage is different from the motor nameplate, determine whether the applied voltage is within the range allowed under the motor guarantee. If not, take the necessary action to have the Contractor change the motor or the applied voltage. When the voltage is off the nameplate value, but within the allowable range, compute the equivalent amperage at nameplate voltage and compare to the overload heater amperage rating range. Then, consider whether the ambient temperature of the starter is above, below, or the same as the ambient temperature are not the same. Advise the Contractor to use overload heaters of higher range for "hot area" starters or ones of lower range for "cold area" starters to compensate the heater trip point for heat gains or losses with the environment.
 - .11 Alignment of Drives: verify the alignment of drives, belt and direct coupled, and the adjustment of belt tension.
 - .12 Control Diagrams and Sequences: provide for coordination with work under the automatic control systems to have the control diagrams and sequences of operation corrected to "as installed", reflecting changes brought about in response to contract modifications and to the more pragmatic changes in diagrams and sequences to make the installed system control the building systems as intended by the designer.
 - .13 Safety and Operating Control Setpoints: systematically verify the safety and operating controls of equipment, including an operational check of associated control sequences.
 - .14 Fin Straightening: inspect finned surface heat transfer coils for damages fins and advise Contractor of repairs required.
 - .15 Verify that manufacturer's start-up procedures have been performed and that equipment is installed in accordance with the manufacturer's written installation recommendations.
 - .16 Where work is noted to be done in stages a complete air balance and verification report will be required at the end of each stage.

3.10 PIPING SYSTEMS VERIFICATION

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

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- .14 Check and record the following items at each cooling and heating element:
 - .1 Inlet water and air temperatures. Note rise or drop in temperature train source.
 - .2 Leaving water and air temperatures.
 - .3 Pressure drop and flow through each coil.
 - .4 Pump operating suction and discharge pressure and final t.d.h. and flow delivered.
 - .5 Pressure drop across bypass valve.
 - .6 All mechanical specifications of pumps.
 - .7 Rated and actual running amperage of pump motor.
- .15 Witness all piping tests.

3.11 AIR SYSTEM VERIFICATION

- .1 Review drawings, specifications and installed work to ensure that systems may be properly balanced in accordance with drawings. Advise installing Contractor of any additional requirements for effective balancing.
- .2 In air handling systems which include supply fans with variable speed drives, airflows shall be verified to design with all filters clean and with all filters loaded to filter manufacturer's recommended final (change-out) resistance. Motor and drive capacity to accommodate full range of filter loadings shall be verified.
- .3 In air handling systems which include supply fans without variable speed drives, air filters shall be verified to design airflows with air filters loaded so that the air pressure drop through each filter is equal to the average of the manufacturers listed initial resistance and recommended final (change-out) resistance.
- .4 Test and record blower rpm for each fan and air handling unit.
- .5 Test and record motor full load amperes.
- .6 Make Pitot tube traverse of main supply and obtain operating air quantities at fans.
- .7 Test and record system static pressures, suction and discharge.
- .8 Test and record system operating recirculated air quantities.
- .9 Test and record system operating outside air quantities.
- .10 Test and record entering drybulb air temperatures (heating and cooling coils).
- .11 Test and record entering wet bulb air temperatures (heating and cooling coils).
- .12 Test and record leaving dry bulb air temperatures (heating and cooling coils).
- .13 Test and record leaving wet bulb air temperatures (cooling coils only).
- .14 Measure airflow in all main and zone branch supply and return air ducts.
- .15 Test and record airflow at each diffuser, grille, and register.
- .16 Witness and verify results of duct leakage tests conducted under section 15810.
- .17 Tabulate and certify test results on suitable forms and submit Consultant for approval and record. Identify each diffuser, grille, and register as to location and area. Identify and list size, type, and manufacturer of diffusers, grilles, registers, and all testing equipment. Use manufacturer's rating on all equipment to make required calculations.

3.12 MODIFICATIONS TO EXISTING SYSTEMS

- .1 Where an existing air/water system is shown to be modified in any way, no work shall be done on it until the air/water flows in that system are measured and a report submitted to the Engineer. On completion of the modifications, the balancing report shall show the unaffected air/water flows in that system have been rebalanced to the original quantities. "Water" systems include glycol-water systems.

3.13 FAN PRESSURE TESTING

- .1 Rooms required to maintain a relative pressure differential from adjacent rooms shall be constructed to maintain a relative pressure differential of 0.05" w.g. (12.5 Pa) with a maximum leakage of 1 cfm/15.0 cu. ft. (1.1 l/s/m³) of room volume.
- .2 Each room shall be tested by the TAB Agency using a portable pressure tester (Fan Pressurization Method) capable of measuring air flow and room static pressure to within +2% accuracy. Room air leakage is to be measured in the inlet duct of the tester by means of a duct traverse.

Testing, Adjusting & Balancing

- .3 Each room supply, exhaust and sanitary exhaust air registers shall be sealed with heavy grade plastic prior to the room test. No other temporary sealing of gaps will be allowed.
- .4 Rooms that require Fan Pressure Testing include;
 - .1 Class 1 rooms required to maintain a relative pressure differential (positive or negative)
 - .2 negative pressure rooms

3.14 ROOM RELATIVE PRESSURES

- .1 Supply, return and exhaust airflows shall be arranged to move air from clean to less clean areas.
- .2 The relative pressure in contaminated or malodorous areas shall be negative in relation to adjacent areas.
- .3 The pressure differential between areas shall be greater than 0.762mm (0.03") of water pressure.
- .4 Each room shall be visually inspected before ceilings are installed to ensure that room enclosures are well sealed and able to maintain required pressure differentials.
- .5 The following areas shall be negative relative to surrounding areas;
 - .1 laboratories - general (refer to Laboratory Biosafety Guidelines)
- .6 The following areas shall be positive relative to surrounding areas;
 - .1 Lab offices - general (positive to corridor and laboratory it supports)
- .7 The following areas shall be neutral relative to surrounding areas;
 - .1 Offices – general (non-laboratory offices)

END OF SECTION

Duct Insulation

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 05 05 & 23 01 01.

1.2 SECTION INCLUDES

- .1 Duct work insulation.
- .2 Insulation jackets.

1.3 REFERENCES

- .1 Section 23 01 01: Requirements for references and standards.
- .2 ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
- .3 ASTM C518 - Steady-State Thermal Transmission Properties by Means of the Heat Flow Metre Apparatus.
- .4 ASTM C553 - Standard Specification for Mineral Fibre Blanket Thermal Insulation for Commercial and Industrial Applications.
- .5 ASTM C612 - Standard Specification for Mineral Fibre Block and Board Thermal Insulation.
- .6 ASTM C921 - Properties of Jacketing Materials for Thermal Insulation.
- .7 ASTM C1071 - Fibrous Glass Duct Lining Insulation(Thermal Sound Absorbing Material).
- .8 ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- .9 ASTM E96 - Water Vapour Transmission of Materials.
- .10 ASTM E162 - Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source.
- .11 ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
- .12 NAIMA National Insulation Standards.
- .13 NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.
- .14 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- .15 UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.
- .16 CGSB-Canadian General Standards Board.
- .17 CAN/CGSB-51.9 Mineral Fiber Thermal Insulation for Piping and Round Ducting.
- .18 CAN/CGSB-51.10 Mineral Fiber Board Thermal Insulation
- .19 CAN/CGSB-51.11 Mineral Fiber Thermal Insulation Blanket.
- .20 CAN/CGSB-5140 Mineral Insulation, Flexible, Elastomeric, Unicellular, Sheet & Pipe Coverup.
- .21 CAN/CGSB-51-GP-52 Ma Vapor Barrier, Jacket and Facing Material for Pipe, Duct & Equipment Thermal Insulation.

1.4 SUBMITTALS FOR REVIEW

- .1 Section 23 01 01: Procedures for submittals.
- .2 Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

1.5 SUBMITTALS FOR INFORMATION

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

1.6 QUALITY ASSURANCE

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

Duct Insulation

1.7 REGULATORY REQUIREMENTS

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

1.8 DELIVERY, STORAGE, AND PROTECTION

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

1.9 ENVIRONMENTAL REQUIREMENTS

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

2 PRODUCTS

2.1 GLASS FIBRE, FLEXIBLE

- .1 Manufacturer: Owens Corning Fiberglas
- .2 Other acceptable manufacturers offering equivalent products:
 - .1 Manson
 - .2 Knauf Fiber Glass
 - .3 Johns Manville
 - .4 CertainTEED "Soft Touch" with FSK jacket
- .3 Insulation: ASTM C553; flexible, noncombustible blanket.
 - .1 'ksi' value : ASTM C518, 0.045 at 24 °C (0.31 @ 75.2 °F).
 - .2 Density: 0.75lb/ft3, 1.01lb/ft3
 - .3 .2 Maximum service temperature: 121 °C (250 °F).
 - .4 .3 Maximum moisture absorption: 0.20 % by volume.
- .4 Vapour Barrier Jacket:
 - .1 Kraft paper with glass fibre yarn and bonded to aluminized film. (FSK)
 - .2 Moisture vapour transmission: ASTM E96; 0.02 perm.
 - .3 Secure with pressure sensitive tape.
- .5 Vapour Barrier Tape:
 - .1 Kraft paper reinforced with glass fibre yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.
- .6 Outdoor Vapour Barrier Mastic:
 - .1 Vinyl emulsion type acrylic or mastic, compatible with insulation, black colour.
- .7 Tie Wire: Annealed steel, 1/16" (1.5 mm).

2.2 GLASS FIBRE, RIGID

- .1 Manufacturer: Owens Corning Fiberglas Model Vapour-Seal.
- .2 Other acceptable manufacturers offering equivalent products:
 - .1 Manson
 - .2 Knauf Fiber Glass
 - .3 Johns Manville
- .3 Insulation: ASTM C612; rigid, noncombustible blanket.
 - .1 'ksi' value : ASTM C518, 0.036 at 75.2 °F (24 °C).
 - .2 Maximum service temperature: 250 °F (121 °C).
 - .3 Maximum moisture absorption: 0.20 percent by volume.
 - .4 Density: 48 kg/cu m.
- .4 Vapour Barrier Jacket:

Duct Insulation

- .1 Kraft paper with glass fibre yarn and bonded to aluminized film.
- .2 Moisture vapour transmission: ASTM E96; 0.04 perm.
- .3 Secure with pressure sensitive tape.

2.3 ELASTOMERIC INSULATION

- .1 Acceptable Manufacturers:
 - .1 Armacell APArmaflex, APArmaflex SA or ArmaTuff Laminated Sheets and Rolls
- .2 Insulation material shall be a flexible, closed-cell elastomeric insulation in sheet form to ASTM C 534, "Specification for preformed elastomeric cellular thermal insulation in sheet and tubular form."
- .3 Insulation materials shall have a closed-cell structure to prevent moisture from wicking.
- .4 Insulation material shall be manufactured without the use of CFC's, HFC's or HCFC's, formaldehyde free, low VOC's, fiber free, dust free and shall resist mold and mildew.
- .5 Materials shall have a flame spread index of less than 25 and a smoke-developed index of less than 50 when tested in accordance with ULC S102, ASTM E 84, latest revision. In addition, the product, when tested, shall not melt or drip flaming particles, the flame shall not be progressive and all materials shall pass simulated end-use fire tests.
- .6 Materials shall have a maximum thermal conductivity of 0.27 Btu-in./h-ft²- °F at a 75°F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518, latest revisions.
- .7 Materials shall have a maximum water vapor transmission of 0.08 perm-inches when tested in accordance with ASTM E 96, Procedure A, latest revision.
- .8 The material shall be manufactured under an independent third party supervision testing program covering the properties of fire performance, thermal conductivity and water vapor transmission.

2.4 JACKETS

- .1 Canvas Jacket: UL listed.
 - .1 Fabric: ASTM C921, 220 g/sq m, plain weave cotton treated with dilute fire retardant lagging adhesive.
 - .2 Lagging Adhesive: Compatible with insulation.
- .2 Mineral Fibre (Outdoor) Jacket: Asphalt impregnated and coated sheet, 2.45 kg/sq m.
- .3 PVC Jacket (Indoor):
 - .1 Jacket: ASTM C921, One piece sheet material.
 - .1 Minimum Service Temperature: -31 °F (-35 °C).
 - .2 Maximum Service Temperature: 150 °F (66 °C).
 - .3 Moisture Vapour Transmission: ASTM E96; 0.03 perm inches.
 - .4 Maximum Flame Spread: ASTM E84; 25 or less.
 - .5 Maximum Smoke Developed: ASTM E84; 50 or less.
 - .6 Thickness: 20 mil (0.4 mm) minimum.
 - .2 Colour: standard off-white OR coloured to suit duct identification [EDIT]
 - .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*
- .4 Aluminum Jacket: ASTM B209M.
 - .1 Thickness: 0.40 mm sheet.
 - .2 Finish: Smooth.
 - .3 Joining: Longitudinal slip joints and 2" (50 mm) laps.
 - .4 Fittings: 0.4 mm thick die shaped fitting covers with factory attached protective liner.
 - .5 Metal Jacket Bands: 3/8" (10 mm) wide; 0.015" (0.38 mm) thick aluminum.
- .5 Sheet Waterproofing (Outdoor):
 - .1 MFM Building Products Corp. Flexclad 400, VentureTape VentureClad 1577-CW, Polyguard Alumaclad LT
 - .2 Prefabricated, Self-Adhering, Sheet-Type Waterproofing Membrane:
 - .1 Description:
 - .1 Top Layer: Stucco-embossed, UV-resistant aluminum weathering surface.
 - .2 Middle Layer: Double layer of high-density polyethylene reinforcement.

Duct Insulation

- .3 Bottom Layer: Uniform layer of rubberized asphalt adhesive, protected by disposable silicone release paper.
- .2 Heat Aging, ASTM D 794: No visible blistering or deterioration.
- .3 Tear Resistance, ASTM D 1424, Average: 660 grams.
- .4 Elongation, ASTM D 412, Minimum: 450 percent.
- .5 Low Temperature Flexibility, 1,000,000 Cycles at -10 Degrees F, 1,200 Cycles at -20 Degrees F: No cracking.
- .6 Water Vapor Transmission, ASTM E 96: 0.009 perms.
- .7 Flame Spread Index, ASTM E84: 0.
- .8 Smoke Density Index, ASTM E84: 5.
- .9 Wind-Driven Rain, SFBC TAS-110-95, 100 mph: No leakage or failure.
- .10 UV Stability: Excellent.
- .11 Adhesive: MFM Spray Adhesive, low VOC.

2.5 ACCESSORIES

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

3 EXECUTION

3.1 EXAMINATION

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

3.2 DUCT INSULATION

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

Service	Insulation Type	Thickness
Air supply - rectangular	rigid	1"
Air supply - round	flexible	1"
Exhaust within 6' of outside - rectangular	rigid	3"
Exhaust within 6' of outside - round	flexible	3"
Fresh air intake - rectangular	rigid	3"
Fresh air intake - round	flexible	3"
Exhaust air plenums	rigid	3"
Ductwork outdoors	rigid	3"
Air supply runouts to terminal units < 10' in length - Rectangular	rigid	1"
Air supply runouts to terminal units < 10' in length - Round	flexible	1"

Duct Insulation

Duct mounted cooling coils	rigid	1 ½"
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Service	Insulation Type	Thickness
Air supply - rectangular	rigid	25 mm
Air supply - round	flexible	25 mm
Exhaust within 2m of outside - rectangular	rigid	75 mm
Exhaust within 2m of outside - round	flexible	75 mm
Fresh air intake - rectangular	rigid	75 mm
Fresh air intake - round	flexible	75 mm
Exhaust air plenums	rigid	75 mm
Ductwork outdoors	rigid	75 mm
Air supply runouts to terminal units < 3m in length - Rectangular	rigid	25 mm
Air supply runouts to terminal units < 3m in length - Round	flexible	25 mm
Duct mounted cooling coils	rigid	40 mm

- .2 Inline duct silencers shall be insulated in the same manner as ductwork.

3.3 INSTALLATION

- .1 Install duct insulations to TIAC National Installation Standards.
- .2 Apply insulation materials, accessories, jackets and finishes in accordance with manufacturer' written instructions and as specified.
- .3 Insulated ductwork conveying air below ambient temperature:
 - .1 Provide insulation with vapour barrier jackets.
 - .2 Finish with tape and vapour barrier jacket.
 - .3 Continue insulation through walls, sleeves, hangers, and other duct penetrations.
 - .4 Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
- .4 Insulated ductwork conveying air above ambient temperature:
 - .1 Provide with all service jacket.
 - .2 Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.
- .5 Ductwork Exposed in Mechanical Equipment Rooms or Finished Spaces below 3 metres above finished floor: Finish with canvas jacket sized for finish painting.
- .6 Exterior Applications: Provide insulation with vapour barrier jacket. Cover with outdoor jacket finished as specified.
- .7 External Duct Insulation Application:
 - .1 Secure insulation with vapour barrier with wires and seal jacket joints with vapour barrier adhesive or tape to match jacket.
 - .2 Secure insulation without vapour barrier with staples, tape, or wires.
 - .3 Install without sag on underside of duct work. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift duct work off trapeze hangers and insert spacers.
 - .4 Seal vapour barrier penetrations by mechanical fasteners with vapour barrier adhesive.
 - .5 Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.
- .8 Duct and Plenum Liner Application:
 - .1 Adhere insulation with adhesive for 90 percent coverage.
 - .2 Secure insulation with mechanical liner fasteners. Refer to SMACNA Standards for spacing.
 - .3 Seal and smooth joints. Seal and coat transverse joints.

Duct Insulation

-
- .4 Seal liner surface penetrations with adhesive.
 - .5 Duct dimensions indicated are net inside dimensions required for air flow. Increase duct size to allow for insulation thickness.
 - .9 Sheet Waterproofing
 - .1 Examine surfaces to receive waterproofing membrane. Notify Consultant if surfaces are not acceptable. Do not begin surface preparation or application until unacceptable conditions have been corrected.
 - .2 Surface Preparation:
 - .1 Prepare surfaces in accordance with manufacturer's instructions.
 - .2 Ensure tops of ducts have sufficient slope to eliminate ponding water.
 - .3 Ensure bottoms of ducts have foil-faced rigid insulation boards installed.
 - .4 Ensure surfaces are clean and dry.
 - .3 Remove dirt, dust, oil, grease, hand oils, processing lubricants, moisture, frost, and other contaminants that could adversely affect adhesion of waterproofing membrane.
 - .4 Prime metal, concrete, and masonry surfaces with primers approved by waterproofing membrane manufacturer.
 - .5 Application:
 - .1 Apply waterproofing membrane in accordance with manufacturer's instructions at locations indicated on the drawings.
 - .2 Apply membrane to clean, dry, primed metal ductwork and foil-faced rigid insulation boards. Do not apply over wet or nonrigid insulation.
 - .3 Apply membrane in accordance with manufacturer's air, material, and surface temperature requirements.
 - .4 Apply firm, uniform pressure with hand roller to entire membrane to ensure proper adhesion. Concentrate pressure at seams and on underside of ductwork.
 - .5 Apply membrane to ducts in accordance with manufacturer's instructions.
 - .6 Apply membrane shingle fashion to shed water over, not against laps.
 - .7 Do not terminate membrane on bottom of duct.
 - .8 Apply minimum 3-inch side laps and minimum 6-inch end laps for ductwork applications.
 - .9 Embed membrane to bottom of ducts over 24 inches wide in light continuous layer of adhesive applied to insulation facer.
 - .10 Apply membrane to bottom of insulated ducts over 36 inches wide using mechanical attachment, in addition to adhesive, in accordance with manufacturer's instructions. Install pins on 12-inch centers with rows staggered.
 - .11 Apply adhesive to areas where special adhesion requirements exist, including duct bottoms, flashings, transitions, joints, elbows, valves, tees, and other fittings.
 - .6 Protect applied waterproofing membrane from damage during construction.

END OF SECTION

Hydronic Piping

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 05 05 & 23 01 01.

1.2 SECTION INCLUDES

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

1.3 REFERENCES

- .1 ASME - Welding and Brazing Qualifications.
- .2 ASME B16.3 - Malleable Iron Threaded Fittings Class 50 and 300.
- .3 ASME B16.5 Pipe Pumps & Fittings.
- .4 ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
- .5 ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
- .6 ASME B31.5 - Refrigeration Piping and Heat Transfer Components.
- .7 ASME B31.1 - Code for Power Piping.
- .8 ASTM A53/A53M - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
- .9 A183 Carbon Steel Track Bolts and Nuts.
- .10 ASTM A234/A234M - Piping Fittings of Wrought-Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
- .11 ASTM B32 - Solder Metal.
- .12 ASTM B88 - Seamless Copper Water Tube.
- .13 ASTM D1785 - Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
- .14 ASTM D2235 - Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings.
- .15 ASTM D2241 - Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR-Series).
- .16 ASTM D2310 - Machine-Made Fibreglass' (Glass Fibre-Reinforced Thermosetting Resin) Pipe.
- .17 ASTM D2466 - Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
- .18 ASTM D2467 - Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
- .19 ASTM D2680 - Acrylonitrile-Butadiene-Styrene (ABS) and Poly(Vinyl Chloride) (PVC) Composite Sewer Piping.
- .20 ASTM D2683 - Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
- .21 ASTM D2751 - Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings.
- .22 ASTM D2855 - Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.
- .23 ASTM D3309 - Polybutylene (PB) Plastic Hot-and Cold-Water Distribution Systems.
- .24 ASTM F477 - Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
- .25 ASTM F708 - Design and Installation of Rigid Pipe Hangers.
- .26 ASTM F876 - Crosslinked Polyethylene (PEX) Tubing.
- .27 ASTM F877 - Crosslinked Polyethylene (PEX) Plastic Hot - and Cold - Water Distribution Systems.
- .28 AWS A5.8 - Filler Metals for Brazing and Braze Welding.
- .29 AWS D1.1 - Structural Welding Code - Steel.
- .30 AWWA C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
- .31 AWWA C110 - Ductile - Iron and Grey -Iron Fittings 3 inch - 48 inch (76 mm - 1219 mm), for Water

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- and Other Liquids.
- .32 AWWA C111 - Rubber-Gasket Joints for Ductile Iron and Pressure Pipe and Fittings.
- .33 AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast, for Water.
- .34 MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacture.
- .35 MSS SP69 - Pipe Hangers and Supports - Selection and Application.
- .36 MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices.

1.4 SUBMITTALS

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

1.5 QUALIFICATIONS

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

1.6 REGULATORY REQUIREMENTS

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

1.7 DELIVERY, STORAGE, AND HANDLING

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

1.8 ENVIRONMENTAL REQUIREMENTS

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

1.9 EXTRA MATERIALS

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

2 PRODUCTS

2.1 VALVES - GENERAL

- .1 Conform to requirements of ANSI, ASTM, ASME, and applicable MSS standards.
- .2 Provide valves of the same manufacturer where possible.
- .3 Manufacturer's name and pressure rating clearly marked on body to MSS-SP-25.
- .4 Valid CRN (Canadian Registration Number) required for each valve.
- .5 Materials:
 - .1 Bronze: ASTM B62 or B61 as applicable
 - .2 Brass: ASTM B283 C3770
 - .3 Cast Iron: ASTM A126 Class B

Hydronic Piping

- | | | |
|----|---|------------------------------------|
| .6 | End Connections: | |
| .1 | Threaded ends: | ANSI B1.20.1 |
| .2 | Flanged ends: | ANSI B16.1 (Class 125), ANSI B16.5 |
| .3 | Face-to-face dimensions: | ANSI B16.10 |
| .7 | Design and Testing: | |
| .1 | Bronze Gate & Check valves: | MSS-SP-80 |
| .2 | Ball Valves: | MSS-SP-110 |
| .3 | Cast Iron Gate Valves: | MSS-SP-70 |
| .4 | Cast Iron Globe Valves: | MSS-SP-85 |
| .5 | Cast Iron Check: | MSS-SP-71 |
| .6 | Butterfly Valves: | MSS-SP-67 |
| .8 | First named product as indicated in paragraphs below; other acceptable manufacturers, subject to equivalent products include: | |
| .1 | Kitz. | |
| .2 | Crane | |
| .3 | Conbraco. | |
| .4 | Nibco | |
| .5 | Jenkins | |

2.2 HYDRONIC SYSTEMS TO 150 PSIG, ABOVE GROUND

- | | | |
|-----|-------------------------------|--|
| .1 | Nominal Operating Pressure | 125 psig |
| .2 | Design Pressure | 150 psig |
| .3 | Test Pressure | 225 psig |
| .4 | Design Temperature | 350°F |
| .5 | Corrosion Allowance | 0.0625 in. |
| .6 | Steel Pipe | ASTM A53 Gr.B ERW or ASTM A106 Gr.B SMLS, sch 40, |
| .7 | Joints, 2" and smaller | screwed |
| .8 | Screwed Fittings | 150 Lb. malleable iron |
| .9 | Unions | Cl.150, ASTM A-47 malleable iron, ASTM A-153 galvanized, ANSI B2.1 threads. |
| .10 | Joints, 2-1/2" and larger | welded, with flanges at connections to equipment |
| .11 | Butt weld fittings | ASTM A234 Gr. WFB |
| .12 | Flanges | ASTM A105, Class 150, raised face, weld neck or slip on |
| .13 | Bolts | ASTM A307 C.S. bolts, sq. head; ASTM A563 nuts, hex head |
| .14 | Gaskets | 1/16" (1.6 mm) thick preformed non-asbestos graphite fibre. |
| .15 | Copper Tubing, 2" and Smaller | ASTM B88, Type L, hard drawn. |
| .16 | Joints: | Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 220°C to 280°C. |
| .17 | Fittings: | ASME B16.18, cast brass, or ASME B16.22, solder wrought copper |
| .18 | Dielectric Unions | Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier. |
| .19 | Valves, 2" and smaller | ASTM A105 |
| | Gate Valves (Isolating) | 300 psig non-shock WOG, ASTM B62 bronze body, solid wedge disc, rising stem, bronze trim, threaded ends, Kitz #25 |
| | Globe Valves (Throttling) | 300 psig non-shock WOG, ASTM B62 bronze body, composition (Teflon) disc, rising stem, bronze trim, threaded ends, Kitz #09 |
| | Check Valves (Backflow) | 300 psig non-shock WOG, ASTM B62 bronze body, Y-pattern horizontal, swing type disc, threaded ends, Kitz #29 |
| | Ball Valves (Drain) | 600 psig non-shock WOG, forged brass, 2-piece, chrome ball and stem, full port, blow-out proof PTFE seats & stem, lever handle, threaded ends, Kitz #68AC. |
| .20 | Valves, 2-1/2" and larger | ASTM A216 WCB |
| | Gate Valves (Isolating) | 200 psig non-shock WOG, ASTM A126 Class B cast iron body, bolted bonnet, bronze mounted, solid wedge disc, OS&Y, non-asbestos packing, flanged ends, Kitz #72. |

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	Globe Valves (Throttling)	200 psig non-shock WOG, ASTM A126 Class B cast iron body, bolted bonnet, bronze mounted, bevelled wedge disc, OS&Y, non-asbestos packing, flanged ends, Kitz #76.
	Check (Backflow)	200 psig non-shock WOG, ASTM 126 Class B cast iron body, bolted cover, bronze mounted, swing type disc, flanged ends, Kitz #78
.21	Provide stem extensions for insulated piping.	
.22	Provide gear operator and chain on valves installed above 10-ft AFF.	
.23	Strainers, 2" and smaller	Class 250, 400 psig WOG, cast iron body, Y-pattern, screwed cap and ends, A167 304 stainless steel screen with 1/32" perforations. Mueller Steam 11M.
.24	Strainers, 2-1/2" and larger	Class 250 psig non-shock WOG, cast iron, Y-pattern, bolted flange cover, blow-out plug, A167 304 stainless steel screen with 1/32" perforations, flanged ends, Mueller Steam 752 .

2.3 HYDRONIC SYSTEMS TO 300 PSIG, ABOVE GROUND

.1	Nominal Operating Pressure	250 psig
.2	Design Pressure	300 psig
.3	Test Pressure	450 psig
.4	Design Temperature	450°F
.5	Corrosion Allowance	0.0625 in.
.6	Pipe	ASTM A106 Gr. B, seamless, schedule 80, black.
.7	Joints, 2" and smaller	screwed
.8	Screwed Fittings	300 Lb., ASTM A-47 malleable iron
.9	Unions	Class 300, ASTM A-47 malleable iron, ASTM A-153 galvanized, ANSI B2.1 threads.
.10	Dielectric Unions	Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.
.11	Joints, 2-1/2" and larger	welded, with flanges at connections to equipment
.12	Butt weld fittings	ASTM A234 Gr. WFB
.13	Flanges	ASTM A105, Class 300, raised face, weld neck or slip on
.14	Bolts	ASTM A193 Gr. B7 studs, ASTM A194 Gr. 2H nuts.
.15	Gaskets	1/16" (1.6 mm) thick preformed non-asbestos graphite fibre.
.16	Valves, 2" and smaller	ASTM A105N
	Gate Valves (Isolating)	Class 800, ASME B16.34 forged steel body, conventional port, outside screw & yoke, bolted bonnet, 1/2 Stellite trim (#8), graphite packing, threaded ends. Bonney Forge HL-11-T.
	Globe Valves (Throttling)	Class 800, ASME B16.34 forged steel body, outside screw & yoke, bolted bonnet, 1/2 Stellite trim (#8), graphite packing, threaded ends. Bonney Forge HL-31-T.
	Check Valves (Backflow)	Class 800, ASME B16.34 forged steel body, bolted bonnet, 1/2 Stellite trim (#8), graphite gasket, swing check, threaded ends. Bonney Forge HL-61-T.
.17	Valves, 2-1/2" and larger	ASTM A216 WCB
	Gate Valves (Isolating)	600 psi non-shock WOG, cast carbon steel body, solid wedge disc (2-1/2" to 4") or flexible wedge disc (6" and over), OS&Y rising stem, non-asbestos packing, flanged ends, Kitz #300 SCLS.
	Globe Valves (Throttling)	600 psi non-shock WOG, ASTM A126 Class B cast carbon steel body, bolted bonnet, swivel disc, OS&Y rising stem, non-asbestos packing, flanged ends, Kitz #300 SCJS.
	Check (Backflow)	600 psi non-shock WOG, cast carbon steel body, bolted cover, swing .type disc, flanged ends, Kitz #300SCOS.
.18	Provide stem extensions for insulated piping.	
.19	Provide gear operator and chain on valves installed above 10-ft AFF.	
.20	Strainers, 1/2" to 24"	Class 300 WSP @ 838°F, cast steel body, Y-pattern, flanged ends, bolted flange cover, A167 304 stainless steel screen with

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1/32" perforations. Mueller Steam 782.

2.4 GROOVED PIPING SYSTEMS TO 150 PSIG, ABOVE GROUND

- .1 Acceptable Manufacturers: Victaulic Company, Anvil International, Gruvlok
- .2 Permitted Applications: grooved joints are permitted in HVAC piping systems where operating temperatures do not exceed 140°F, including;
 - .1 chilled water
 - .2 condenser water, open
 - .3 condenser water, closed
- .3 Nominal Operating Pressure 125 psig
- .4 Design Pressure 150 psig
- .5 Test Pressure 225 psig
- .6 Design Temperature 350°F
- .7 Corrosion Allowance 0.0625 in.
- .8 Pipe ASTM A53 Gr. B or ASTM A106 Gr. B, schedule 40, black
- .9 Fittings: Roll Grooved, malleable iron to ASTM A 47/A47M
- .10 Joints, 2-1/2" and larger roll grooved to CSA B242, in accordance with manufacturers instructions and recommendations, with flanges at connections to equipment
- .11 Gaskets EPDM

2.5 EQUIPMENT DRAINS AND OVERFLOWS

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

2.6 CIRCUIT BALANCING VALVES

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

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- .1 Precise flow measurement.
- .2 Precision flow balancing.
- .3 Positive shut off with no drip seat and teflon disc.
- .3 Valves shall have twelve 360° adjustment turns of handwheel for maximum vernier-type setting with "Hidden Memory" feature to program the valve with precision tamper-proof balancing setting.
- .4 Valves shall be suitable for maximum working pressure of 250 psi (1720 kPa) and maximum operating temperature of 250°F (120°C).
- .5 Acceptable Products: S.A. Armstrong CBV II indicated or Tour & Anderson STA-F or Newman Hattersley.

3 EXECUTION

3.1 PREPARATION

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

3.2 APPLICATIONS

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

3.3 INSTALLATION

- .1 Install to manufacturer's instructions.
- .2 Install heating water piping to CSA B51.
- .3 Route piping in orderly manner, parallel to building structure, and maintain gradient.
- .4 Install piping to conserve building space, and not interfere with use of space.
- .5 Group piping whenever practical at common elevations.
- .6 Sleeve pipe passing through partitions, walls and floors.
- .7 Slope piping and arrange to drain at low points.
- .8 Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

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- .9 Inserts:
 - .1 Provide inserts for placement in concrete formwork.
 - .2 Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - .3 Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4" (100 mm).
 - .4 Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
 - .5 Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- .10 Pipe Hangers and Supports:
 - .1 Install to CSA B51.
 - .2 Support horizontal piping as scheduled.
 - .3 Install hangers to provide minimum 1/2" (13 mm) space between finished covering and adjacent work.
 - .4 Place hangers within 12" (300 mm) of each horizontal elbow.
 - .5 Use hangers with 1-1/2" (38 mm) minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
 - .6 Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
 - .7 Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
 - .8 Provide copper plated hangers and supports for copper piping.
 - .9 Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
- .11 Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
- .12 Provide access where valves and fittings are not exposed.
- .13 Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.
- .14 Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer (VOC content not to exceed 250 g/L) to welds.
- .15 Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting.
- .16 Install valves with stems upright or horizontal, not inverted.
- .17 Air vents shall be selected to suit the system operating pressures and shall be automatic and complete with isolating valves.
- .18 All strainers 1-1/2" (38mm) & larger shall be fitted with chain valves.
- .19 Unless specified otherwise, drain piping shall be sloped down in the direction of flow not less than 1" in 40 feet.
- .20 Eccentric reducers shall be provided to keep the bottom of sloped piping aligned in order to minimize risk of water hammer and to facilitate drainage.
- .21 Valves shall be installed with stems upright or angled 45 deg. above horizontal unless instructed otherwise.
- .22 Pipe all discharge from temperature & pressure safety relief valves to a point of safe discharge directly into a floor drain, hub drain or safe outdoor location.

3.4 EQUIPMENT CONNECTIONS

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

3.5 VALVES, COCKS AND FAUCETS

Hydronic Piping

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

3.6 HYDRONIC SPECIALTIES

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

3.7 CONTROLS DEVICES

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

3.8 TESTING AND INSPECTION

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

3.9 ADJUSTING AND BALANCING

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

Hydronic Piping

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

END OF SECTION

Hydronic Specialties

PART 1 - GENERAL

1.1 General Requirements

- .1 Comply with General Requirements of Section 20 05 05 & 23 01 01.

1.2 Section Includes

- .1 Air vents.
- .2 Strainers.
- .3 Relief Valves.

1.3 References

- .1 ASME - SEC 8D - Boilers and Pressure Vessels Code - Rules for Construction of Pressure Vessels.

1.4 Submittals

- .1 Section 23 01 01: Procedures for submittals.
- .2 Product Data: Provide product data for manufactured products and assemblies required for this project. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description, model and dimensions.
- .3 Submit inspection certificates for pressure vessels from TSSA.
- .4 Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
- .5 Record actual locations of flow controls.
- .6 Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.5 Qualifications

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

1.6 Delivery, Storage, and Handling

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

PART 2 - PRODUCTS

2.1 Air Vents

- .1 Manual Type: Short vertical sections of 2" (50 mm) diameter pipe to form air chamber, with 3 mm brass needle valve at top of chamber.
- .2 Float Type:

Hydronic Specialties

- .1 Manufacturers:
 - .1 Armstrong.
 - .2 Amtrol.
 - .3 Taco.
- .2 Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.

2.2 Strainers

- .1 Size 2" (50 mm) and Under:
 - .1 Manufacturers:
 - .1 Sarco SB
 - .2 Crane
 - .3 Armstrong
 - .4 Colton
 - .2 Screwed brass or iron body for 175 psi (1200 kPa) working pressure, Y pattern with 0.8 mm stainless steel perforated screen.
- .3 Size 2-1/2" to 4" (65 mm to 100 mm):
 - .1 Flanged iron body for 175 psi (1200 kPa) working pressure, Y pattern with 1.2 mm stainless steel perforated screen.
- .4 Size 5" (125 mm) and Larger:
 - .1 Flanged iron body for 175 psi (1200 kPa) working pressure, basket pattern with 3.2 mm stainless steel perforated screen.

2.3 Relief Valves

- .1 Manufacturers:
 - .1 Sarco.
 - .2 Other acceptable manufacturers offering equivalent products.
 - .1 Watts
 - .2 Bell & Gossett
 - .3 Conbraco
- .2 Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labelled

PART 3 - EXECUTION

3.1 Installation

Hydronic Specialties

- .1 Install specialties to manufacturer's instructions.
- .2 Where large air quantities can accumulate, provide enlarged air collection standpipes.
- .3 Provide manual air vents at system high points and as indicated.
- .4 For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain for water systems and to holding tank for glycol/water systems.
- .5 Provide valved drain and hose connection on strainer blowdown connection.
- .6 Provide relief valves on pressure tanks, low pressure side of reducing valves, heat exchangers, and expansion tanks.
- .7 Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.
- .8 Pipe relief valve outlet to nearest floor drain for water systems.
- .9 Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

END OF SECTION

HVAC WATER TREATMENT

1 GENERAL

1.01 SUBMITTALS

- .1 **Product Data:** Submit product data sheets for all new water treatment chemical feed equipment and associated hardware. Product data must confirm that feed equipment meets all requirements of the Contract Documents.
- .2 **Start-Up and Certification Letters:** Submit water treatment manufacturer/supplier certification letters as specified in Part 3 of this Section.

2 PRODUCTS

2.01 EXISTING TREATMENT SYSTEMS

- .1 The Owner has a contract with a treatment chemical supplier to maintain proper levels of chemical in the building systems. New chemicals and/or treatment delivery hardware are to be supplied by this supplier. **Obtain the supplier's name during the bidding process and obtain the required pricing information.**

2.02 PIPING SYSTEM FLUSHING AND CLEANING CHEMICAL

- .1 Liquid form alkaline type cleaner consisting of a concentrated blend of highly active penetrating agents and detergents with a 12.5 pH and specifically formulated to remove oil, mill scale and oxides from piping and equipment.

2.03 BOILER BOIL-OUT CHEMICALS

- .1 Boiler boil-out chemicals are to be selected by the chemical treatment manufacturer/supplier in consultation with the Consultant and the boiler manufacturer, and the chemicals selected must be approved by the boiler manufacturer.

3 EXECUTION

3.01 PIPING SYSTEM FLUSHING AND CLEANING

- .1 After **new** heat transfer system piping has been installed and leakage testing has been satisfactorily completed, but before connection to existing piping and mechanical equipment start-up and performance tests, flush and chemically clean the piping systems.
- .2 Provide all required temporary piping connections, including bypass piping to isolate dirt sensitive mechanical plant equipment. Remove instrumentation such as flow meters and switches, orifice plates, meter valves and similar devices and plug pipe openings. Reinstall when flushing and cleaning work has been certified complete by the chemical manufacturer/installer. Ensure that control valves are operational and fully open during flushing and cleaning.
- .3 **Flushing Prior to Chemical Cleaning:** Flush the piping, including dead ends, with water to remove loose solids. Clean all strainers. Replace chemical feeder line filters as required. Flush and drain until the water runs clear.

HVAC WATER TREATMENT

- .4 **Chemical Cleaning:** When flushing with water is complete, fill the systems with fresh clean water. Meter the amount of water required to fill each system or otherwise calculate system capacity. Ensure that all air is vented from the systems. Add cleaning chemical as instructed by the chemical manufacturer and circulate the solution for a period of time and at a temperature as required to produce a clean piping system. Conduct daily pH, conductivity, and total iron tests in accordance with the chemical supplier's instructions.
- .5 **Flushing After Chemical Cleaning:** When test results indicate a clean system, drain the solution from the piping, refill with clean water and circulate the water for a minimum of twenty-four hours to flush out remaining chemical solution, then drain the water from the piping using all drain points and again clean all system strainers and replace filters. Arrange for the chemical supplier to check each system after flushing and cleaning is complete and to certify in writing that flushing and cleaning procedures have been properly performed. Submit a copy of the certification letter. Fill the systems.

END OF SECTION

Ductwork

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 05 05 & 23 01 01.

1.2 REFERENCES

- .1 ASHRAE HANDBOOK, HVAC SYSTEMS & EQUIPMENT, Duct Construction Recommendations
- .2 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
- .1 HVAC Duct Construction Standards - Metal and Flexible
- .2 HVAC Duct Systems Design
- .3 Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems
- .4 Accepted Industry Practice for Industrial Duct Design
- .5 HVAC Systems - Testing, Adjusting and Balancing
- .6 Round Industrial Duct Construction Standards
- .7 Rectangular Industrial Duct Construction Standards
- .8 HVAC Air Duct Leakage Test Manual.
- .9 Guide for Steel Stack Construction
- .3 National Fire Protection Association (NFPA)
- .1 80 Standard for Fire Doors and Windows
- .2 90A Standard for Installation of AC and Ventilation Systems
- .3 90B Standard for Installation of Warm Air Heating and AC Systems
- .4 96 Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
- .5 255 Building Materials, Test of Burning Characteristics (same as ASTM E84)
- .4 American Society for Testing and Materials (ASTM)
- .1 A90/A90M - Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
- .2 A167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
- .3 A480/A480M - General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
- .4 A653/A653M - Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- .5 A1011/A1011M - Standard Specification for Steel, Sheet, and Strip Hot-Rolled, Carbon, Structural, High-Strength, Low-Alloy with Improved Formability.
- .6 B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
- .7 A240 - Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels
- .8 A480 - Standard Specification for General Requirements for Flat Rolled Stainless Heat-Resisting Steel Plate, Sheet and Strip
- .9 A653 - Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated by the Hot Dip Process
- .10 E84 - Standard Test Method for Surface Burning Characteristics of Building Materials
- .11 E477 - Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Material and Prefabricated Silencers
- .12 E814 - Standard Test Method for Fire Tests of Through Penetration Fire Stops
- .5 American Welding Society (AWS)
- .1 B2.2 Brazing Procedures and Performance Qualifications
- .2 D9.1 Sheet Metal Welding Code
- .6 Underwriter's Laboratories (UL)
- .1 181 Factory Made Air Ducts and Air Connectors
- .2 555 Standard for Safety Fire Dampers

Ductwork

.3	555S	Leakage Rated Dampers for Use in Smoke Control Systems
.4	723	Test for Surface Burning Characteristics of Burning Materials (ASTM E84)

1.3 PERFORMANCE REQUIREMENTS

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

1.4 SUBMITTALS

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

1.5 PROJECT RECORD DOCUMENTS

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

1.6 QUALITY ASSURANCE

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

1.7 REGULATORY REQUIREMENTS

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

1.8 ENVIRONMENTAL REQUIREMENTS

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

Ductwork

2 PRODUCTS

2.1 MATERIALS

.1 Table of Materials

APPLICATIONS	MATERIALS
Rigid HVAC ducts, casings and fittings	ASTM A653 galvanized steel sheet, lock form quality, G90 zinc coating (0.90 oz/ft ²) to ASTM A90. Sheets free of pits, blisters, slivers, and ungalvanized spots.
Fume exhaust hoods, canopies and ductwork.	Type 316L steel sheet per ASTM A480 and ASTM A240 with a finished surfaced No. 4 for exposed locations, and No. 2B for concealed locations. Longitudinal seams welded, transverse joints and connections to equipment or accessories welded or flanged. Welds on exposed ducts shall be ground smooth and polished to a bright finish.
Perchloric Acid exhaust	Type 316L steel sheet per ASTM A480 and ASTM A240 with a 2B finish. All seams and joints continuously welded. Connections to equipment or accessories flanged with appropriate gasket.

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

2.2 DUCT CONSTRUCTION

.1 Duct Construction Schedule

Duct Application	Duct Pressure	Pressure Class (in.wg.)	Seal Class	Leakage Class
Rectangular HVAC Supply from AHU to terminal unit or reheat coil	Positive	4	A	6
Round HVAC Supply from AHU to terminal unit or reheat coil	Positive	4	A	3
Rectangular HVAC Supply from terminal unit or reheat coil to air outlet	Positive	2	A	6

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Round HVAC Supply from terminal unit or reheat coil to air outlet	Positive	2	A	3
Rectangular General HVAC exhaust ductwork	Negative	2	A	6
Round General HVAC exhaust ductwork	Negative	2	A	3
Laboratory exhaust ductwork ¹ .	Negative	4	A	0

Notes:

1. Pressure class shall be the lower of exhaust fan shut-off pressure or value shown

2.3 DUCT SEALING

.1 Duct Sealing Requirements

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

2.4 DUCT LEAKAGE

- .1 Leakage Class is defined as
 $CL = F / (P)^{0.65}$
 where: CL = Leakage Class
 F = Leakage Factor (cfm/100-ft² of duct surface)
 P = Static pressure in the duct (in.wg.)
- .2 Table

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

2.5 DUCTWORK FABRICATION

- .1 All Ductwork shall be constructed to withstand 1-1/2 times fan pressure at shut-off and 2" (500 Pa) minimum.
- .2 Fabricate and support to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated in

Ductwork

- accordance with recommendations of ASHRAE and SMACNA.
- .3 Joints and reinforcements:
 - .1 to SMACNA and ASHRAE
 - .2 may be made with the Ductmate System or Nexus System. System components shall be made of standard catalogue manufacture as supplied by Ductmate Industries, Inc. or Nexus Inc.
 - .4 Construct Tees, bends, and elbows with radius of not less than 1-1/2 times width of duct on centreline. Where not possible and where rectangular elbows are used, provide air foil turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fibre insulation.
 - .5 Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
 - .6 Fabricate continuously welded round and oval duct fittings two gauges heavier than duct gauges indicated in SMACNA Standard. Joints: minimum 100 mm cemented slip joint, brazed or electric welded. Prime coat welded joints.
 - .7 Provide standard 45-degree lateral wye takeoffs. Alternative 90-degree conical tee connections may be used only where specifically indicated.
 - .8 Stainless steel ductwork for utility use, shall be fabricated from type 304 stainless steel, 2B finish, one gauge lighter than if the duct were to be fabricated from galvanized steel.
 - .9 High Transmission Loss (HTL) Ductwork: galvanized ductwork of same gauge as outer casing of adjacent duct silencer, minimum 16 gauge.
 - .10 Zero (0) leakage ductwork shall have all seams and joints continuously welded to SMACNA standards and recommendations.

2.6 ROUND SPIRAL LOCK SEAM DUCTWORK

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

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

ROUND SPIRAL LOCK SEAM DUCTWORK - SI			
Diameter		Minimum Steel Gauge	
From	To	Spiral Lock	Fittings
75	356	0.56	0.70
380	660	0.71	0.86

Ductwork

686	914	0.86	1.01
939	1270	1.01	1.32
1321	1524	1.32	1.62

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

2.7 FLEXIBLE DUCTWORK

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

FLEXIBLE DUCTWORK - IP		
Pressure rating	Low & Medium Pressure	High Pressure
Maximum positive pressure	6" wg	12" wg
Maximum negative pressure	4"wg	5" wg
Maximum velocity	4000 fpm	5500 fpm
Permeance	0.1 perm	0.1 perm
Operating temperature	-20°F to 250°F	-20°F to 250°F
Maximum thermal conductance	0.23 BTU/Hr-F°	0.23 BTU/Hr-F°
Listed & Labelled	Class 0, Class 1	Class 0, Class 1
Flexmaster type	5	3

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

- .2 Accessories: conical spin-in collars with butterfly volume dampers for connections to ductwork, round rigid galvanized steel fittings fabricated to SMACNA Standards and ASHRAE recommendations, bridge and gear clamps.
- .3 Acceptable Manufacturers:
- .1 Flexmaster

2.8 FIRE-RATED DUCT WRAP

Ductwork

- .1 Manufacturers:
 - .1 Thermal Ceramics FireMaster FastWrap XL
 - .2 3M Canada Company Fire Barrier Duct Wrap 615.
 - .3 CL4 Fire Protection Thermal Insulation Quickwrap
- .2 Ductwork required to be fire-rated shall be greater than or equal to the minimum gauge listed for the design no., G-90 galvanized steel, wrapped with 3M Fire Master Duct Wrap 615 consisting of a 1-1/2" (38 mm) thick non-combustible, flexible fireproof blanket, fully encapsulated in a foil scrim and supplied in roll form. The wrap material shall be applied directly onto the installed ductwork strictly in accordance with the manufacturers instructions and the ULC Listing and Design No., Guide No. 40 U21, 'Fire Resistant Ducts', as tested to ISO Standard 6944.

3 EXECUTION

3.1 INSTALLATION

- .1 Install and seal ducts to SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- .2 Install ductwork parallel to building lines.
- .3 Support all ductwork from structural members. Where structural bearings do not exist, suspend strapping or hangers from steel channels or angles. Provide supplementary structural members. Do not suspend from metal deck.
- .4 Do not break continuity of insulation vapour barrier by hangers or rods.
- .5 Hangers shall be steel angles with supporting rods, locking nuts and washers to following table; [Except for Fire Rated Ventilation Ductwork or Fire Rated Kitchen Exhaust Grease Duct which shall comply with ULC Listing and manufacturers instructions]

DUCT HANGERS - IP			
Duct Sizes (Largest side)	Angle Size	Rod Size	Spacing
Up to 30"	1" x 1" x 1/8"	1/4" diameter	10 ft
31" to 42"	1-1/2" x 1-1/2" x 1/8"	1/4" diameter	10 ft
43" to 60"	1-1/2" x 1-1/2" x 1/8"	3/8" diameter	10 ft
61" to 84"	2" x 2" 1/8"	3/8" diameter	8 ft

DUCT HANGERS - SI			
Duct Sizes (Largest side)	Angle Size	Rod Size	Spacing
Up to 30"	25 x 25 x 3 mm	6mm diameter	3 m
31" to 42"	40 x 40 x 3 mm	6mm diameter	3 m
43" to 60"	40 x 40 x 3 mm	10mm diameter	3 m
61" to 84"	50 x 50 x 3 mm	10mm diameter	2.5 m

- .6 Anchor all risers at bottom and support from building structure at each floor level.
- .7 Vertical ducts passing through floors shall be supported on angles secured to duct bearing on the floor.
- .8 Where ducts pass through walls, floors, openings required to have a fire resistance rating the opening in the construction around the duct shall be filled with an approved fire stop material as per NFPA 90A and fire damper shall also be installed with access doors as per the code.
- .9 Duct Sizes are inside clear dimensions. For lined ducts, maintain sizes inside lining.
- .10 Provide openings in duct work where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork,

Ductwork

- .11 install insulation material inside a metal ring.
- .12 Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- .12 Use crimp joints with or without bead for joining round duct sizes 8" (200 mm) and smaller with crimp in direction of air flow.
- .13 Use double nuts and lock washers on threaded rod supports.
- .14 Connect terminal units to supply ducts directly or with 12" (300 mm) maximum length of flexible duct. Do not use flexible duct to change direction.
- .15 Connect diffusers to low pressure ducts directly or with 60" (1.5 m) maximum length of flexible duct held in place with strap or clamp.
- .16 Connect flexible ducts to metal ducts with adhesive and metal or nylon straps.
- .17 Ground across flexible connector with No. 2/0 braided copper strap.
- .18 During construction provide temporary closures of metal or taped polyethylene on open duct work to prevent construction dust from entering duct work system.
- .19 Balancing dampers shall be installed on branches as per locations shown on the drawings and as per the requirements of NEBB and AABC listing/measuring standards.
- .20 Perform duct leakage testing for all ductwork installed under this contract.
- .21 Paint all visible internal portions of duct outlets to grilles dull black. Internal painting of ductwork behind grilles shall be by Sheet Metal Contractor.
- .22 Seams and penetrations in ductwork and plena shall be sealed in accordance with seal classifications as described in SMACNA and ASHRAE.
- .23 Do not begin air balance until system has been completed and is in full working order. Put all heating, ventilating, and air conditioning system and equipment into full operation and continue the operation of same during each working day of balancing procedures. Provide assistance to the Testing and balancing Agency as required.

3.2 WATERTIGHT DUCTWORK

- .1 Spiral ducts and elbows shall not be used for watertight exhaust systems.
- .2 Provide watertight ductwork for:
 - .1 Fume hood exhaust
- .3 Form bottom of duct without longitudinal seams.
- .4 All seams and joints welded. Connections to equipment and accessories flanged and gasketed.
- .5 Slope horizontal branch ductwork down toward hood or equipment served.
- .6 Slope header ducts down toward risers.
- .7 Fit base of risers with 6" (150 mm) deep drain and 1-1/4" (32 mm) drain connection, with deep seal trap and valved drain line to open funnel drain.

3.3 CORRIDOR PENETRATION DUCTWORK

- .1 Site measurement shall be taken before fabrication in the factory shall begin.
- .2 The ductwork, joints, hangers, access doors and all other accessories shall be manufactured and installed as per manufacturer's instructions and in accordance with the ULC listing, meeting the requirements of NFPA 96.
- .3 The final installation shall be inspected and approved by the duct manufacturer. Contractor to submit letters from manufacturer to authority having jurisdiction verifying undertaking to inspect and final approval.

3.4 FIRE-RATED DUCT WRAP

- .1 Ductwork required to be fire-rated shall be minimum 24 USGa., G-90 galvanized steel, wrapped with 3M Fire Master Duct Wrap 615 consisting of a 1-1/2" (38 mm) thick non-combustible, flexible fireproof blanket, fully encapsulated in a foil scrim and supplied in roll form. The wrap material shall be applied directly onto the installed ductwork strictly in accordance with the manufacturer's instructions and the ULC Listing and Design No., Guide No. 40 U21, 'Fire Resistant Ducts', as tested to ISO Standard 6944.

Ductwork

- .2 Duct construction shall be as per ASHRAE and SMACNA using water tight construction (See 3.1 Watertight Ductwork in Specification). Hangers shall be threaded steel rod and angle iron cradles.
- .3 One layer of wrap shall be applied to ductwork requiring a 1 hour fire resistance rating and two layers shall be applied to ductwork requiring a 2 hour fire resistance rating. Seams and joints to be lapped minimum 3" (75mm), taped and secured with steel banding. Tape and banding to comply with ULC listing and manufacturer's instructions.
- .4 All hangers, support rods, concrete anchors and firestopping of duct penetrations through fire separations shall be in accordance with the ULC Listing and the manufacturer's instructions.

3.5 FLEXIBLE DUCTWORK

- .1 Flexible ductwork may be installed for final connections to air outlets provided that not more than 5 ft. (1.5 m) in length is used for each connection, and where specifically indicated on drawings.
- .2 All fittings used with flexible ductwork shall be rigid round duct.
- .3 Use pre-insulated flexible ductwork where application is to be insulated.

3.6 DUCT CLEANLINESS

- .1 All ductwork shall be handled and installed in accordance with the advanced level described in SMACNA Duct Cleanliness for New Construction Guidelines.
- .2 Ductwork leaving the premises of the manufacturer may include some or all of the following:
 - .1 self-adhesive labels or marking for part(s) identification shall be applied to external surfaces only;
 - .2 exposed mastic sealant;
 - .3 light zinc oxide coating on the metal surface;
 - .4 a light coating of oil on machine formed ductwork;
 - .5 minor protrusions into the airway of rivets, screws, bolts and other jointing devices;
 - .6 internal insulation and associated fasteners;
 - .7 discoloration marks from plasma cutting process.
 - .8 to maintain cleanliness during transportation, all ductwork shall be sealed either by blanking or capping duct ends, bagging small fittings, surface wrapping or shrink wrapping. Care must be taken to prevent damage during transportation and off loading.
- .3 A clean and dry environment where the ductwork is protected from dust must be provided for the storage of ductwork prior to installation. All sealed ends shall be visually examined and if damaged resealed with an appropriate material.
- .4 During installation, the working area shall be clean, dry and the ductwork protected from dust.
- .5 The internal surfaces of the uninsulated ductwork shall be wiped to remove excess dust immediately prior to installation.
- .6 Open ends on completed ductwork and overnight work-in-progress shall be sealed.
- .7 Access covers shall be firmly fitted in position on completion of each section of the work.
- .8 Protective coverings shall only be removed immediately before installation and inspected to determine if additional wipe down is necessary.

3.7 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 MSDS documentation and safety certifications for products employed in the cleaning operations at the site at all times. Submit a copy of all MSDS sheets to Owner.
- .3 Standards: Conform to NADCA Standard ACR 2006, Assessment, Cleaning and Restoration of HVAC Systems and NADCA Guidelines.
- .4 Scope of HVAC System Cleaning Work;
 - .1 clean each HVAC System and component as follows;

Ductwork

-
- .1 interior surfaces of all new ductwork and accessories installed as part of this project
 - .2 interior surfaces of all existing ductwork and accessories that are to remain in service on completion of this project,
 - .3 interior surfaces of all new and existing HVAC System components that are to remain in service on completion of this project, including; air handling units, fans, fan housings, air coils, drain pans, humidifiers, filters, filter frames, intake and exhaust and mixing plenums, air blenders, air outlets and inlets, air terminal units, power ventilators, sound attenuators, reheat coils, turning vanes, dampers, and sensors
 - .2 Verify the cleanliness of each HVAC System and component through visual inspection, video recording and testing indicated hereinafter.
 - .5 Cleaning & Disinfection Requirements;
 - .1 conduct visual/video inspections of HVAC Systems and components without disruption of settled dust or debris and without microbial amplification. Record and submit video inspections before and after cleaning as follows;
 - .1 ducts serving Class 1 areas (critical care): 100%
 - .2 ducts serving Class 2 areas (patient care): 25%
 - .3 ducts serving Class 3 areas (admin, office): 10%

Area classifications per CSA Standard Z-317.1.
 - .2 mark and record position of any and all adjustable devices and ensure that they are re-set to their original position on completion of cleaning and verification work,
 - .3 document and report any and all damage to HVAC Systems and components discovered during inspections to Consultant and to Owner,
 - .4 Cleaning: remove all visible surface contaminants and deposits from each HVAC System and component
 - .5 Disinfection: disinfect all internal surfaces of ductwork, equipment and accessories that serve one or more Class 1 areas.
 - .6 Containment: ensure that dust and debris collected during the cleaning process is contained within the HVAC System and not otherwise dispersed outside of the system.
 - .7 Particulate Collection: high power vacuums with HEPA filtration to 99.97% efficiency on particles greater than 0.3-micron size
 - .8 Odours and Mist control: ensure that odours and mist vapours arising from cleaning operations are contained within the HVAC System and are prevented from escaping to and dispersing outside of the system.
 - .9 Provide adequate access into ductwork for cleaning purposes. Provide access doors conforming to project specifications.
 - .10 Flexible ducts shall be disconnected to provide access for cleaning.
 - .11 Protect components which may be harmed by excessive dirt with filters, 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

Ductwork

- cm2 concentration levels. Maximum 1 cfu per cm2.
- .2 Bacterial Samples: tryptic soy agar contact plates, incubated for 3 days at 37°C with number of micro-organisms counted and reported in both per plate and per cm2 concentration levels. Maximum 1 cfu per cm2.
- .4 Particle Profiling Procedures: In the event of a dispute between Contractor and Owner regarding cleanliness, Contractor shall perform NADCA PP procedures in accordance with Chapter 2 of NADCA Guideline to ACR 2006; Particle Measurement, Air Sampling and Surface Sampling for each supply air system at representative locations selected by Owner and in the discharge plenum of each air handling unit.
- .7 Report:
 - .1 submit three (3) copies of cleaning report
 - .2 report shall include;
 - .1 certificate of cleanliness from third party inspection service with following minimum qualifications;
 - .1 Environmental Engineer licensed in the province of Ontario or
 - .2 Certified Industrial Hygienist, and
 - .3 minimum 3 years experience in duct cleaning
 - .2 photographic/video record of cleaned surfaces and components
 - .3 comparative record of damage discovered on initial inspection and of remedial measures implemented by others

3.8 DUCT LEAKAGE TESTING

- .1 Ductwork shall be leak tested in accordance with the SMACNA "HVAC Air Duct Leakage Test Manual". The maximum permitted duct leakage shall be determined by multiplying the leakage factor from paragraph 2.4 above by the surface area of the ductwork in the test zone.
- .2 Ductwork that exceeds the maximum permitted leakage shall be re-sealed and re-tested.
- .3 Duct leakage test shall be witnessed and certified by the Systems Verification Agency of section 23 01 05.
- .4 Record and submit three (3) copies of test results to the Consultant for review prior to application of duct insulation or concealment of ductwork.

3.9 CONTROLS DEVICES

- .1 Install remote sensors such as temperature, pressure and airflow sensors. Supply of sensors and controls wiring will be under [Section 25](#).
- .2 Install remote mounted control dampers for airflow control. Supply of dampers, damper actuators and controls wiring will be under [Section 25](#).
- .3 Install duct type smoke detectors in accordance with manufacturer's instructions. Supply of detectors and fire alarm wiring will be under [Division 26](#).

END OF SECTION

Air Duct Accessories

PART 1 - GENERAL

1.1 General Requirements

- .1 Comply with General Requirements of Section 20 05 05 & 23 01 01.

1.2 Section Includes

- .1 Volume Control dampers
- .2 Duct access doors.
- .3 Duct test holes.
- .4 Flexible Duct Connections
- .5 Hangers and Supports
- .6 Duct Lining
- .7 Duct Sealants
- .8 Heat Shrink Duct Bands

1.3 References

- .1 NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
- .2 NFPA 92A - Smoke-Control Systems.
- .3 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- .4 UL 33 - Heat Responsive Links for Fire-Protection Service.

1.4 Submittals

- .1 Section 23 01 01: Submittals.
- .2 Shop Drawings for shop fabricated assemblies including balancing dampers, volume control dampers, duct access doors and duct test holes.
- .3 Product Data for shop fabricated assemblies including volume control dampers, duct access doors, duct test holes and hardware used. Include electrical characteristics and connection requirements.
- .4 Manufacturer's Installation Instructions for fire dampers and combination fire and smoke dampers.

1.5 Project Record Documents

- .1 Section 23 01 01: Submittals for project closeout.
- .2 Record actual locations of access doors.

1.6 Regulatory Requirements

- .1 Products Requiring Electrical Connection: CSA Listed as suitable for the purpose specified and indicated.

1.7 Delivery, Storage, And Handling

Air Duct Accessories

- .1 Transport, handle, store, and protect products.
- .2 Protect dampers from damage to operating linkages and blades.

1.8 Extra Materials

- .1 Section 23 01 01: Submittals for project closeout.
- .2 Provide two of each size and type of fusible link.

PART 2 PRODUCTS

2.1 Volume Control Dampers

- .1 Fabricate to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.
- .2 Splitter Dampers:
 - .1 Material: Same gauge as duct to 24" (600 mm) size in either direction, and two gauges heavier for sizes over 24" (600 mm).
 - .2 Blade: Fabricate of single thickness sheet metal to streamline shape, secured with continuous hinge or rod.
 - .3 Operator: Minimum 24" (600 mm) diameter rod in self aligning, universal joint action, flanged bushing with set screw.
- .3 Single Leaf Dampers: fabricated from minimum 20 gauge (1.0 mm) galvanized steel, suitably reinforced to prevent vibration and fitted with indicating regulator. Duro-Dyne, Lawson & Taylor, Dyn-Air.
- .4 Multi-Blade Opposed Action Dampers: fabricated from 16 gauge (1.6 mm) galvanized steel, mounted in separate channel frames, reinforced to prevent vibration, and fitted with opposed action linkage hardware. Duro-Dyne "Opax" blade kit, Lawson & Taylor, Dyn-Air
- .5 End Bearings: Except in round ductwork 12" (300 mm) and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon or sintered bronze bearings.
- .6 Quadrants:
 - .1 Provide locking, indicating quadrant regulators on single and multi-blade dampers.
 - .2 On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.
 - .3 Where rod lengths exceed 30" (750 mm) provide regulator at both ends.
- .7 Acceptable Manufacturers: Duro-Dyne, Dyn-Air, Price, Lawson & Taylor

2.2 Duct Access Doors

- .1 Fabricate to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.
- .2 Fabrication: Rigid and close-fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated duct work, install minimum 1" (25 mm) thick insulation with sheet

Air Duct Accessories

metal cover.

- .1 Less Than 12" (300 mm) Square: Secure with sash locks.
- .2 Up to 18" (450 mm) Square: Provide two hinges and two sash locks.
- .3 Up to 24" x 48" (600 x 1200 mm): Three hinges and two compression latches with outside and inside handles.
- .4 Larger Sizes: Provide an additional hinge.
- .3 Access doors with sheet metal screw fasteners are not acceptable.
- .4 Acceptable Manufacturer: Acudoor, Duro-Dyne, Dyn-Air, Nailor, Kreuger

2.3 Duct Test Holes

- .1 Provide test ports to suit intended application, (ie. insulated/uninsulated duct, round/rectangular duct).
- .2 Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.
- .3 Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.
- .4 Acceptable Manufacturers: Air Power Co. Dial 1000, Dial 2000 or Duro-Dyne IP-1, IP-2, IPG-3, IP-4, Dyn-Air.

2.4 Flexible Duct Connections

- .1 Fabricate to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.
- .2 Connector: Fabric crimped into metal edging strip.
 - .1 Fabric: UL listed fire-retardant neoprene coated woven glass fibre fabric to NFPA 90A, minimum density 1.0 kg/sq m.
 - .2 Net Fabric Width: Approximately 2" (50 mm) wide.
 - .3 Metal: 3" (75 mm) wide, 1/32" (0.6 mm) thick.
- .3 Acceptable Manufacturers" Durp-Dyna, Dyn-Air

2.5 Hangers And Supports

- .1 Fabricate strap hangers to same material as duct. Hanger configuration to SMACNA details. 20" (500 mm) is maximum duct size to be supported by strap hanger.
- .2 Rod and angle hangers: galvanized steel to SMACNA details.
- .3 Hanger attachments: manufactured concrete inserts, expansion shields and bolted steel clamps. Do not weld rods to steel decks or use powder actuated fasteners.

2.6 Duct Lining

Air Duct Accessories

- .1 Knauf fibre free duct lining: self-sealing engineered polymer foam (3/4") (19mm) thick, complies with;
 - .1 UL 181 for erosion, mould growth and humidity,
 - .2 CAN/ULC-102.2, UL 723 and ASTM E84 flame spread (25) and smoke developed (50),
 - .3 ASTM C665 fungi resistance
- .2 AP Armaflex SA Duct Lining (1") (25mm) thick, flexible, closed-cell elastomeric insulation in sheet form meeting following requirements;
 - .1 ASTM C1534 "Specification for Flexible Polymeric Foam Sheet Insulation Used as a Thermal and Sound Absorbing Liner for Duct Systems"
 - .2 CAN/ULC-102.2 and ASTM E84 flame spread index of 25 or less and smoke developed index of less than 50.
 - .3 Maximum thermal conductivity of 0.27 Btu-in./ft²-°F at a mean temperature of 75°F
 - .4 Maximum water absorption rate of 0.2% (by volume) to ASTM C209
 - .5 Maximum vapour transmission rate of 0.08 perm-inches to ASTM E96, Procedure A
 - .6 Approved for installation in air plenums
 - .7 NFPA 90A, NFPA 90B and UL 181 Class 1 specifications.
 - .8 ASTM C411, materials perform up to 250°F
 - .9 ASTM C1071 erosion resistance
 - .10 ASTM G21 and ASTM C1338 fungi resistance
 - .11 ASTM G22 bacterial resistance
 - .12 Dust free, fibre free, non-particulating

2.7 Duct Sealant

- .1 General: Low VOC, water based sealant, non-toxic, non-combustible, non-flammable, and tested in accordance with CAN4/ULC-S102. Flame spread shall not exceed 25 and smoke developed shall not exceed 50.
- .2 Acceptable Products: Multi-Purpose Duct Sealant as manufactured by Trans Continental Equipment, Duro Dyne SWB Duct Sealer, Iron Grip 601 as supplied by Alpha Sheet Metal Co., or Uni-Grip Duct Sealer from United McGill Corporation.

2.8 Heat Shrink Duct Bands

- .1 Thermofit Wrap around Duct Band duct-joint sealing tape (band).
- .2 Construction: two-layer system
 - .1 first layer: copolymer adhesive

Air Duct Accessories

- .2 second layer: thick-walled, radiation-cross-linked, high-density polyethylene.
- .3 Hot applied duct sealing tape composed of heat-shrinkable backing with heat resistant pressure sensitive, non-drip adhesive and closure patch.
- .4 Standard size: 4" wide x 100 LF rolls, with 30 closure strips
- .5 Available from RB, L.L.C., PO Box 23781, New Orleans, La 70183
phone: 504-841-0035, fax: 504-841-0036, e-mail: sales@rbllc.com through
Claremont Sales Corp. Durham, CT 06422, Contact: Dean Williams 800-222-4448.

PART 3 EXECUTION

3.1 Preparation

- .1 Verify that electric power is available and of the correct characteristics.

3.2 Installation

- .1 Install accessories to manufacturer's instructions, NFPA 90A, and follow SMACNA HVAC Duct Construction Standards - Metal and Flexible. Refer to Section 23 31 00 for duct construction and pressure class.
- .2 Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- .3 Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, and elsewhere as indicated. Provide minimum 8" x 8" (200 x 200mm) size for hand access, 18" x 18" (450 x 450 mm) size for shoulder access, and as indicated. Provide 4" x 4" (100 x 100 mm) for balancing dampers only. Review locations prior to fabrication.
- .4 Provide duct test holes where indicated and required for testing and balancing purposes.
- .5 Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment, and supported by vibration isolators. For fans developing static pressures of 1250 Pa and over, cover connections with loaded vinyl sheet, held in place with metal straps.
- .6 Use splitter dampers only where indicated.
- .7 Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.
- .8 Install control dampers as indicated.
- .9 Install duct type smoke detectors in accordance with manufacturer's instructions.
- .10 Provide test ports as required by Balancing Agency to completely test and balance the system. No temporary holes will be permitted in ductwork or flexible connections.

3.3 Duct Access Doors

- .1 Provide duct access doors of suitable size in ductwork in the following locations:
 - .1 Suction inlet of all fans
 - .2 At not more than 12m intervals

Air Duct Accessories

- .3 At not more than 6m intervals on the ductwork installed after a high efficiency filter
 - .4 At the base of all main risers
 - .5 In front of and behind all turning vanes and coils
 - .6 At all fire, smoke, and motorized dampers
 - .7 At all locations having an internally mounted piece of equipment or device. Provide a section of transparent plexiglass to permit viewing without opening the access doors.
 - .8 Where required for duct cleaning.
- .2 Wherever possible, doors shall be mounted to close in direction of air flow.

3.4 Duct Lining

- .1 Line internal surfaces of all ductwork shown cross hatched on drawings with 1" (25 mm) thick duct lining.
- .2 No allowance has been made in duct sizes indicated for internal lining. Increase duct size 1" (25 mm) all around where lining is to be internally applied.
- .3 Adhere directly to clean, oil-free surfaces with full coverage of flame resistant adhesive.
- .4 Ambient temperature must be between 40°F and 100°F.
- .5 Armaflex:
 - .1 Smooth side shall be exposed to airstream.
 - .2 Butt edges tightly with a compression fit. Overlap the insulation 1/4" at the butt-edges and compress edges into place. Leave a 1/2" wide release liner border at the butt edge.
 - .3 Apply metal nosing to every leading edge for air velocities over 4000-fpm (20.3m/sec.)

3.5 Heat Shrink Duct Bands

- .1 Install in accordance with manufacturer's installation instructions.
- .2 Join duct sections using internal sleeves. Two screws 180° apart are usually sufficient for initial securement.
- .3 Wipe joint area to remove foreign materials, and pre-heat to remove moisture and surface oil that may be present.
- .4 Cut TDAB III duct band to allow a loose fit plus approx. 2" overlap.
- .5 Using supplied high temperature tape, secure the loose TDAB III end by taping in place.
- .6 Using a standard propane torch, heat TDAB III on all sides until it has shrunk uniformly and adhesive is showing at each side.
- .7 Smooth down overlap with gloved hand to ensure proper contact with duct.

END OF SECTION

Air Terminal Units

1 GENERAL

1.1 GENERAL REQUIREMENTS

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

1.2 SECTION INCLUDES

- .1 Single duct variable volume units.
- .2 Integral sound attenuator.
- .3 Integral heating coils.
- .4 Integral damper motor operators.
- .5 Integral controls.

1.3 REFERENCES

- .1 ADC 1062 - Air Distribution and Control Device Test Code.
- .2 NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
- .3 UL 181 - Factory-Made Air Ducts and Connectors.

1.4 PERFORMANCE TOLERANCES

- .1 Base performance on tests conducted to ADC 1062.

1.5 SUBMITTALS

- .1 Section 23 01 01: Procedures for submittals.
- .2 Shop Drawings: Indicate configuration, general assembly, and materials used in fabrication, and electrical characteristics and connection requirements.
- .3 Product Data: Provide data indicating configuration, general assembly, and materials used in fabrication. Include catalogue performance ratings which indicate air flow, static pressure, and NC designation. Include electrical characteristics and connection requirements.
- .4 Include schedules listing discharge and radiated sound power level for each of second through sixth octave bands at inlet static pressures of 250 to 1000 Pa.
- .5 Manufacturer's Installation Instructions: Indicate support and hanging details, and service clearances required.

1.6 PROJECT RECORD DOCUMENTS

- .1 Section 15010: Submittals for project closeout.
- .2 Record actual locations of units.

1.7 OPERATION AND MAINTENANCE DATA

- .1 Section 15010: Submittals for project closeout.
- .2 Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant volume regulators.

1.8 QUALIFICATIONS

Air Terminal Units

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

1.9 REGULATORY REQUIREMENTS

- .1 Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories Inc., as suitable for the purpose specified and indicated.

1.10 WARRANTY

- .1 Section 23 01 01: Submittals for project closeout.
- .2 Provide five year warranty.
- .3 Warranty: Include coverage of system powered control systems.

1.11 EXTRA MATERIALS

- .1 Section 23 01 01: Submittals for project closeout.
- .2 Provide two additional electric motors of each size.

2 PRODUCTS

2.1 MANUFACTURERS

- .1 E. H. Price products indicated.
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Titus
 - .2 Anemostat
 - .3 Krueger
 - .4 Metalaire

2.2 SINGLE DUCT TERMINAL UNITS

- .1 Basic Unit:
 - .1 Configuration: Air volume damper assembly inside unit casing. Locate control component inside protective metal shroud.
 - .2 Volume Damper: Construct of galvanized steel with peripheral gasket and self lubricating bearings; maximum damper leakage: 2 percent of design air flow at 0.25 kPa inlet static pressure.
 - .3 Mount damper operator to position damper normally open.
- .2 Basic Assembly:
 - .1 Casings: Minimum 22-ga (0.85 mm) G-90 galvanized steel.
 - .2 Lining:
 - 1" thick 1.5 lb/cu.ft. density fibreglass insulation with woven fabric and perforated metal liner, Price WFPM
 - .3 Plenum Air Inlets: Round stub connections for duct attachment.
 - .4 Plenum Air Outlets: S slip and drive connections.
- .3 Attenuator Section: Line attenuator sections with 2" (50 mm) thick fibre free foam insulation.
- .4 Multi Outlet Attenuator Section: provide 6" (150 mm) diameter collars, each with butterfly balancing damper and lock.

Air Terminal Units

- .5 Round Outlet: Discharge collar matching inlet size.
- .6 Damper Operator: electronic
- .7 Thermostat: Electronic type with appropriate mounting hardware.

ALTERNATE

- .8 Furnish and install Price single duct, variable volume air distribution assemblies SDV 5000 of the sizes and capacities as shown on the plans.
- .9 The assemblies shall be pressure independent and shall reset to any air flow between zero and the maximum cataloged air volume.
- .10 At an inlet velocity of 2,000 fpm, the differential static pressure for any unit with attenuator section, sizes 4 through 16, shall not exceed 0.11" w.g.
- .11 Sound ratings of air distribution assemblies, shall not exceed 25 NC at 1.0" wg (250 Pa) static pressure.
- .12 Performance shall be ARI Certified.
- .13 The air flow sensor shall be of a cross configuration located at the inlet of the assembly. The sensor shall have twelve total pressure sensing ports and a center averaging chamber designed to accurately average the flow across the inlet of the assembly. Sensor shall provide accuracy within 5% with a 90° sheet metal elbow directly at the inlet of the assembly. The air flow sensor shall amplify the sensed air flow signal.
- .14 The assembly casing shall be constructed of 22 gauge zinc coated steel, internally lined with 3/4" (19mm) thick Fiber Free Foam Insulation System that complies with the following industry standards and tests: UL 181 (Air Erosion), UL 181 (Mold Growth & Humidity), ASTM E 84 (25/50) (Flame & Smoke), ASTM C 665 (Fungi Resistance), CAN/ULC-102.2-M88 (Flame and Smoke)
- .15 The casing shall be constructed to maintain leakage rates not exceeding the maximum values listed in Table A.

Standard Unit Leakage, CFM			
Size	.25"Ps	0.5"Ps	1.0"Ps
4, 5, 6	1	2	3
7, 8	1	2	3
9, 10	1	2	3
12	1	2	3
14	2	2	3
16	2	3	4
Ps – inlet static pressure (in w.g.)			

- .16 The primary air valve damper shall be heavy gauge metal, with peripheral gasket and solid steel shaft, pivoted in self-lubricating bearings. In the full closed position, air leakage past the closed damper shall not exceed 2% of the nominal catalog rating at 3"w.g. inlet static pressure, when tested in accordance with ASHRAE 130.
- .17 Controls: DDC controllers will be supplied by the Owner or installation in the terminal unit manufacturer's factory prior to shipment to the site.

Air Terminal Units

3 EXECUTION

3.1 INSTALLATION

- .1 Install to manufacturer's instructions.
- .2 Provide ceiling access doors or locate units above easily removable ceiling components.
- .3 Support units individually from structure. Do not support from adjacent ductwork.
- .4 Provide safety chains for ceiling mounted units.
- .5 Connect to ductwork.
- .6 Install heating coils.
- .7 Verify that electric power is available and of the correct characteristics.

3.2 ADJUSTING

- .1 Reset volume with damper operator attached to assembly allowing flow range modulation from 100 percent of design flow to 0 percent full flow. Set units with heating coils for minimum 50 percent full flow.

END OF SECTION

Laboratory Ventilation Systems

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 05 05 & 23 01 01.

1.2 SECTION INCLUDES

- .1 Laboratory Airflow Control Systems (LACS)
- .2 Controllable Airflow Venturis (CAFV).

1.3 REFERENCES

- .1 ADC 1062 - Air Distribution and Control Device Test Code.
- .2 NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
- .3 UL 181 - Factory-Made Air Ducts and Connectors.
- .4 ANSI Z9.5 American National Standard for Laboratory Ventilation

1.4 PERFORMANCE TOLERANCES

- .1 Base performance on tests conducted to ADC 1062.

1.5 SUBMITTALS

- .1 Section 23 01 01: Procedures for submittals.
- .2 Shop Drawings: Indicate configuration, general assembly, and materials used in fabrication, and electrical characteristics and connection requirements.
- .3 Product Data: Provide data indicating configuration, general assembly, and materials used in fabrication. Include catalogue performance ratings which indicate air flow, static pressure, and NC designation. Include electrical characteristics and connection requirements.
- .4 Provide schematics of wiring of all air valves, hydronic control valves, fume hood and makeup air controllers, generated specifically for this project, including all terminal numbers for the BAS interconnection and other point to point wiring.
- .5 Controllable Air Flow Venturi (CAFV) schedule listing CAFV minimum and maximum as well as operating minimum and maximum air flows, turndown range, air valve sizes, and room differential offsets. These values shall be considered the calculated values of the commissioning report.
- .6 Manufacturer's Installation Instructions: Indicate support and hanging details, and service clearances required.

1.6 PROJECT RECORD DOCUMENTS

- .1 Section 23 01 01: Submittals for project closeout.
- .2 Record actual locations of units.

1.7 OPERATION AND MAINTENANCE DATA

- .1 Section 23 01 01: Submittals for project closeout.
- .2 Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant volume regulators.

1.8 QUALIFICATIONS

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

1.9 REGULATORY REQUIREMENTS

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- .1 Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories Inc., as suitable for the purpose specified and indicated.

1.10 WARRANTY

- .1 Section 23 01 01: Submittals for project closeout.
- .2 Provide five year warranty.

1.11 EXTRA MATERIALS

- .1 Section 23 01 01: Submittals for project closeout.

2 PRODUCTS

2.1 MANUFACTURERS

- .1 Basis of Design: Phoenix Controls
- .2 Other acceptable manufacturers offering equivalent products. Other than listed below, no other alternates shall be accepted:
 - .1 Siemens
 - .2 Johnson Controls Inc.

2.2 GENERAL DESCRIPTION OF SYSTEMS

- .1 Furnish a fully installed and wired integrated high performance laboratory airflow control systems (LACS) for each area specified or shown on the drawings. Each LACS shall provide sufficient air flow for minimum dilution ventilation, purge ventilation, make-up air flow for fume hoods and other exhaust devices, and temperature control, while maintaining constant, usually negative room pressurization control under all operating conditions.
- .2 Each LACS shall be networked or operate standalone. There shall be a BACnet interface to the Building Automation System (BAS). The BAS shall accept signals from the LACS to provide meaningful information for the BAS graphics. However, it should be noted this new building will not be added to the existing University Iconics 32 Graphic User Interface (GUI), therefore there is no scope of work for graphics updates in this project.
- .3 Controls to accommodate the sum of all offsets into/out of rooms shall maintain area or floor air balance under all operating conditions.
- .4 Integrated LACS shall respond to full scale air flow change commands within less than 1 second under all operating conditions to maintain air balance even under transient conditions.

2.3 CONTROLLABLE AIR FLOW VENTURI (CAFV)

- 1. The airflow control device shall be a Phoenix Controls Accel II pressure independent venturi valve.
- 2. The valve assembly manufacturer's Quality Management System shall be registered to ISO 9001:2008.
- 3. Airflow control device shall be OSHPD tested and certified per 2013 CBC, 2012, IBC, ASCE 7-10, and ICC- ES-AC-156.
- 4. All Components of the valve, its controllers, and wiring shall be ROHS compliant.
- 5. The airflow control device shall be mechanically pressure independent over its specified differential static pressure operating range. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of

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- pressure and/or flow change (within product specifications) or quantity of airflow controllers on a manifolded system.
6. The airflow control device shall maintain accuracy within $\pm 5\%$ of signal to set point over an airflow turndown range of no less than:
 - a. 12.5 to 1 (medium pressure all valve sizes)
 - b. 16 to 1 (medium pressure w/o 14" valve)
 - c. 7 to 1 (low pressure all valve sizes)
 - d. 11 to 1 (low pressure w/o 14" valve)
 - e. 8 to 1 (medium pressure shut-off all valve sizes)
 - f. 14 to 1 (medium pressure shut-off w/o 14" valve)
 - g. 5 to 1 (low pressure shut-off all valve sizes)
 - h. 9 to 1 (low pressure shut-off w/o 14" valve)
 7. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.
 8. No rotational/axial orientation requirements shall be required to ensure accuracy and/or pressure independence.
 9. The airflow control device shall maintain pressure independence regardless of loss of power. "Electronically pressure independent" devices will not be acceptable.
 10. Airflow control devices utilizing ASHRAE 130 minimum operating pressure as a rating for minimum design pressure at required flow will not be acceptable on basis on minimum operating pressure alone. Valve manufacturer will provide minimum required differential pressure in writing for each size valve they offer.
 11. Airflow control device shall be able to achieve its maximum turndown ratio at its stated minimum operating differential pressure. I.E. if minimum operating pressure is 0.6" wc dp, a 10" air valve must be able to achieve its minimum of 50cfm and its maximum of 1000 cfm at stated 0.6" wc dp. Devices that require duct static pressure to be increased to achieve maximum flow shall not be acceptable.
 12. The airflow control device shall be constructed of one of the following four types:
 - a. Class A—The airflow control device for non-corrosive airstreams, such as supply and general exhaust, shall be constructed of 16-gauge aluminum. The device's shaft and internal "S" link shall be made of 316 stainless steel. The shaft support brackets shall be made of galvaneal (non shutoff valves) or 316 stainless steel (shutoff valves). The pivot arm shall be made of aluminum (for non shutoff valves) and 303/304 stainless (for shut off valves). The pressure independent springs shall be a spring-grade stainless steel. All shaft bearing surfaces shall be made of a PP (polypropylene) or PPS (polyphenylene sulfide) composite. Sound attenuating devices used in conjunction with general exhaust or supply airflow control devices shall be constructed using 24 gauge galvanized steel or other suitable material used in standard duct construction. No sound absorptive materials of any kind shall be used.
 - b. Class B—The airflow control device for corrosive airstreams, such as fume hoods and biosafety cabinets, shall have a baked-on, corrosion-resistant phenolic coating. The device's shaft shall be made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal "S" link shall be made of 316 or 303 stainless steel. The pressure independent springs shall be a spring-grade stainless steel. The internal nuts, bolts and rivets shall be stainless steel. All shaft bearing surfaces shall be made of PP (polypropylene) or PPS (polyphenylene sulfide) composite.
 - c. Class C—The airflow control device for highly corrosive airstreams shall be constructed as defined in 2.2.B.6.B. In addition, these devices shall have no exposed aluminum or stainless steel components. Shaft support brackets, pivot arm, and pressure independent springs shall have a baked-on, corrosion-resistant phenolic coating in addition to the materials defined in 2.2.B.6.B. The internal "S" link, nuts, bolts, and rivets shall be epoxy phenolic coated stainless steel. Only devices clearly defined as "high corrosion resistant" on project drawings will require this construction.
 - d. Class D— The airflow control device for extremely corrosive airstreams, such as acid digestion fume hoods, shall have a PVDF (polyvinylidene fluoride fluoropolymer) coating. The device's shaft shall be made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 stainless steel with PVDF coating. The pivot arm and internal mounting link shall be made of 316 or 303 stainless steel with PVDF coating. The pressure independent springs shall be a spring-grade stainless steel with Teflon (PTFE) coating. The internal nuts, bolts and rivets shall be stainless

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steel with PVDF coating. All shaft bearing surfaces shall be made of Teflon or PPS (polyphenylene sulfide) composite. Only devices clearly defined as “extremely corrosion resistant” on project drawings will require this construction.

Note: Airflow Control Devices utilizing vortex shedding sensors and installed in fume hoods or corrosive environments MUST be constructed with Stainless steel bodies, and MUST have stainless steel Vortex Shedding sensors. PolyCarbonate Vortex Shedding sensors will NOT be acceptable in corrosive environments.

13. Actuation

- a. For high speed electrically actuated VAV operation, a CE certified, UL Listed, IP56 rated for dust and water, electronic actuator shall be factory mounted to the valve. Loss of main power shall cause the valve to position itself in an appropriate failsafe state. Options for these failsafe states include: normally open-maximum position, normally closed-minimum position and fail-to-last position. This position shall be maintained constantly without external influence, regardless of external conditions on the valve (within product specifications).

In fail safe conditions the Airflow Control Device must remain pressure independent and in control of airflow at its failed position. I.E. if a device fails in position at 500 cfm, the airflow control device must remain pressure independent regardless of having power/controller operating and will deliver the 500cfm at that given control point regardless of duct pressure. Airflow control devices with single or dual blades that fail in position or fail open will not be acceptable as the airflow delivered cannot be guaranteed due to device not being mechanically pressure independent.

- b. During normal operation, the high speed actuated airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within 1 second or less.
- c. For Standard Speed electrically actuated VAV operation, a CSA certified, UL recognized (IP54 rating and CE certification optional on single valves, standard on dual valves) electronic actuator shall be factory mounted to the valve. The fail-safe state for standard speed operation valves shall be fail to last position unless otherwise noted.

In fail-safe conditions the Airflow Control Device must remain pressure independent and in control of airflow at its failed position. I.E. if a device fails in position at 500 cfm, the airflow control device must remain pressure independent regardless of having power/controller operating and will deliver the 500cfm at that given control point regardless of duct pressure. Airflow control devices with single or dual blades that fail in position or fail open will not be acceptable as the airflow delivered cannot be guaranteed due to device not being mechanically pressure independent.

- d. During normal operation, the standard speed actuated airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within 60 seconds (90 seconds for a shutoff valve from shutoff to maximum flow or vice Versa).
 - 1) Standard speed actuation should not be used for valves that are connected to VAV fume hoods.
 - 2) Standard speed actuation can be used on 2-state fume hoods or vented cabinets or snorkels with on/off conditions.
 - 3) Constant volume valves do not require actuators.

14. The controller for the airflow control devices shall be microprocessor based and operate using peer-to-peer control architecture. The room-level airflow control devices shall function as a standalone network. The room-level control network shall utilize a LonTalk communications protocol.
15. There shall be no reliance on external or building-level control devices to perform room-level control functions. Each laboratory control system shall have the capability of performing fume hood control, pressurization control, standard and advanced temperature control, humidity control, and implement

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- occupancy and emergency mode control schemes. A Room controller or PLC performing these functions shall not be acceptable.
16. The LACS shall have the option of digital integration with the BMS or BAS. If digital integration device, room controller, laboratory space controller or similar is lost or offline or fails then the valve controllers shall have distributed controllability and will keep the basic room functions of zone balance, temperature, humidity control, offset control, etc. operating to maintain a safe and comfortable zone.
 17. NVLAP Accreditation (Lab Code 200992-0)
 - a. Each airflow control device shall be factory characterized on air stations NVLAP Accredited (a program administered by NIST) to ISO/IEC 17025:2005 standards.
 - b. Each airflow control device shall be factory characterized to the job specific airflows as detailed on the plans and specifications using NVLAP Accredited air stations and instrumentation having a combined uncertainty of no more than $\pm 1.4\%$ of signal (4,200 to 250cfm), $\pm 2.5\%$ of signal (249 to 100cfm) and $\pm 4\%$ of signal (199 to 35cfm). Electronic airflow control devices shall be further characterized and their accuracy verified to $\pm 5\%$ of signal at a minimum of 48 different airflows across the full operating range of the device.
 - c. Each airflow control device shall be marked with device-specific factory characterization data. At a minimum, it should include the room number, tag number, serial number, model number, eight-point characterization information (for electronic devices), date of manufacture and quality control inspection numbers. All information shall be stored by the manufacturer for use with as-built documentation. Characterization data shall be stored indefinitely by the manufacturer and backed up off site for catastrophic event recovery.
 18. Airflow control devices that are not venturi valves and are airflow measuring devices (e.g., pitot tube, flow cross, air bar, orifice ring, vortex shedder, etc.) shall only be acceptable, provided these meet all the performance and construction characteristics as stated throughout this specification and:
 - a. The airflow control device employs transducers manufactured by Rosemount, Bailey, Bristol, or Foxboro. Accuracy shall be no less than $\pm 0.15\%$ of span (to equal $\pm 5\%$ of signal with a 15 to 1 turndown) over the appropriate full-scale range, including the combined effects of nonlinearity, hysteresis, repeatability, drift over a one-year period, and temperature effect. 316L stainless steel materials shall be provided for all exhaust applications. The use of 304 stainless steel or aluminum materials shall be provided for all supply air applications.
 - b. Airflow sensors shall be of a multi-point averaging type, 304 stainless steel for all supply and general exhaust applications, 316L stainless steel for all fume hood, canopy, snorkel, and biosafety cabinet applications. Single point sensors are not acceptable.
 - c. Suppliers of airflow control devices or airflow measuring devices requiring minimum duct diameters shall provide revised duct layouts showing the required straight duct runs upstream and downstream of these devices. Coordination drawings reflecting these changes shall be submitted by the supplier of the LACS. In addition, suppliers shall include static pressure loss calculations as part of their submittals. All costs to modify the ductwork, increase fan sizes and horsepower and all associated electrical changes shall be borne by the LACS supplier.
 - d. Suppliers of airflow control devices that utilize measurement tools (closed loop venturi type, vortex shedder type, flow cross type, orifice ring type, or flow station type) shall provide a minimum required differential pressure rating of all their devices when in control. ASHRAE 130 is not an acceptable method of minimum operating pressure and values generated from ASHRAE 130 testing shall not be accepted as a basis for minimum operating pressure when airflow control device in control.
 - e. Suppliers of airflow control devices that utilize measurement tools (closed loop venturi type, vortex shedder type, flow cross type, orifice ring type, or flow station type) shall provide a recommended interval for cleaning and recalibrating flow measurement sensors including but not limited to vortex shedding devices, and pressure transducers. Transducer drift shall be included in this recalibration interval by manufacturer. Any device using a pressure transducer shall have the accuracy and drift of the pressure transducer in writing in the submittal.

2.4 EXHAUST AND SUPPLY AIRFLOW DEVICE CONTROLLER

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1. The airflow control device shall be a microprocessor-based design and shall use closed loop control to linearly regulate airflow based on a digital control signal. The device shall generate a digital feedback signal that represents its airflow.
2. During normal operation the airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within:
 - a. 1 second or less with high speed actuation.
 - b. 60 seconds for standard speed actuation (90 seconds from shutoff to max flow and vice versa).
3. The airflow control device shall store its control algorithms in non-volatile, re-writeable memory. The device shall be able to stand-alone or to be networked with other room-level digital airflow control devices using an industry standard protocol.
4. Room-level control functions shall be embedded in and carried out by the airflow device controller using distributed control architecture. Critical control functions shall be implemented locally; no separate room-level controller shall be required.
5. The airflow control device shall use industry standard 24 VAC power.
6. The airflow control device shall have provisions to connect a Phoenix Controls Workbench (WKB100) commissioning tool and every node on the network shall be accessible from any point in the system.
7. The airflow control device shall have built-in integral input/output connections that address fume hood control, temperature control, humidity control occupancy control, emergency control, and non-network sensors switches and control devices. At a minimum, the airflow controller shall have:
 - a. Three universal inputs capable of accepting 0 to 10 VAC, 4 to 20 mA, 0 to 65 K ohms, or Type 2 or Type 3 10 K ohm @ 25 degree C thermistor temperature sensors.
 - a. One digital input capable of accepting a dry contact or logic level signal input.
 - b. Two analog outputs capable of developing either a 0 to 10 VAC @ 1 mA (10Kohm min) or 4 to 20 mA (500 ohm max) linear control signal.
 - c. One Form C (SPDT) relay output capable of driving up to 1 A @ 24 VAC/VAC.
8. The airflow control device shall meet FCC Part 15 Subpart J Class A, CE, and CSA Listed per file #228219.
9. The airflow control device shall be ROHS compliant.

2.5 REMOTE SWITCHES

1. Supply emergency exhaust push buttons to initiate the PURGE mode in a laboratory, if specified. Devices shall be of the maintained contact, or momentary contact push button type as required.
2. Canopies specified for ON-OFF operation, shall be controlled from a remotely mounted switch. This switch shall be supplied and installed by this Section. It shall meet the requirements of the specified service and sequence, and shall have sufficient auxiliary contacts for all requirements.

3 EXECUTION

3.1 GENERAL

1. Verify that mechanical and control systems are complete and ensure that the systems are capable of being started and operated in a safe and normal condition before attempting to operate the FMS.
2. Install software in the Management Server. Implement all features of programs to specified requirements and as appropriate for sequence of operation.
3. Connect and configure equipment and software to achieve sequence of operation specified.
4. Assure all CAFV's are installed horizontally to insure factory calibrated performance, unless specifically ordered for vertical installation. Vertical CAFV's shall be so marked on the plans as well as on the product.

Laboratory Ventilation Systems

5. All CAFV shall be installed as per manufacturers' recommendations.
6. Perform all control wiring, make necessary electrical connections, and install all equipment specified under this Section, unless otherwise noted.
7. Unless specified otherwise, install SPS and its cable in a concealed manner in the service cavity of the fume hood, and make accessible from the top of the hood for field servicing.
8. BAS supplier to update existing controls graphics to reflect new system layouts.

END OF SECTION

Air Inlets & Outlets

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 05 05 & 23 01 01.

1.2 SECTION INCLUDES

- .1 Diffusers.
- .2 Grilles and Registers

1.3 REFERENCES

- .1 ADC 1062 - Air Distribution and Control Device Test Code.
- .2 AMCA 500 - Method of Testing Louvres for Ratings.
- .3 AMCA 5000 - Method of Testing Dampers for Ratings.
- .4 AHRI 650 - Air Outlets and Inlets.
- .5 ASHRAE 70 - Method of Testing for Rating the Performance of Outlets and Inlets.
- .6 SMACNA - HVAC Duct Construction Standard - Metal and Flexible.
- .7 NFPA 90A - Installation of Air Conditioning and Ventilating Systems.

1.4 SUBMITTALS

- .1 Section 23 01 01: Procedures for submittals.
- .2 Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.
- .3 Samples: Submit two of each required air outlet and inlet type.
- .4 As built record drawings to record actual locations of air outlets and inlets.

1.5 QUALITY ASSURANCE

- .1 Test and rate air outlet and inlet performance to ADC Equipment Test Code 1062 and ASHRAE 70.
- .2 Test and rate louvre performance to AMCA 500.

1.6 QUALIFICATIONS

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

2 PRODUCTS

2.1 MANUFACTURERS

- .1 Diffusers, grilles and registers shall be Price model indicated or equivalent products by;
 - .1 Titus
 - .2 Kreuger
 - .3 Metalaire
 - .4 Nailor
 - .5 Carnes

2.2 DIFFUSER, GRILLES & REGISTERS PERFORMANCE/TYPE

- .1 Performance: Refer to mechanical schedules.
- .2 Type: Refer to mechanical schedules.

Air Inlets & Outlets

3 EXECUTION

3.1 INSTALLATION

- .1 Install in accordance with manufacturer's instructions.
- .2 Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.
- .3 Install diffusers and grilles and connect to ductwork with air tight connections.
- .4 Provide balancing dampers in duct take-off to diffusers, grilles and registers, whether or not dampers are included as part of the diffuser, grille or register assembly.
- .5 Paint visible ductwork behind air outlets and inlets matte black.
- .6 Provide safety chains for ceiling mounted filter units and for diffusers 24" x 48" (600 x 1200mm) and larger.
- .7 Install filters in diffusers, grilles and registers after final cleaning of rooms and ductwork has been completed and accepted and when environmental conditions are suitable. Ensure that air tight seal is achieved.

3.2 PROTECTION

- .1 Protect each diffuser, grille and register from damage during construction.
- .2 Protect each diffuser, grille, register and ductwork from contamination and entry of dust and debris during construction.

END OF SECTION

Process Chiller, Air Cooled

1 GENERAL

1.1 GENERAL

- .1 Read and conform to:
 - .1 The General Conditions of the Contract
 - .2 Comply with Division 1 requirements and documents referred to herein.

1.2 SECTION INCLUDES

- .1 Process Chiller

1.3 REFERENCES

- .1 Local and district by-laws, regulations and published engineering standards.
- .2 The Ontario Building Code
- .3 CAN/CSA - B52-92: Mechanical Refrigeration Code.
- .4 ASHRAE Standard 15

1.4 SUBMITTALS FOR REVIEW

- .1 Product Data: Provide catalogue data indicating rated capacity, dimensions, duct and service connections, electric nameplate data and wiring diagrams.
- .2 Shop Drawings: Indicate layout of system and components.

1.5 SUBMITTALS AT PROJECT CLOSEOUT

- .1 Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.
- .2 Warranty: Submit manufacturer warranty and ensure forms have been completed in Owners 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 PRODUCTS

- .1 Process chiller has been pre-purchased by the owner. Contractor is responsible to take ownership of said chiller and complete the installation to manufacturers requirements.

3 EXECUTION

3.1 INSTALLATION

- .1 Install in strict accordance with manufacturer's requirements, shop drawings, and contract documents.
- .2 Adjust and level chiller in alignment on supports.

Process Chiller, Air Cooled

- .3 Install condensing unit(s) level and plumb on vibration pads and concrete slabs where indicated.
- .4 Install and connect refrigerant lines and specialties as indicated and as recommended by the equipment manufacturers.
- .5 Coordinate electrical installation with electrical contractor.
- .6 Coordinate controls with control contractor.
- .7 Provide all appurtenances required to insure a fully operational and functional chiller.

3.2 TESTING

- .1 Prepare system for start-up by having manufacturer's field engineer or factory trained representative supervise testing, and charging of machines.
- .2 Provide sufficient refrigerant, dry nitrogen and refrigeration oil for pressure and operational testing under manufacture's supervision.
- .3 Prior to testing ensure that system is complete. Protect relief valves during test procedure. After completion of test, reconnect and make good piping connections and leak test entire system.

3.3 START-UP

- .1 Provide proper charge of refrigerant and oil.
- .2 Provide Factory Authorized starting of chillers, and instruction to the owner on proper operation and maintenance.

END OF SECTION

Custom Outdoor Air Handling Units

1 GENERAL

1.1 GENERAL REQUIREMENTS

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

1.2 REFERENCES

- .1 AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
- .2 AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
- .3 AMCA 99 - Standard Handbook.
- .4 AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
- .5 AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
- .6 AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices.
- .7 AMCA 500 - Method of Testing Louvres for Ratings.
- .8 AMCA 5000 - Method of Testing Dampers for Ratings.
- .9 AMCA 611 - Methods of Testing Airflow Measurement Stations for Rating
- .10 ARI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils.
- .11 ARI 260 - Sound Rating of Ducted Air Moving and Conditioning Equipment
- .12 ARI 430 - Fabrication of Central Station Air Handling Units.
- .13 ARI 435 - Application of Central-Station Air-Handling Units.
- .14 ARI 610 - Central System Humidifiers for Residential Applications.
- .15 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- .16 ANSI/UL 900 - Test Performance of Air Filter Units
- .17 ASHRAE 52.1/52.2 - Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size
- .18 ASHRAE 62 - Ventilation for Acceptable Indoor Air Quality
- .19 ASHRAE 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings
- .20 ASTM-C 1338 - Standard Test Method for Determining Fungi Resistance of Insulation Material and Facings.
- .21 MNECB - Model National Energy Code for Buildings
- .22 SMACNA - HVAC Duct Construction Standards
- .23 UL-181 - Mold Growth and Humidity Test
- .24 UL-1995 - Standard for Safety for Heating and Cooling Equipment
- .25 ISO/PWD 13261-3 - Sound Power Rating of air-conditioning and air-source heat pump equipment: Part 3, Ducted Equipment.
- .26 ISO 9614 - Determination of sound power levels of noise sources using sound intensity: Part 1, Measurement at discrete points; Part 2, Measurement by scanning, and Part 3, Precision method for measurement by scanning.

1.3 RATINGS AND CERTIFICATIONS

- .1 Air Handling Unit safety: CSA, ETL or UL
- .2 Air Handling Unit energy use: ASHRAE 90.1
- .3 Fans: AMCA 210
- .4 Air Coils: ARI 410
- .5 Air Handling Unit certification program: ARI 430

Custom Outdoor Air Handling Units

- .6 Filter media: ANSI/UL 900 listed Class I or Class II
- .7 Control wiring: Ontario Electrical Safety code, CSA & ETL requirements
- .8 Motors: Federally mandated Energy Efficiency Regulations (NRCan)
- .9 Airflow Monitoring Stations: AMCA 611

1.4 SUBMITTALS

- .1 Section 23 01 01: Procedures for submittals.
- .2 Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.
- .3 Product Data:
 - .1 Provide literature which indicates dimensions, operating weights, capacities, ratings, fan performance, gauges and finishes of materials, and electrical characteristics and connection requirements.
 - .2 Provide data of filter media, filter performance data, filter assembly, and filter frames.
 - .3 Provide fan curves with specified operating point clearly plotted.
 - .4 Submit sound power level data for both fan outlet and casing radiation at rated capacity.
 - .5 Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
- .4 Samples: Submit two of each type of replacement filter media with frame.
- .5 Manufacturer's Installation Instructions.

1.5 OPERATION AND MAINTENANCE DATA

- .1 Section 23 01 01: Submittals for project closeout.
- .2 Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

1.6 QUALIFICATIONS

- .1 Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience, who issues complete catalogue data on total product.

1.7 DELIVERY, STORAGE, AND HANDLING

- .1 Section 23 01 01: Transport, handle, store, and protect products.
- .2 Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.
- .3 Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.8 ENVIRONMENTAL REQUIREMENTS

- .1 Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under

Custom Outdoor Air Handling Units

observation.

1.9 EXTRA MATERIALS

- .1 Section 23 01 01: Submittals for project closeout.
- .2 Provide one spare set for each unit of the following;
 - .1 fan belts
 - .2 filters

2 PRODUCTS

- .1 Custom outdoor air handling units have been pre-purchased by the owner. Contractor is responsible to take ownership of said air handling units and complete the installation to manufacturers requirements.

3 EXECUTION

3.1 INSTALLATION

- .1 Install to manufacturer's instructions.
- .2 Install to ARI 435.
- .3 Assemble high pressure units by bolting sections together. Isolate fan section with flexible duct connections.
- .4 Install assembled unit on Mason Super `W' 0.1 Deflection Isolation.
- .5 Units mounted on new/existing roof curbs.

3.2 AIR HANDLING UNIT SCHEDULE

- .1 Air Handling Unit Scheduled: As scheduled on drawings.

END OF SECTION

Terminal Heat Transfer Units

1 GENERAL

1.1 GENERAL REQUIREMENTS

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

1.2 SECTION INCLUDES

- .1 Fan coil units

1.3 SUBMITTALS FOR REVIEW

- .1 Product Data: Provide typical catalogue of information including arrangements.
- .2 Shop Drawings:
 - .1 Indicate cross sections of cabinets, grilles, bracing and reinforcing, and typical elevations.
 - .2 Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.
 - .3 Indicate mechanical and electrical service locations and requirements.
- .3 Manufacturer's Instructions: Indicate installation instructions and recommendations.
- .4 Project Record Documents: Record actual locations of components and locations of access doors in radiation cabinets required for access or valving.
- .5 Operation and Maintenance Data: Include manufacturers descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.
- .6 Warranty: Submit manufacturer warranty and ensure forms have been completed in Owners name and registered with manufacturer.

1.4 QUALITY ASSURANCE

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

1.5 REGULATORY REQUIREMENTS

- .1 All equipment and material to be furnished and installed on this Project shall be CSA or ETL listed, in accordance with the requirements of the authorities having jurisdiction and suitable for its intended use on this Project.

2 PRODUCTS

2.1 FAN COIL UNITS

- .1 Manufacturer: JAGA
- .2 Other acceptable manufacturers:
 - .1 Carrier
 - .2 Engineered Air
 - .3 McQuay

Terminal Heat Transfer Units

- .3 Factory-built concealed vertical fan coil units shall be as indicated on drawings and shall meet the capacity and acoustical performance requirements specified and indicated in the schedules on the Contract Documents. All vertical fan coil units shall be tested in accordance with the latest version of ARI Standard 440. All vertical fan coil units shall be CSA or ETL listed as a complete factory wired assembly.
- .4 All unit chassis shall be fabricated of 20 gauge, G-60 galvanized steel panels able to meet 125 hour salt spray test per ASTM B-117. All exterior panels shall be insulated with 1/2" thick, 2lb. per cubic foot CertainTeed ToughGard insulation with a max velocity of 6000 f.p.m. and tested to 9600 f.p.m. Insulation shall conform to UL 181 for erosion and NFPA 90A and NFPA 90B, for fire and smoke, and carry no more than a 25/50 Flame Spread and Smoke Developed Rating, per ASTM E-84 and UL 723. In addition it shall also meet ASTM Standards C-665 and G-21 for biological growth in insulation and shall be water repellent. Fan deck shall be minimum 20 gauge galvanized steel. The fan coil unit shall have a flat discharge panel to facilitate a flanged duct connection being screwed directly to the unit. The unit face shall be free and clear of obstructions for the sheet metal screw penetrations. Units that are designed for exposed mounting shall have smooth discharge openings for mounting grilles directly to the unit face.
- .5 The welded cooling coil condensate drain pan shall have 1" sides and be fabricated of 20 gauge, 304 stainless steel. The unit shall be designed to be installed sloped to drain completely dry upon fan coil unit shutdown. The drain pan shall be externally insulated with minimum 1/4" thick elastomer foam fire retardant insulation similar to Armstrong Type AT Armaflex. The insulation shall carry no more than a 25/50 Flame Spread and Smoke Developed Rating per ASTM E-84 and UL 723 and an Antimicrobial Performance Rating of "0, no observed growth" per ASTM G-21. Insulation shall be adhered to the stainless steel drain pan with a full coat of waterproof adhesive.
- .6 All coils shall be ARI 410 certified and tagged with an ARI 410 label. All cooling and heating coils shall have the minimum rows required to meet the specified capacity. Coils shall have 1/2" O.D. seamless copper tubes, and collared and corrugated aluminum fins. All tubes shall be mechanically expanded to provide an efficient, permanent bond between the tube and fin. Coil frames shall be constructed of minimum G-90 galvanized steel. All coils shall be pressure tested under water at 1.5 times the working pressure classification indicated in the Contract Documents, but the test pressure in no case shall be less than 300 psig. Heating coils shall be furnished in the reheat position as standard. All water coils shall be provided with a manual air vent fitting to allow for coil venting. Water velocity in the tubes shall not exceed eight (8) feet per second and the coil face velocity shall not exceed 500 fpm. The coils shall be factory piped with Type L copper pipe with wrought copper fittings and brazed joints. The factory piped assembly shall include: manual air vent, two (2) two-way modulating quiet actuation electric control valve assemblies, extended handle supply and return ball valves, temperature and pressure test ports in the supply and return lines similar to "Petes Plugs". The ball valve on the balancing return piping shall be equipped with a memory stop and locking feature. Control valves shall be piped normally closed to the coil unless modulating valves are used then the 0-10volt signal will set the valve opening. Maximum entering water temperature on the control valve shall be 200°F, and maximum close-off pressure differential of 25 PSIG.

Terminal Heat Transfer Units

- Maximum operating pressure shall be 300 PSIG. Piping packages shall be completely factory assembled, including interconnecting pipe, and mounted inside the unit in a serviceable location over the primary or secondary drain pan. Refer to the appropriate section of the specifications for ball valve, pipe fabrication and vibration isolation.
- .7 The fan coil unit manufacturer shall furnish a factory mounted controls transformer 120V:24V and a fully labelled terminal strip to accommodate remote control through the Building Automation System (BAS). The factory supplied control package shall include a two-way heating/cooling control valve and shall provide automatic changeover from heating to cooling. The fan coil unit manufacturer shall furnish and install a dynamic fan volume control system to automatically vary the fan airflow in response to heating and cooling load. The factory supplied controls shall allow automatic fan modulation based on room load demand as determined by BAS room temperature sensor . The fan speed shall change slowly. No manual speed selection will be required at the wall mounted control device. The fan coil unit shall be capable of operation as described herein with discharge static pressure of 0 to 0.5" w.g. (120 Pa) at full airflow.
- .8 The entire fan coil unit assembly shall be factory wired to a single point connection. All power and control wiring shall conform to Ontario Electrical Safety Code. The fan coil unit assembly shall include all required devices, including but not limited to, service switch, relay, control power transformers and control packages, low voltage remote shutdown relays, etc.
- .9 The fan coil unit manufacturer shall furnish the unit with 1" thick pleated MERV 7 throw-away type media air filters.
- .10 The fan coil unit and acoustical treatment shall limit the noise in the room 3' away from any discharge and return air opening to an amount that will not produce more than the NC sound curve scheduled on drawings.
- .11 Each size of fan coil unit installed on this Project shall be completely acoustically tested in the Owner's room mock-up or an independent laboratory for air performance and acoustics. The acceptability of the independent testing laboratory is subject to review by the Owner, Project Acoustical Consultant, and the Consultant. The fan coil unit manufacturer shall submit complete test details, brochures, instrumentation information, etc., for review. The air volume listed on the Drawings or in the schedules for the fan coil units shall be tested. If the fan coil unit manufacturer has conducted the hereinbefore specified air performance and acoustical tests and has demonstrated to the Consultant and Owner compliance with the specified Project criteria, the previous testing will be accepted and will not need to be repeated. Base sound power data shall be provided as tested according to the latest version of ARI Standard 350. This data is for guideline purposes only, the mock up described above is the qualifying test.
- .12 The fan coil unit manufacturer shall submit six (6) certified copies of the field performance and acoustical performance test results to the Consultant and the Project Acoustical Consultant.
- .13 The fan coil manufacturer shall verify at the manufacturer's factory the operation of each fan coil before shipment. Testing shall include at least the following:
- .1 Apply electric power to the unit.
 - .2 Energize the electric two (2) position and modulating control valves and verify

Terminal Heat Transfer Units

- satisfactory performance.
- .3 Provide a written inspection report for each unit signed and dated by the factory test technician verifying all fan coil unit wiring and testing has been performed per the manufacturer's testing and quality assurance requirements.
 - .14 The fan coil unit manufacturer shall factory set the brushless "ECM" motor and associated controller/inverter to the maximum discharge airflow for heating and cooling and minimum deadband airflow specified and indicated in the Contract Documents.
 - .15 All fan coil units shall be factory-built and tested in accordance with the latest applicable industry standards as specified herein and be CSA or ETL listed.

3 EXECUTION

3.1 MOCK-UP

- .1 Prior to the installation of multiple fan coil units, the Contractor shall install one of each size of the fan coil units as mock-up conditions generally representative of each typical installation.
- .2 Each mock-up condition shall be complete with piping, condensate piping ductwork, fan coil unit hangers, control, electrical connections and code clearances.
- .3 Mock-up installations shall be located within one of the typical areas of the project.
- .4 The Contractor shall advise the appropriate City Building Inspector, Consultant, and Owner's Representative after the mock-up is complete and ready for review and inspection. The Contractor shall arrange a time mutually agreeable to these parties so they can meet at the project site, review the mock-up installation, and determine any changes that need to be made for the installation to be acceptable to the City Building Inspector.
- .5 Issues regarding access and OESC clearances plus obstructions and conflicts with other trades shall be discussed and mutually agreed upon.
- .6 The mock-up condition, review of the mock-up condition by the appropriate parties, and the necessary modifications for the mock-up to become code compliant in the opinion of the City Building Authority shall be completed prior to the installation of additional fan coil units.
- .7 The Contractor shall account for this requirement in the schedule of construction so this procedure does not delay the construction progress.
- .8 If multiple fan coil units are installed prior to the mock-up approval, the Contractor shall be responsible for the remedial work required to comply with the approved mock-up condition at no additional cost to the Owner.
- .9 The Contractor shall provide a minimum of seven working days advance notice to the appropriate parties of the fan coil unit's mock-up inspection.
- .10 If additional or follow-up field inspections of the mock-up modifications are required to establish the approval of the City Building Inspector, the Contractor shall provide these modifications and additional follow-up field inspections as required without additional cost to the Owner.

3.2 INSTALLATION

Terminal Heat Transfer Units

- .1 Install to manufacturer's instructions.
- .2 Install equipment exposed to finished areas after walls and ceiling are finished and painted. Avoid damage.
- .3 Hydronic Units: Provide with shut-off valve on supply and lockshield balancing valve on return piping. If not easily accessible, extend vent to exterior surface of cabinet for easy servicing. for cabinet unit heaters, fan coil units, and unit heaters, provide float operated automatic air vents with stop valve.
- .4 Install electric heating equipment including devices provided by manufacturer but not factory-mounted. Provide copy of manufacturer's wiring diagram submittal. Install electrical wiring to manufacturer's submittals and to Division 26.

3.3 CLEANING

- .1 After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.
- .2 touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials provided by manufacturer (VOC content not to exceed 250 g/L).
- .3 Install new filters.

END OF SECTION

DUCT MOUNTED (ELECTRIC) HEATING COILS

1 GENERAL

1.01 SUBMITTALS

- .1 **Product Data:** Submit product data sheets for heating coils, including accessories. Product data sheets must confirm that equipment conforms to requirements of the Contract Documents.

2 PRODUCTS

2.01 DUCT MOUNTED ELECTRONIC HEATING COILS

- .1 Electric heating coils as per the drawing schedule and complete with:
 - .1 **casing:** flanged galvanized steel casing arranged to prevent air bypass around the coil and factory punched for duct connections
- .2 Acceptable manufacturers are:
 - .1 Ouelette
 - .2 Thermolec

3 EXECUTION

3.01 INSTALLATION OF DUCT MOUNTED ELECTRIC HEATING COILS

- .1 Provide duct mounting heating coils in supply ductwork where shown.
- .2 Secure each coil in place from the structure by means of hanger rods, independent of connecting ductwork but ready for duct connection.
- .3 Coordinate electrical connections.

END OF SECTION

General Requirements

PART 1 - GENERAL

1.1 General Requirements

- .1 Read and conform to:
 - .1 The Contract CCDC2-2008, Stipulated Price Contract as amended,
 - .2 Division 1 requirements and documents referred to therein.
- .2 Section 25 01 01 applies to and governs the work of all Sections of Division 25.
- .3 The technical Sections of this Division are generally divided into units of work for the purpose of ready reference. The division of the work among subcontractors is not the Consultant's responsibility and the Consultant assumes no responsibility to act as an arbiter and/or to establish subcontract limits between any Sections of the work.
- .4 The specifications are integral with the drawings which accompany them. Neither is to be used alone. Any item or subject omitted from one but implied in the other is fully and properly required.
- .5 Wherever differences occur in the tender documents, the most onerous condition governs. Base the bid on the most costly arrangement.

1.2 Definitions

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

1.3 Work Included

- .1 Products and methods mentioned or shown in the Contract Documents complete with incidentals necessary for a complete operating installation. Provide all tools, equipment and services required to do the work.
- .2 Cutting and patching of new or existing work
- .3 Identification of equipment, valves, dampers and controllers
- .4 Motors required for equipment supplied under this Division.

General Requirements

- .5 Take such measures and include in Bid Price for the proper protection of the existing building and its finishes at all times during alterations and construction of the new addition. Coordinate this protective work with all trades.
- .6 Refer to Mechanical/Electrical Equipment Schedule for extent of wiring and electrical characteristics.
- .7 Verify the correct operation of each equipment item provided and/or altered and each system in total and obtain the Owner's approval prior to starting and/or returning to operation.

1.4 Submittals

- .1 Approval Drawings: Prepare and submit drawings necessary for approval to any authority having jurisdiction, and obtain two (2) copies of approved drawings for retention by Consultant prior to commencement of work under this Division.
- .2 Shop Drawings: Prepare and submit two (2) copies of shop drawings of major equipment items (including those items specifically indicated under Part 1: General of each Section), to the Consultant for review. The Consultant will return one copy, marked with comments and his review stamp as he deems appropriate. Prepare the necessary number of copies of the returned set and distribute to the Owner, the Prime Consultant, the General Contractor, the site, and to subcontractors and suppliers.
 - .1 Clearly indicate manufacturer's and supplier's names, catalogue model numbers, details of construction, accurate dimensions, capacities and performance. Prior to submission check and certify as correct, shop drawings and data sheets. Do not order equipment until a copy of the shop drawings, reviewed by Consultant, has been returned to Contractor.
 - .2 Clearly indicate the weight, location, method of support and anchor point forces and locations for each piece of equipment on shop drawings.
 - .3 The Consultant will not review shop drawings that fail to bear the Contractor's stamp of approval or certification.
 - .4 Read the following in conjunction with the wording on the shop drawing review stamp applied to each and every drawing submitted:
"This review by the Consultant is for the sole purpose of ascertaining conformance with general design concept. This review shall not mean that the Consultant approves the detail design inherent in the shop drawings, responsibility for which shall remain with the Contractor submitting same, and such review shall not relieve the Contractor of his responsibility for errors or omissions in the shop drawings or of his responsibility for meeting all requirements of the Contract Documents. The Contractor is responsible for dimensions to be confirmed and correlated at the job site, for information that pertains solely to fabrication processes or to techniques of construction and installation and for coordination of the work of all sub trades."
- .3 Composite Wiring Diagrams: Prepare and submit three (3) copies of complete 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,

General Requirements

- .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 name of project]
[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.

General Requirements

- .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 Electrical & Electronic Manufacturer's Association of Canada
 - .11 NBC National Building Code of Canada
 - .12 NEBB National Environmental Balancing Bureau
 - .13 NFPA National Fire Protection Association
 - .14 NEMA National Electrical Manufacturers Association
 - .15 OBC Ontario Building Code
 - .16 OFC Ontario Fire Code
 - .17 OFM Ontario Fire Marshall
 - .18 ULC Underwriter's Laboratories of Canada Ltd
 - .19 UL Underwriter's Laboratories (including cUL)
- .3 Use latest editions and amendments in effect on date of Bid call subject to requirements of OBC.
- .4 Arrange and pay for permits and inspections by authorities having jurisdiction, required in the undertaking of this Division. Make modifications required by authorities.
- .5 All tradesmen employed on the project shall hold valid trade certificates/licenses and shall make a copy available for review by the Consultant and/or Owner when requested.

1.6 Product Delivery, Handling and Storage

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

General Requirements

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 25 01 01 General Requirements.
- .2 Arrange with each manufacturer/supplier to extend warranties as necessary to coincide with warranty period or those periods specified.
- .3 Make submissions necessary to register product warranties to the benefit of the Owner.
- .4 Submit to Consultant, prior to Substantial Performance of the Contract, manufacturer's written warranties covering periods longer than one year or offering greater benefits than required in specifications and in the Owner's name.

1.10 Extras and Credits

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

PART 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.

General Requirements

- .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.

General Requirements

- .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.

PART 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

General Requirements

- .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

General Requirements

- 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 01 80 50 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 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.
- .4 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.
- .5 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.
- .6 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.
- .7 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,
 - .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.
- .8 Commissioning manuals shall include machine printable index dividers to organize each manual by system and by commissioning stage.

END OF SECTION

Demolition & Renovations

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 05 05 & 25 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 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.
- .6 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 all authorities of intent to demolish and schedule for the work. Obtain required permits from authorities.
- .2 Conform to all 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 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.

1.5 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 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.

Demolition & Renovations

1.6 PHASING AND SCHEDULING

- .1 Refer to Division 1 PHASING AND SCHEDULING OF THE WORK.
- .2 Coordinate with the work of all Sections of Division 25 with other trades and assist in the development of the Phasing Strategy.

2 PRODUCTS

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 shut downs 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, supported above floors 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 any and all damage to the building and components resulting from failure to provide sufficient protection, to the satisfaction of the Consultant.
- .3 All existing air intake and exhaust openings that may be affected by dust and/or debris from the construction work shall be fitted with appropriate filter media to protect against entry of dust and/or debris into the building and its air distribution systems. Filters shall be closely monitored and replaced when necessary. The Contractor shall replace existing filters that become contaminated with dust and/or debris from construction work with new filters.
- .4 In the event that dust and debris from construction work does penetrate the building and/or its air distribution systems, the Contractor shall be responsible for cleaning the affected areas and/or systems.
- .5 Temporary filters shall be removed on completion of the construction works.

3.4 DEMOLITION

- .1 Notify all authorities of intent to demolish and schedule for the work.
- .2 All demolition work shall conform to all codes, regulations, standards and by-laws applicable to the

Demolition & Renovations

- 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, natural gas service, steam service, condensate return, water supply to standpipe and sprinkler systems, fire suppression systems hot water heating systems, steam and condensate 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 all service shut downs 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 All demolition work shall 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 Waste disposal shall conform to the requirements of Division 1, municipal By-Laws and Ministry of the Environment regulations and standards.
 - .10 All existing air intake and exhaust openings that may be affected by dust and/or debris from the demolition work shall be fitted with appropriate filter media to protect against entry of dust and/or debris into the building and its air distribution systems. Filters shall be closely monitored and replaced when necessary. The Contractor shall replace existing filters that become contaminated with dust and/or debris from demolition work with new filters.
 - .11 In the event that dust and debris from demolition work does penetrate the building and/or its air distribution systems, this Section shall be responsible for cleaning the affected areas and/or systems.
 - .12 Disconnect, remove, cap and identify all utilities within demolition areas.
 - .13 Demolish in an orderly and careful manner. Protect existing supporting structural members.
 - .14 Remove demolished materials from site except where specifically noted otherwise. Do not burn or bury materials on site.
 - .15 Remove materials as Work progresses. Upon completion of Work, leave areas in clean condition.
 - .16 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 Existing items to be relocated shall be cleaned and repaired or altered as required to suit new location. All damaged or ineffective parts shall be replaced and the item made "as new".
- .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 all surfaces and finishes in areas from which items have been removed and in which items are relocated. Cap all existing services required to be severed to effect alterations and do all other work necessary to make good such areas to satisfaction of consultant.
- .6 Openings in existing floor assemblies and vertical fire separations necessitated by installation of equipment and systems or construction in general must be temporarily sealed 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.

Demolition & Renovations

- .8 Existing refrigerant indicated to be removed shall not be discharged to the atmosphere, but shall be salvaged and reclaimed or disposed of following the guidelines of the authority having jurisdiction.
- .9 All existing air intake and exhaust openings that may be affected by dust and/or debris from the renovation work shall be fitted with appropriate filter media to protect against entry of dust and/or debris into the building and its air distribution systems. Filters shall be closely monitored and replaced when necessary. The Contractor shall replace existing filters that become contaminated with dust and/or debris from renovation work with new filters.
- .10 In the event that dust and debris from renovation work does penetrate the building and/or its air distribution systems, the Contractor shall be responsible for cleaning the affected areas and/or systems.
- .11 Temporary filters shall be removed on completion of the renovation work.

3.6 INSPECTION AND RE-CERTIFICATION

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

END OF SECTION

Common Work Results

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 05 05 & 25 01 01.

1.2 COMMON WORK RESULTS

- .1 Section 25 05 00 applies to and governs all work of Division 25.

1.3 REFERENCE STANDARDS

- .1 Provide all work in accordance with requirements of Regulatory Agencies and conform to:
 - .1 Local and district by-laws, regulations and published engineering standards.
 - .2 the Ontario Building Code (OBC) as amended,
 - .3 the Ontario Fire Code (OFC) as amended,
 - .4 the Ontario Electrical Safety Code (OESC).
 - .5 Regulations for Construction Projects under The Occupational Health and Safety Act.
- .2 Conform to following National Research Council Canada publications:
 - .1 National Building Code of Canada (NBC) and Supplements to National Building Code of Canada
 - .2 National Fire Code of Canada (NFC).
- .3 Conform to following National Fire Protection Association publications:
 - .1 NFPA 70 National Electrical Code (NEC)

1.4 FIELD QUALITY CONTROL

- .1 All work, materials, and equipment shall comply with the rules and regulations of applicable local, provincial and federal codes and standards.
- .2 Contractor shall continually monitor the field installation for code compliance and quality of workmanship.

1.5 QUALIFICATIONS

- .1 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.

1.6 SUBMITTALS

- .1 Submit shop drawings in accordance with Section 25 01 01, for the following items:
 - .1 firestopping compounds and applications schedule
 - .2 access doors

1.7 DELIVERY, STORAGE, AND HANDLING

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

Common Work Results

1.8 WASTE MANAGEMENT & DISPOSAL

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

1.9 WARRANTY

- .1 Provide extended coverage five year warranty for controls and instrumentation components.

2 PRODUCTS

2.1 ELECTRICAL COMPONENTS AND WIRING

- .1 Conform to requirements of Division 26 for all wiring, conduits and raceways, boxes, and cable trays included in Division 25.
- .2 All pre-wired equipment provided by Sections under Division 25 shall conform to requirements of Division 26. Ensure that all pre-wired electrical equipment is CSA approved. Arrange and pay for special approval where this is not possible.
- .3 Communication and control wiring and power supplies specified as conforming to NEC Class 1, Class 2 and Class 3 wiring practices must also conform to OESC Section 16 requirements.

2.2 COMMUNICATION AND CONTROL WIRING

- .1 General:
 - .1 Provide copper wiring, plenum cable, and raceways as specified in the applicable Sections of Division 26 unless otherwise noted herein.
 - .2 All insulated wire to be copper conductors, ULC labeled for 90°C minimum service.
- .2 Wire Sizing and Insulation
 - .1 Wiring shall comply with minimum wire size and insulation based on services listed below:

Service	Minimum Gage/Type	Insulation Class
AC 24V Power	12 Ga Solid	600 Volt
DC 24V Power	10 Ga Solid	600 Volt
Class 1	14 Ga Stranded	600 Volt
Class 2	18 Ga Stranded	300 Volt
Class 3	18 Ga Stranded	300 Volt

- .2 Provide plenum-rated cable when open cable is permitted in supply or return air plenum.
- .3 Power Wiring:
 - .1 115V power circuit wiring above 100 feet distance shall use minimum 10 gage.
 - .2 24V control power wiring above 200 feet distance shall use minimum 12 gage.
- .4 Control Wiring:
 - .1 Digital Input/Output wiring shall use Class 2 twisted pair, insulated.
 - .2 Analog inputs shall use Class 2 twisted shielded pair, insulated and jacketed and require a grounded shield.
 - .3 Actuators with tri-state control shall use Class 3 conductor with same characteristics

Common Work Results

- .5 Communication Wiring
 - .1 Ethernet Cable shall be minimum CAT5e and as required for system components.
 - .2 Secondary level network shall be 24 gage, TSP, low capacitance cable
- .6 Approved Cable Manufacturers: Wiring from the following manufacturers which meet the above criteria shall be acceptable:
 - .1 Anixter
 - .2 Belden
 - .3 Cerco

2.3 POWER SUPPLIES AND LINE FILTERING

- .1 Control transformers shall be ULC listed. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.
- .2 DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand a 150% current overload for at least three seconds without trip-out or failure.
 - .1 Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
 - .2 Line voltage units shall be ULC recognized and CSA approved.
- .3 Power line filtering: Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component. Surge protection shall have the following at a minimum:
 - .1 Dielectric strength of 1000 volts minimum
 - .2 Response time of 10 nanoseconds or less
 - .3 Transverse mode noise attenuation of 65 dB or greater
 - .4 Common mode noise attenuation of 150 dB or better at 40 Hz to 100 Hz.

2.4 FIRESTOPPING COMPOUNDS

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

2.5 NAMEPLATES

- .1 Provide laminated plastic plates with black face and white centre of minimum size 3-1/2" x 1-1/2" x 3/32" (90 x 40 x 2 mm) nominal thickness, engraved with 1/4" (6 mm) high lettering. Use 1" (25 mm) lettering for major equipment.
- .2 Fasten nameplates securely in conspicuous place. Where nameplates cannot be mounted on cool surface, provide standoffs.
- .3 Identify equipment type and number and service of areas or zone of building served.
- .4 For each item of equipment supplied and/or installed under this Division which may be started automatically or remotely, provide a red lamacoid plate, 2-1/2" x 9" (60 x 230 mm), reading:
"WARNING. THIS EQUIPMENT IS AUTOMATICALLY
CONTROLLED AND MAY START AT ANY TIME."

2.6 TAGS

Common Work Results

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

3 EXECUTION

3.1 INSPECTION

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

3.2 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 Coordinate all wiring requirements with other Divisions. Line voltage wiring from power distribution panels to starters and from starters to motors will be provided under Division 26. All other field wiring for equipment shall be included under Division 25.

3.4 PROTECTION

- .1 Protect finished and unfinished work by tarpaulins, or other covering, from damage due to execution of work under this Division.
- .2 Repair to satisfaction of Consultant, damage to building resulting from failure to provide such protection.
- .3 All existing air intake and exhaust openings that may be affected by dust and/or debris from the construction work of this Division shall be fitted with appropriate filter media to protect against entry of dust and/or debris into the building and its air distribution systems. Filters shall be closely monitored and replaced when necessary. The Contractor shall replace existing filters that become contaminated with dust and/or debris from construction work with new filters.
- .4 In the event that dust and debris from construction work does penetrate the building and/or its air distribution systems, the Contractor shall be responsible for cleaning the affected areas and/or systems.
- .5 Temporary filters shall be removed on completion of the construction works.

3.5 CUTTING AND PATCHING

Common Work Results

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

3.6 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.

3.7 FIRESTOPPING

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

3.8 SUPPORT AND ATTACHEMENT

- .1 Support and attach raceways and equipment from load bearing structures such as beams, joists, reinforced concrete slabs and concrete block walls.

Common Work Results

- .2 Do not support from or attach to steel roof deck and/or wall or ceiling finishes.

3.9 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.

3.10 FLOW DIAGRAMS AND DIRECTORIES

- .1 Provide Consultant with six identification flow diagrams of approved size for each system. Include tag schedule, designating number, service, function, and location of each tagged item and normal operating position of valves.
- .2 Install where agreed with the Owner one copy of each flow diagram and valve schedule mounted in glazed frame. Provide one copy of each in Operation and Maintenance Manual.

3.11 INSTALLATION PRACTICES

- .1 BMS Wiring
 - .1 All conduit, wiring, accessories and wiring connections required for the installation of the Building Management System, as herein specified, shall be provided by the BMS Contractor unless specifically shown on the Electrical Drawings under Division 26 Electrical. All wiring shall comply with the requirements of applicable portions of Division 26 and all local and national electric codes, unless specified otherwise in this section.
 - .2 All BMS wiring materials and installation methods shall comply with BMS manufacturer recommendations.
 - .3 Class 2 Wiring
 - .1 All Class 2 (24VAC or less) wiring shall be installed in conduit unless otherwise specified.
 - .2 Class 2 wiring in concealed accessible locations shall be FT-6 plenum rated.
 - .3 Class 2 wiring not installed in conduit shall be supported every 5' from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements.
 - .4 Class 2 signal wiring and 24VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.
 - .5 Provide for complete grounding of all applicable signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops.
- .2 BMS Line Voltage Power Source
 - .1 120-volt AC circuits used for the Building Management System shall be taken from panel boards and circuit breakers provided under Division 26.
 - .2 Circuits used for the BMS shall be dedicated to the BMS and shall not be used for any other purposes.
 - .3 DDC terminal unit controllers may use AC power from motor power circuits.
- .3 BMS Raceway
 - .1 All wiring shall be installed in conduit or raceway except as noted elsewhere in this specification. Minimum control wiring conduit size 1/2".
 - .2 Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used as approved by the Architect.
 - .3 All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.

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- .4 Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.
- .4 Penetrations
 - .1 Provide fire stopping for all penetrations used by dedicated BMS conduits and raceways.
 - .2 All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.
 - .3 All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.
 - .4 Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.
- .5 BMS Identification Standards
 - .1 Node Identification. All nodes shall be identified by a permanent label fastened to the enclosure. Labels shall be suitable for the node location.
 - .2 Cable types specified in Item A shall be color coded for easy identification and troubleshooting.
- .6 BMS Panel Installation
 - .1 The BMS panels and cabinets shall be located as indicated at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer's recommendations.
 - .2 The BMS contractor shall be responsible for coordinating panel locations with other trades and electrical and mechanical contractors.
- .7 Input Devices
 - .1 All Input devices shall be installed per the manufacturer recommendation
 - .2 Locate components of the BMS in accessible local control panels wherever possible.
- .8 HVAC Input Devices - General
 - .1 All Input devices shall be installed per the manufacturer recommendation
 - .2 Locate components of the BMS in accessible local control panels wherever possible.
 - .3 The mechanical contractor shall install all in-line devices such as temperature wells, pressure taps, airflow stations, etc.
 - .4 Input Flow Measuring Devices shall be installed in strict compliance with ASME guidelines affecting non-standard approach conditions.
 - .5 Air Flow Measuring Stations:
 - .1 Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct.
 - .2 Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.
 - .6 Duct Temperature Sensors:
 - .1 Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
 - .2 The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.
 - .3 For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.
 - .4 The sensor shall be mounted to suitable supports using factory approved element holders.
 - .7 Space Sensors:
 - .1 Shall be mounted per ADA requirements.
 - .2 Provide lockable tamper-proof covers in public areas and/or where indicated on the plans.
 - .8 Air Differential Pressure Status Switches:
 - .1 Install with static pressure taps, tubing, fittings, and air filter.
- .9 HVAC Output Devices
 - .1 All output devices shall be installed per the manufacturers' recommendation. The mechanical

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- contractor shall install all in-line devices such as control valves, dampers, airflow stations, pressure wells, etc.
- .2 Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke. When any pneumatic actuator is sequenced with another device, pilot positioners shall be installed to allow for proper sequencing.
 - .3 Control Dampers: Shall be opposed blade for modulating control of airflow. Parallel blade dampers shall be installed for two position applications.
 - .4 Control Valves: Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI.
 - .5 Electronic Signal Isolation Transducers: Whenever an analog output signal from the Building Management System is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input a signal from a remote system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between systems. Signals shall provide optical isolation between systems

3.12 WIRING

- .1 All control and interlock wiring shall comply with provincial electrical codes, standards and Division 26.
- .2 All NEC Class 1 wiring shall be ULC Listed in approved conduit according to OESC and Division 26 requirements.
- .3 All low-voltage wiring shall meet NEC Class 2 requirements. Low-voltage power circuits shall be sub-fused when required to meet NEC Class 2 current limitations.
- .4 Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in conduit may be used provided that cables are ULC Listed for the intended application. For example, cables used in ceiling plenums shall be ULC Listed specifically for that purpose.
- .5 All wiring in mechanical, electrical, or service rooms-or where subject to mechanical damage- shall be installed in conduit.
- .6 Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).
- .7 Do not install wiring in conduit containing tubing.
- .8 Where plenum rated cable is run exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 3 m (10 ft) intervals.
- .9 Where plenum rated cable is used without conduit, it shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical conduits, piping, or ceiling suspension systems.
- .10 All wire-to-device connections shall be made at a terminal block or wire nut. All wire-to-wire connections shall be at a terminal strip or wire nut.
- .11 All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
- .12 Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, this Division shall provide step-down transformers or interposing relays.
- .13 All plenum rated wiring shall be installed as continuous lengths, with no splices permitted between termination points
- .14 All wiring in conduit shall be installed as continuous lengths, with no splices permitted between termination points or junction boxes.
- .15 Maintain fire rating at all penetrations. Install plenum wiring in sleeves where it passes through walls and floors.
- .16 Size and type of conduit and size and type of wire shall be the responsibility of the contractor, in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.
- .17 Include one pull string in each conduit 3/4 in. or larger.

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- .18 Control and status relays are to be located in designated enclosures only. These enclosures can include packaged equipment control panel enclosures unless they also contain Class 1 starters.
- .19 Conceal all conduit, except within mechanical, electrical, or service rooms. Install conduit to maintain a minimum clearance of 15 cm (6 in.) from high-temperature equipment (e.g., steam pipes, gas vents or flues).
- .20 Secure conduit with conduit clamps fastened to the structure and spaced according to code requirements. Conduit and pull boxes may not be hung on flexible duct strap or tie rods. Conduits may not be run on or attached to ductwork.
- .21 Adhere to this specification's Division 26 requirements where conduit crosses building expansion joints.
- .22 This Division shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
- .23 Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 1 m (3 ft) in length and shall be supported at each end. Flexible metal conduit less than ½ in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.
- .24 Conduit must be adequately supported, properly reamed at both ends, and left clean and free of obstructions. Conduit sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

3.13 COMMUNICATION WIRING

- .1 This Division shall adhere to the items listed in the "Wiring" article 3.14.
- .2 All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.
- .3 Do not install communication wiring in raceway and enclosures containing NEC Class 1 or other Class 2 wiring.
- .4 Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.
- .5 Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.
- .6 When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lightning arrestor shall be installed according to the manufacturer's instructions.
- .7 All runs of communication wiring shall be unspliced length when that length is commercially available.
- .8 All communication wiring shall be labeled to indicate origination and destination data.
- .9 Grounding of coaxial cable shall be in accordance with OESC and NEC regulations on "Communications Circuits, Cable, and Protector Grounding."

3.14 INPUT/OUTPUT INTERFACE

- .1 Hardwired inputs and outputs may tie into the system through building or application specific controllers.
- .2 All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no damage to the controller.
- .3 Binary inputs shall allow the monitoring of On/Off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.
- .4 Pulse accumulation input objects. This type of object shall conform to all the requirements of binary input objects and also accept up to 10 pulses per second for pulse accumulation.
- .5 Analog inputs shall allow the monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or

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- resistance signals (thermistor, RTD). Analog inputs shall be compatible with-and field configurable to commonly available sensing devices.
- .6 Binary outputs shall provide for On/Off operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers shall have three-position (On/Off/Auto) override switches and status lights. Outputs shall be selectable for either normally open or normally closed operation.
 - .7 Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC, 4 to 20 mA or 0-20 PSI signal as required to provide proper control of the output device. Analog outputs on building or custom application controllers shall have status lights and a two-position (AUTO/MANUAL) switch and manually adjustable potentiometer for manual override. Analog outputs shall not exhibit a drift of greater than 0.4% of range per year.
 - .8 Tri-State Outputs. Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point floating devices shall be limited to zone control and terminal unit control applications (VAV terminal units, duct-mounted heating coils, zone dampers, radiation, etc.). Control algorithms shall run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.
 - .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.

3.15 INSTALLATION OF SENSORS

- .1 General:
 - .1 Install sensors in accordance with the manufacturer's recommendations.
 - .2 Mount sensors rigidly and adequately for the environment within which the sensor operates.
 - .3 Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.
 - .4 All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.
 - .5 Sensors used in mixing plenums and hot and cold decks shall be of the averaging type.
 - .6 Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across the full face of the coil.
 - .7 All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.
 - .8 Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.
- .2 Room Instrument Mounting
 - .1 Room instruments, including but not limited to wall mounted thermostats and sensors located in occupied spaces shall be mounted 53 inches above the finished floor unless otherwise shown.
- .3 Instrumentation Installed in Piping Systems
 - .1 Thermometers and temperature sensing elements installed in liquid systems shall be installed in thermowells.
 - .2 Gauges in piping systems subject to pulsation shall have snubbers.
 - .3 Gauges for steam service shall have pigtail fittings with isolation valve.
- .4 Duct Smoke Detectors
 - .1 Duct smoke detectors will be provided by the Fire Alarm System Contractor in supply and return air ducts in accordance with Division 26
 - .2 Contractor shall connect the DDC System to the auxiliary contacts provided on the Smoke Detector as required for system safeties and to provide alarms to the DDC system.
- .5 Averaging Temperature Sensing Elements
 - .1 Sensing elements shall be installed in a serpentine pattern.

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- .2 Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
- .6 Relative Humidity Sensors
 - .1 Relative humidity sensors in supply air ducts shall be installed at least 3m (10 feet) downstream of humidity injection elements.

3.16 ACTUATORS

- .1 Mount and link control damper actuators according to manufacturer's instructions.
 - .1 To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
 - .2 Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
 - .3 Provide all mounting hardware and linkages for actuator installation.
- .2 Electric/Electronic
 - .1 Dampers: Actuators shall be direct-mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° available for tightening the damper seals. Actuators shall be mounted following manufacturer's recommendations.
 - .2 Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.
- .3 Identification of Tubing and Wiring
 - .1 All wiring and cabling including that within factory-fabricated panels shall be labeled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.
 - .2 Permanently label or code each point of field terminal strips to show the instrument or item served.
 - .3 All pneumatic tubing shall be labeled at each end within 5 cm (2 in.) of termination with a descriptive identifier.

3.17 IDENTIFICATION OF HARDWARE AND WIRING

- .1 All wiring and cabling, including that within factory-fabricated panels shall be labeled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.
- .2 All pneumatic tubing shall be removed.
- .3 Permanently label or code each point of field terminal strips to show the instrument or item served.
- .4 Identify control panels and major control components on outside with minimum 1 cm (½ in.) letters on laminated plastic nameplates.
- .5 Identify all other control components with permanent labels. All plug-in components shall be labeled such that removal of the component does not remove the label.
- .6 Identify room sensors relating to terminal box or valves with nameplates.
- .7 Manufacturers' nameplates and ULC or CSA labels are to be visible and legible after equipment is installed.
- .8 Identifiers shall match record documents.
- .9 Degrease and clean surfaces to receive adhesive for identification materials.
- .10 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).
- .11 Install tags with corrosion resistant chain.
- .12 Clearly identify abandoned services left in place as "ABANDONED".
- .13 For each item of equipment which may be started automatically or remotely, add a red lamacoid plate, 2-3/8" x 9" (60 x 230 mm), reading: **"WARNING. THIS EQUIPMENT IS AUTOMATICALLY CONTROLLED. IT MAY START AT ANY TIME."**

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- .14 Provide colour coded self-adhesive dots to locate control devices and panels located above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

3.18 EQUIPMENT TESTING AND INSPECTION

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

3.19 ADJUST AND CLEAN

- .1 Clean up all debris resulting from their activities daily. Remove all cartons, containers, crates, etc. as soon as their contents have been removed. Collect and sort waste and deposit in designated locations.
- .2 At the completion of work in any area, clean all work keeping it free from dust, dirt, and debris. Check all equipment furnished under this Division for paint damage. Repair any factory-finished paint that has been damaged to match the adjacent areas. Any equipment item, cabinet or enclosure that has been deformed shall be replaced with new material and painted to match adjacent areas.
- .3 Lubricate mechanical equipment installed under this Division.
- .4 Test and adjust control devices, instrumentation, valves, dampers, etc. installed under this Division after cleaning of systems and leave in perfect order ready for operation.
- .5 Remove from the premises upon completion of work of this Division, debris, surplus, and waste materials resulting from operations.

END OF SECTION

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PART 1 - GENERAL

1.1 Product Data

- .1 Submit product data in accordance with Section 01 33 00 - submittal procedures.

1.2 Waste Management And Disposal

- .1 Separate and recycle waste materials in accordance with Section 01 74 03 - construction/demolition waste management and disposal, and with the waste reduction work plan.
- .2 Ensure emptied containers are sealed and stored safely for disposal away from students.

1.3 Scope Of Work

- .1 Installation/integration of new Laboratory & Office control system utilizing Distributed Digital Control (DDC) for energy management, equipment monitoring and control consisting of microprocessor based DDC Controllers and Floor Level third party BACnet Integrators. The apex of the new BAS architecture shall be a Facility Explorer Supervisory Controller which can be accessed via operator workstation or through a web-based interface. The supervisory controller shall be open protocol BACnet MS/TP and have the capability to be integrated the existing Campus wide BAS.
- .2 The new laboratory control system shall consist generally of 1 supply venturi with reheat coil and 1 general exhaust venturi. The supply and general exhaust terminals modulate between the minimum and maximum airflows. The total exhaust air volume and the total supply air volume for the lab is monitored and controlled to maintain a negative/positive airflow relative to the exhaust air flow.
- .3 The new office control system shall consist generally of 1 supply variable air volume box with electric reheat coil and open-ended ceiling return. The AHU return air fan will track the supply air fan at an offset of -5% airflow to provide typical VAV system operation.
- .4 The installation of the control system shall be performed with the shop drawings, flow diagrams, bill of materials, component designation or identification number and sequence of operation.
- .5 All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed specifically for this project. All systems and components shall have been thoroughly tested and proven in actual use for at least two years.
- .6 Contractor shall be responsible for all BAS and temperature control wiring for a complete and operable system.
- .7 Provide power wiring to field panels and other devices requiring a main supply from circuit breakers.
- .8 Contractor shall provide temperature sensor wells if required.
- .9 The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC Controllers and operator interface devices.

1.4 Quality Assurance

- .1 The BAS system shall be designed and installed, commissioned and serviced by factory trained personnel.
- .2 The contractor shall provide an experienced project supervisor and single contract person.
- .3 Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's

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latest standard design that complies with the specification requirements. All BAS Peer-To-Peer Network Controllers, Central System Controllers And Local User Displays Shall Be UL Listed Under Standard UL 916, Category PAZX; Standard ULC C100, Category UUKL7; And Under Standard UL 864, Categories UUKL, UDTZ, And QVAX, And Be So Listed At The Time Of Bid. All Floor Level Controllers Shall Comply, at a minimum, with UL Standard UL 916 category PAZX; Standard UL 864, Categories UDTZ, And QVAX. And Be So Listed At The Time Of Bid.

- .4 Provide electric and electronic equipment that is CSA or Ontario Hydro approved where the regulatory authorities require such approvals.
- .5 The manufacturer of the building automation system shall provide documentation supporting compliance with iso-9002 (model for quality assurance in production, installation, and servicing) and iso-140001 (the application of well-accepted business management principles to the environment). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a quality system and framework that will assure consistency in the products delivered for this project.
- .6 This system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability to upgrade existing field panels to current level of technology, and extend new field panels on a previously installed network.
- .7 Compatibility shall be defined as the ability for any existing field panel microprocessor to be connected and directly communicate with new field panels without bridges, routers, or protocol converters.

1.5 Manufacturers

- .1 Base Building Controls Contractor: Johnson Controls Inc.

1.6 Related Work

- .1 Provide interfacing of all controls to the BAS under this contract as described in this specification.
- .2 Provide hardware interfacing to all controls instrumentation provided as specified in this section.

1.7 Electrical Wiring

- .1 All wiring shall be in accordance with the governing electrical authority and Electrical Contractor requirements. This includes wiring between control components and wiring from such components to electrical circuits of fans, pumps, and any other equipment.
- .2 Electrical interlock wiring of field devices (i.e., flow switches, thermostats) associated with equipment specified under other sections of this division is the responsibility of this section, unless indicated otherwise.
- .3 The BAS contractor is responsible for all communication wiring interconnecting the panels to the BAS.

1.8 Co-ordination of Work

- .1 The controls contractor shall design, provide, install, test, commission, and guarantee the system.
- .2 Provide all control devices, instrumentation, relays, auxiliary contacts, and transformers as specified and as required to meet the control and monitoring points and sequence of operation.
- .3 Mount and wire third party open protocol interface panels.

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.4 Automatic control valves

- .1 Supply all automatic control valves required by the sequences of operation, and not specified as an integral part of equipment specified elsewhere in this Division, for installation by Section 23 21 13 – Hydronic Piping. Controls contractor shall provide and connect all associated valve actuators.

1.9 Shop Drawings

.1 Submit shop drawings for the following:

- .1 All building automation and other control components.
- .2 Workstation hardware (if applicable).
- .3 Identified schematic control diagrams for all systems, each diagram indicating control components, component catalogue numbers, operation sequence, and interlocking.
- .4 Riser diagram showing the physical location of building control system equipment and the system architecture. DDC Controller trunk conductors shall also be shown.
- .5 List of connected data points, including DDC Controller's to which they are connected and input/output devices (sensors, transducers, etc.), show panel spare capacity.
- .6 Drawings of each HVAC system showing all connected (connected and calculated) point addresses and operator notations.
- .7 Complete sequences of operation of the DDC systems in both flow chart and program format.
- .8 BAS central system configuration complete with all peripheral devices, batteries, power supplies, modems, etc. with interconnection diagrams.
- .9 Technical specification data sheets of each system component and software module.
- .10 Descriptive data and sequence of operation of all operating, user, and application software including a complete Operators Manual and Programmers Manual tailored to the job.
- .11 Valve and damper schedules.

1.10 Reference Standards

- .1 Provide electrical and electronic equipment, which is C.S.A. or Ontario Hydro approved where such approvals are required by the regulatory authorities.
- .2 Provide ASCII American standard for communication and information interchange code input/output devices with standard via electronic industry association interface.

1.11 Submittals

- .1 Submit operation and maintenance manuals prior to acceptance testing. Manuals shall include:
 - .1 Index sheet, listing contents in alphabetical order
 - .2 Manufacturer's equipment parts list of all functional components of the system
 - .3 Auto-CAD disk of system schematics, including wiring diagrams
 - .4 Description of sequence of operations
 - .5 As-Built interconnection wiring diagrams

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- .6 Operator's Manual
- .7 Trunk cable schematic showing remote electronic panel locations and all trunk data
- .8 List of connected data points, including panels to which they are connected and input device (ionization detector, sensors, etc.)
- .9 Conduit routing diagrams
- .2 Provide programmer information.
- .3 Provide manufacturer's certification letter.

1.12 Networking Communications

- .1 The network architecture shall consist of multiple levels for communication efficiency with DDC controller floor level local area BACnet MS/TP networks with access being totally transparent to the user when accessing data or developing control programs.
- .2 The design of BAS shall allow the co-existence of new Facility Explorer DDC controllers with other third party DDC controllers in the same network without the use of gateways or protocol converters. The intent is to use the system provided under this contract to communicate with control systems provided by other vendors. A PICS must be provided describing the BACnet, ANSI/ASHRAE 135-2004 implementation. Minimum system functionality must include monitoring, commanding, and alarming for daily operator functions from a common workstation.
- .3 Peer-to-peer building level network:
 - .1 All operator devices either network resident or connected remotely shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the peer-to-peer network. No hardware or software limits shall be imposed on the number of devices with global access to the network data at any time.
 - .2 The peer-to-peer network shall support a minimum of 100 DDC controllers and PC workstations
 - .3 The system shall support integration of third party systems (fire alarm, security, lighting, fume hoods) via panel mounted BACnet open protocol processor. This processor shall exchange data between the two systems for processing control. All exchange points shall have full system functionality as specified herein for hardwired points.
 - .4 Field panels must be capable of integration with open standards including Modbus, BACnet, and LonWorks as well as with third party devices via existing vendor protocols.
 - .5 The peer-to-peer Building Level Network shall use BACnet IP over Ethernet. All devices must:
 - .1 Auto-sense 10/100 Mbps networks.
 - .2 Receive an IP Address from a Dynamic Host Configuration Protocol (DHCP) Server or be configured with a Fixed IP Address.
 - .3 Resolve Name to IP Addresses for devices using a Domain Name Service (DNS) Server on the Ethernet network.
 - .4 Allow access using Telnet.

1.13 DDC SUPERVISORY CONTROLLER LEVEL NETWORK

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- .1 A web-based, Niagara 4 supervisor class Facility Explorer controller shall support a family of application specific controllers using BACnet MS/TP protocol and shall communicate with the peer-to-peer network through DDC controllers for transmission of global data.

1.14 PCX MODULAR & COMPACT DDC CONTROLLERS

- .1 The Facility Explorer Programmable DDC controllers shall reside on the building level network.
- .2 DDC controllers shall use the same programming language and tools. DDC controllers, which require different programming language or tools on a network, are not acceptable.
- .3 DDC controllers, which do not meet the functions specified in Section 1.7.4 are not acceptable.
- .4 DDC controller
 - .1 The PCX Modular DDC Controllers shall be a 32-bit stand-alone, multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point I/O schedule. Each controller shall support a single floor level application specific controller device network.
 - .2 Each DDC Controller shall have sufficient memory, a minimum of 72 MB, to support its own operating system and databases, including:
 - .1 Control processes
 - .2 Energy management applications
 - .3 Alarm management applications including custom alarm messages for each level alarm for each point in the system.
 - .4 Historical/trend data for points specified
 - .5 Maintenance support applications
 - .6 Custom processes
 - .7 Password-protected Operator I/O
 - .8 Internet/Intranet communications
 - .3 Each DDC Controller shall support firmware upgrades without the need to replace hardware.
 - .4 Provide all processors, power supplies, and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.
 - .5 DDC Controllers shall provide a RS-485 serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. DDC Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or terminals.

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- .6 Each DDC Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failure to establish communication.
- .7 Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
 - .1 RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3 V
 - .2 Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact
 - .3 Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500 V signal, 1 kV power
 - .4 Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max)
- .8 Isolation shall be provided at all peer-to-peer panel's AC input terminals to suppress induced voltage transients consistent with:
 - .1 IEEE Standard 587-1980
 - .2 UL 864 Supply Line Transients
 - .3 Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)
- .9 In the event of the loss of normal power, there shall be an orderly shutdown of all DDC Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and SDRAM battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 60 days.
 - .1 Upon restoration of normal power, the DDC Controller shall automatically resume full operation without manual intervention.
 - .2 Should DDC Controller memory be lost for any reason, the user shall have the capability of reloading the DDC Controller via the local RS-485 port, via telephone line dial-in or from a network workstation PC.
- .10 Provide a separate DDC Controller for each AHU or other HVAC system equipment. It is intended that each unique system be provided with its own point resident DDC Controller.

1.15 PCX Modular & Compact DDC Controller Resident Software Features

- .1 General
 - .1 The software programs specified in this section shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer for execution.
 - .2 All points shall be identified by up to 30-character point name and 16-character point descriptor. The same names shall be used at the PC workstation.
 - .3 All digital points shall have user defined two-state status indication (descriptors with minimum of 8 characters allowed per state (i.e. summer/winter)).
- .2 Control software description:

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- .1 The DDC Controllers shall have the ability to perform the following pre-tested control algorithms:
 - .1 Two-position control
 - .2 Proportional control
 - .3 Proportional plus integral control
 - .4 Proportional, integral, plus derivative control
 - .5 Automatic tuning of control loops
- .3 DDC controllers shall provide the following energy management routines for the purpose of optimizing energy consumption while maintaining occupant comfort.
 - .1 Start-Stop Time Optimization (SSTO) shall automatically be coordinated with event scheduling. The SSTO program shall start HVAC equipment at the latest possible time that will allow the equipment to achieve the desired zone condition by time of occupancy. The SSTO program shall also shut down HVAC equipment at the earliest possible time before the end of the occupancy period, and still maintain desired comfort conditions.
 - .1 The SSTO program shall operate in both the heating and cooling seasons.
 - .1 It shall be possible to apply the SSTO program to individual fan systems.
 - .2 The SSTO program shall operate on both outside weather conditions as well as inside zone conditions and empirical factors.
 - .2 The SSTO program shall meet the local code requirements for minimum outside air while the building is occupied.
 - .2 Event Scheduling: Provide a comprehensive menu driven program to automatically start and stop designated points or groups of points according to a stored time.
 - .1 It shall be possible to individually command a point or group of points.
 - .2 For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start and stop within that group.
 - .3 The operator shall be able to define the following information:
 - .1 Time, day
 - .2 Commands such as on, off, auto, and so forth.
 - .3 Time delays between successive commands.
 - .4 There shall be provisions for manual overriding of each schedule by an appropriate operator.
 - .4 It shall be possible to schedule events up to one year in advance.
 - .1 Scheduling shall be calendar based.
 - .2 Holidays shall allow for different schedules.
 - .3 Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.

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- .4 Night setback control: The system shall provide the ability to automatically adjust set points for night control.
- .4 DDC controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
 - .1 A single process shall be able to incorporate measured or calculated data from any and all other DDC and HVAC Mechanical Equipment Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC and HVAC Mechanical Equipment Controllers on the network. Database shall support 30-character, English language point names, structured for searching and logs.
 - .2 Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.
 - .3 DDC Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task-orientated information from the user manual.
 - .4 DDC Controller shall be capable of comment lines for sequence of operation explanation.
- .5 Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC and HVAC mechanical equipment controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC controllers ability to report alarms be affected by either operator or activity at a pc workstation, local i/o device, or communications with other panels on the network.
 - .1 All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
 - .2 The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each DDC Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
 - .3 Alarm reports and messages will be directed to a user-defined list of operator devices or PCs based on time (after hour's destinations) or based on priority.
 - .4 In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.
 - .5 In dial-up applications, operator-selected alarms shall initiate a call to a remote operator device.
- .6 A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for points as specified in the i/o summary. The entire collection process shall be automated so that the data collection definition, amount of data to be collected, collection report and scheduling take the form a wizard, or online assist utility, in order to complete this process within a short amount of time for a large group of points. Ability to produce a summary

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of changes in a log file.

- .1 Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC Controllers point group. Two methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of 1 minute to 7 days shall be provided. Each DDC shall have a dedicated RAM-based buffer for trend data and shall be capable of storing data samples. All trend data shall be available for transfer to a Workstation without manual intervention.
 - .1 Time-interval based trending shall have the capability of synchronizing the trend sampling of discrete points. This allows for the comparison of values of several different points at the same moment in time.
 - .2 Trended points shall have the option of sampling data values based on the condition of a "trigger" point (i.e., conditional trending). Options for sampling shall include: always sampling as defined, only sampling when the trended point is in the alarm condition, or not sampling.
- .2 DDC Controllers shall also provide high-resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point I/O summary.
 - .1 Loop tuning shall be capable of being initiated either locally at the DDC Controller, from a network workstation or remotely using dial-in modems. For all loop-tuning functions, access shall be limited to authorized personnel through password protection.
- .7 DDC controllers shall be capable of automatically accumulating and storing run-time hours for digital input and output points and automatically sample, calculate and store consumption totals for analog and digital pulse input type points, as specified in the point i/o schedule.
- .8 The peer-to-peer network shall allow the DDC controllers to access any data from or send control commands and alarm reports directly to any other DDC and HVAC mechanical equipment controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC and HVAC mechanical equipment controllers shall send alarm reports to multiple workstations without dependence upon a central or intermediate processing device. The peer-to-peer network shall also allow any DDC and HVAC mechanical equipment controller to access, edit, modify, add, delete, back up, and restore all system point database and all programs.
- .9 The peer-to-peer network shall allow the DDC controllers to assign a minimum of 50 passwords access and control priorities to each operator individually. The login password (at any pc workstation or portable operator terminal) shall enable the operator to monitor, adjust, and control the points that the operator is authorized for. All other points shall not be displayed on the PC workstation or portable terminal (e.g. all base building and all tenant points shall be accessible to any base building operators, but only tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.
 - .1 Passwords shall have the option to be configured to expire within a selected timeframe (1-365 days).

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- .1 Configuring the password expiration shall also enable the functionality to lock out a user account after three failed log-on attempts.

1.16 Floor Level Network Application Specific Controllers (ASC)

- .1 Each DDC controller shall be able to extend its performance and capacity through the use of remote application specific controllers (ASCs) through floor level LAN device networks using BACnet MS/TP advanced application controller (B-AAC) device profile.
- .2 Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor. Each ASC shall be capable of control of the terminal device independent of the manufacturer of the terminal device.
- .3 Terminal equipment controllers:
 - .1 Provide for control of each piece of equipment, including, but not limited to, the following:
 - .1 Venturi Air Valves
 - .2 Air Handling Units
 - .3 Chiller
 - .4 Exhaust Fans
 - .5 Reheat Coils
 - .6 VAV Boxes
 - .7 Control Valves & Dampers
 - .2 Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be industry standard signals such as 24V floating control and 0 to 10V, allowing for interface to a variety of modulating actuators.
 - .3 All controller sequences and operation shall provide closed loop control of the intended application. Closing control loops over the FLN, BLN or MLN is not acceptable.

1.17 Operator Interface

- .1 The installed system is to have the capabilities described in this section.
- .2 Basic existing operator server interface description
 - .1 Operator interface software shall minimize operator training through the use of user-friendly and interactive graphical applications, 30-character English language point identification, on-line help, and industry standard Windows application software. Interface software shall simultaneously communicate with and share data between any combination of dedicated, modem autodial, and Ethernet-connected building level networks. The software shall provide, as a minimum, the following functionality:
 - .1 Real-time graphical viewing and control of the BAS environment
 - .2 Reporting
 - .3 Scheduling and override of building operations
 - .4 Collection and analysis of historical data

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- .5 Point database editing, storage, and downloading of controller databases.
- .6 Utility for combining points into logical Point Groups. The Point Groups shall then be manipulated in Graphics, trend graphs and reports in order to streamline the navigation and usability of the system
- .7 Alarm reporting, routing, messaging, and acknowledgment
- .8 “Collapsible tree,” dynamic system architecture diagram application:
 - .1 Showing the real-time status and definition details of all workstations and devices on a management level network
 - .2 Showing the real-time status and definition details of all DDC and HVAC Mechanical Controllers at the building level
 - .3 Showing the status and definition details of all field-level application controllers
- .9 Definition and construction of dynamic colour graphic displays.
- .10 Online, context-sensitive help, including an index, glossary of terms, and the capability to search help via keyword or phrase.
- .11 On-screen access to User Documentation, via online help or PDF-format electronic file.
- .12 Automatic database backup at the workstation for database changes initiated at DDC Controller operator interface terminals
 - .1 Backups shall produce a configuration file that contains pertinent details regarding the specific backup. This log file shall be created each time a backup is run and be stored in the backup directory.
 - .2 Restore dialog box shall list detailed information to facilitate the restore of the correct database.
 - .3 Ability to restore selected components of a backup.
 - .4 Delete old backup directories automatically or individually from a detailed list.
- .13 Display dynamic trend data graphical plot.
 - .1 Must be able to run multiple plots simultaneously
 - .2 Each plot must be capable of supporting 10 pts/plot minimum
 - .3 Must be able to command points directly off dynamic trend plot application.
 - .4 Must be able to plot both real-time and historical trend data
- .14 Program editing
- .15 Transfer trend data to 3rd party spreadsheet software
- .16 Scheduling reports
- .17 Operator Activity Log
- .18 Open communications via OPC Server option

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- .19 Open communications via BACnet Client & Server option
- .20 Tracking of supervised objects
- .21 Tracking of points through the alarm process
- .22 Provide remote notification of points in alarm
- .2 Provide a graphical user interface that shall minimize the use of keyboard through the use of a mouse or similar pointing device, with a "point and click" approach to menu selection and a "drag and drop" approach to inter-application navigation. Selection of applications within the workstation software shall be via a graphical toolbar menu – the application toolbar menu shall have the option to be located in a docked position on any of the four sides of the visible desktop space on the workstation display monitor, and the option to automatically hide itself from the visible monitor workspace when not being actively manipulated by the user.
- .3 The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. BAS software shall run on a Windows XP, 2000 or Server 2003 operating system. System database parameters shall be stored within an object-oriented database, which is compliant with the Open Database Connectivity (ODBC) or Structured Query Language (SQL) standards. Standard Windows applications shall run simultaneously with the BAS software. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BAS alarms and monitoring information
 - .1 Provide functionality such that any of the following may be performed simultaneously on-line, and in any combination, via adjustable user-sized windows. Operator shall be able to drag and drop information between the following applications, reducing the number of steps to perform a desired function (e.g., Click on a point on the alarm screen and drag it to the dynamic trend graph application to initiate a dynamic trend on the desired point):
 - .1 Dynamic colour graphics application
 - .2 Alarm management application
 - .3 Scheduling application
 - .4 Dynamic trend graph data plotter application
 - .5 Dynamic system architecture diagram application
 - .6 Control Program and Point database editing applications
 - .7 Reporting applications
 - .2 Report and alarm printing shall be accomplished via Windows Print Manager, allowing use of network printers.
- .4 Operator-specific password access protection shall be provided to allow the administrator/manager to limit users' workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall "follow" the operator to any workstation logged onto (up to 999 user accounts shall be supported). The administrator/manager shall be able to

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grant discrete levels of access and privileges, per user, for each point, graphic, report, schedule, and BAS workstation application. And each BAS workstation user account shall use a Windows user account as a foundation.

- .1 The workstation software shall also include an application to track the actions of each individual operator, such as alarm acknowledgement, point commanding, schedule overriding, database editing, and logon/logoff. The application shall list each of the actions in a tabular format, and shall have sorting capabilities based on parameters such as ascending or descending time of the action, or name of the object on which the action was performed. The application shall also allow querying based on object name, operator, action, or time range.
- .5 Dynamic Colour Graphics application shall include the following:
 - .1 Must include graphic editing and modifying capabilities
 - .2 A library of standard control application graphics and symbols must be included
 - .3 Must be able to command points directly off graphics application
 - .4 Graphic display shall include the ability to depict real-time point values dynamically with animation, picture/frame control, symbol association, or dynamic informational text-blocks
 - .5 Animation status indicators shall give you a quick visual indication of a point's value, priority, or status in the form of an icon.
 - .6 Navigation through various graphic screens shall be optionally achieved through a hierarchical "tree" structure or view recently opened graphics through a backward and forward paging.
 - .7 Graphics viewing shall include zoom capabilities
 - .8 Graphics shall automatically display the HAND status of points that have been overridden by a field HAND switch, for points that have been designed to provide a field HAND override capability.
 - .9 Advanced linking within the Graphics application shall provide the ability to navigate to outside documents (e.g., .doc, .pdf, .xls, etc.), Internet web addresses, e-mail, external programs, and other workstation applications, directly from the Graphics application window with a mouse-click on a customizable link symbol.
- .6 Reports shall be generated on demand or via pre-defined schedule, and directed to CRT displays, printers, or file. As a minimum, the system shall allow the user to easily obtain the following types of reports:
 - .1 A general listing of all or selected points in the network
 - .2 List of all points currently in alarm
 - .3 List of all points currently in override status
 - .4 List of all disabled points
 - .5 List of all points currently locked out
 - .6 List of user accounts and access levels
 - .7 List all weekly schedules and events

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- .8 List of holiday programming
- .9 List of control limits and dead bands
- .10 Custom reports from 3rd party software
- .11 System diagnostic reports including, list of DDC panels on line and communicating, status of all DDC terminal unit device points
- .12 List of programs
- .13 List of point definitions
- .14 List of logical point groups
- .15 List of alarm strategy definitions
- .16 List of DDC Control panels
- .17 Point totalization report
- .18 Point Trend data listings
- .19 Initial Values report
- .20 User activity report
- .7 Scheduling and override
 - .1 Provide a calendar type format for simplification of time and date scheduling and overrides of building operations. Schedule definitions reside in the PC workstation, DDC Controller, and HVAC Mechanical Equipment Controller to ensure time equipment scheduling when PC is off-line -- PC is not required to execute time scheduling. Provide override access through menu selection, graphical mouse action, or function key. Provide the following capabilities as a minimum:
 - .1 Weekly schedules
 - .2 Zone schedules
 - .3 Event schedules – an event consists of logical combinations of equipment and/or zones
 - .4 Report schedules
 - .5 Ability to schedule for a minimum of up to 365 days in advance
 - .2 Additionally, the scheduling application shall:
 - .1 Provide filtering capabilities of schedules, based on name, time, frequency, and schedule type (event, zone, report)
 - .2 Provide sorting capabilities of schedules, based on name, time and type of schedule (zone, event, report)
 - .3 Provide searching capabilities of schedules based on name – with wildcarding options
- .8 Collection and Analysis of Historical Data
 - .1 Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals (up to four time-based definitions

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per point) or change of value, both of which shall be user-definable. Trend data shall be collected stored on hard disk for future diagnostics and reporting. Automatic Trend collection may be scheduled at regular intervals through the same scheduling interface as used for scheduling of zones, events, and reports. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.

- .2 The entire collection process shall be automated so that the data collection definition, amount of data to be collected, collection report and scheduling take the form a wizard, or online assist utility, in order to complete this process within a small amount of time for a large group of points. Ability to produce a summary of changes in a log file.
- .3 Trend data reports shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of selected points. Provide additional functionality to allow predefined groups of up to 250 trended points to be easily transferred on-line to Microsoft Excel. DDC contractor shall provide custom designed spreadsheet reports for use by the owner to track energy usage and cost, equipment run times, equipment efficiency, and/or building environmental conditions. DDC contractor shall provide setup of custom reports including creation of data format templates for monthly or weekly reports.
- .4 Provide additional functionality that allows the user to view real-time trend data on trend graphical plot displays. A minimum of fifteen points may be plotted, of either real-time or historical data. The dynamic graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the graph and take "snapshots" of plot screens to be stored on the workstation disk for future recall and analysis. Exact point values may be viewed and the graphs may be printed. A minimum of 8 true graphs shall run simultaneously. Operator shall be able to command points directly on the trend plot by double clicking on the point. Operator shall be able to zoom in on a specific time range within a plot. The dynamic trend plotting application shall support the following types of graphs, with option to graph in 3D: line graph, area graph, curve graph, area-curve graph, step graph, and scatter graph. Each graph may be customized by the user, for graph type, graph text, titles, line styles and weight, colours, and configurable x- and y-axes.

.3 Dynamic colour graphic displays

- .1 Create colour graphic floor plan displays and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems and hot water boiler systems, and room level terminal units, shall be provided by the BAS contractor to optimize system performance, analysis and speed alarm recognition.
- .2 The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, point alarm association, or text-based commands. Graphics software shall permit the importing of AutoCAD or scanned pictures for use in the system.
- .3 Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations within the system schematics or graphic floor

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plan displays, and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.

- .1 Provide the user the ability to display real-time point values by animated motion or custom picture control visual representation. Animation shall depict movement of mechanical equipment, or air or fluid flow. Picture Control shall depict various positions in relation to assigned point values or ranges. A library (set) of animation and picture control symbols shall be included within the workstation software's graphics application. Animation shall reflect, ON or OFF conditions, and shall also be optionally configurable for up to five rates of animation speed. Animation shall also indicate the priority and alarm status of the point.
 - .2 Sizable analog bars shall be available for monitor and control of analog values; high and low alarm limit settings shall be displayed on the analog scale. The user shall be able to "click and drag" the pointer to change the setpoint.
 - .3 Provide the user the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.
 - .4 Equipment state or values can be changed by clicking on the associated point block or graphic symbol and selecting the new state (on/off) or set point.
 - .5 State text for digital points can be user-defined up to eight characters.
 - .4 Colours shall be used to indicate status and change as the status of the equipment changes. The state colours shall be user definable.
 - .5 Advanced linking within the Graphics application shall provide the ability to navigate to outside documents (e.g., .doc, .pdf, .xls, etc.), Internet web addresses, e-mail, external programs, and other workstation applications, directly from the Graphics application window with a mouse-click on a customizable link symbol.
 - .6 The windowing environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
 - .7 Off the shelf graphic software, Micrografx Designer or Corel Draw software, shall be provided to allow the user to add, modify or delete system graphic background displays.
 - .8 A clipart library of HVAC application and automation symbols shall be provided including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams and laboratory symbols. The user shall have the ability to add custom symbols to the clipart library. The clipart library shall include a minimum of 400 application symbols. In addition, a library consisting of a minimum of 700 graphic background templates shall be provided.
 - .9 The Graphics application shall include a set of standard Terminal Equipment controller application-specific background graphic templates. Templates shall provide the automatic display of a selected Terminal Equipment controller's control values and parameters, without the need to create separate and individual graphic files for each controller.
- .4 System configuration & definition
- .1 A "Collapsible tree" dynamic system architecture diagram/display application of the site-specific BAS architecture showing status of controllers, PC workstations and networks shall

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be provided. This application shall include the ability to add and configure workstations, DDC Controllers or HVAC Mechanical Equipment controllers, as well as 3rd-party integrated components. Symbols/Icons representing the system architecture components shall be user-configurable and customizable, and a library of customized icons representing 3rd-party integration solutions shall be included. This application shall also include the functionality for real-time display, configuration, and diagnostics of dial-up modems to DDC Controllers.

- .2 Network wide control strategies shall not be restricted to a single DDC Controller or HVAC Mechanical Equipment controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.
 - .3 Provide automatic backup and restore of all DDC controller and HVAC Mechanical Equipment controller databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate DDC Controller or HVAC Mechanical Equipment Controller. Changes made at the user-interface of DDC Controllers or HVAC Mechanical Equipment Controllers shall be automatically uploaded to the workstation, ensuring system continuity.
 - .4 System configuration, programming, editing, graphics generation shall be performed on-line. If programming and system backup must be done with the PC workstation off-line, the BAS contractor shall provide at least 2 operator workstations.
 - .5 Point database configuration shall be available to the user within a dedicated point database editor application included in the workstation software. The editor shall allow the user to create, view existing, modify, copy, and delete points from the database. The point editor shall also allow the user to configure the alarm management strategy for each point. The editor shall provide the option for editing the point database in an online or offline mode with the DDC Controllers.
 - .1 The workstation software shall also provide the capability to perform bulk modification of point definition attributes to a single or multiple user-selected points. This function shall allow the user to choose the properties to copy from a selected point to another point or set of points. The selectable attributes shall include, but are not limited to, Alarm management definitions and Trend definitions.
 - .6 Control program configuration shall be available to the user within a dedicated control program editor application included in the workstation software. The editor shall allow for creation, modification, and deletion of control programs. The editor shall include a programming assistance feature that interactively guides the user through parameters required to generate a control program. The editor shall also include the ability to automatically compile the program to ensure its compatibility with the DDC Controllers. The editor shall provide the option for editing the control programs in an online or offline mode, and also the ability to selectively enable or disable the live program execution within the DDC Controllers.
- .5 Alarm management
- .1 Alarm Routing shall allow the user to send alarm notification to selected printers or workstation location(s) based on time of day, alarm severity, or point type.

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- .2 Alarm Notification shall be presented to each workstation in a tabular format application, and shall include the following information for each alarm point: name, value, alarm time & date, alarm status, priority, acknowledgement information, and alarm count. Each alarm point or priority shall have the ability to sound a discrete audible notification.
- .3 Alarm Display shall have the ability to list & sort the alarms based on alarm status, point name, ascending or descending alarm time.
- .4 Directly from the Alarm Display, the user shall have the ability to acknowledge, silence the alarm sound, print, or erase each alarm. The interface shall also have the option to inhibit the erasing of active acknowledged alarms, until they have returned to normal status. The user shall also have the ability to command, launch an associated graphic or trended graphical plot, or run a report on a selected alarm point directly on the Alarm Display.
- .5 Each alarm point shall have a direct link from the Alarm Display to further user-defined point informational data. The user shall have the ability to also associate real-time electronic annotations or notes to each alarm, which can be viewed from the alarm display screen, graphic display screen, and anytime the point is being commanded to a new value or state.
- .6 Alarm messages shall be customizable for each point, or each alarm priority level, to display detailed instructions to the user regarding actions to take in the event of an alarm. Alarm messages shall also have the optional ability to individually enunciate on the workstation display via a separate pop-up window, automatically being generated as the associated alarm condition occurs.
- .7 Alarm Display application shall allow workstation operators to send and receive real-time messages to each other, for purposes of coordinating Alarm and BAS system management.
- .8 Remote notification of messages
 - .1 Workstation shall be configured to send out messages to numeric pagers, alphanumeric pagers, phones (via text to speech technology), SMS (Simple Messaging Service, text messaging) Devices, and email accounts based on a point's alarm condition. A point's alarm status will be configurable for remote notification whether the point is in a specific alarm priority, has returned to normal, failed, out of service, in trouble, alarm disabled by program or operator and alarm by command.
 - .2 There shall be no limit to the number of points that can be configured for remote notification of alarm conditions and no limit on the number of remote devices, which can receive messages from the system.
 - .3 On a per point basis, system shall be configurable to send messages to an individual or group and shall be configurable to send different messages to different remote devices based on alarm message priority level.
 - .4 Remote devices may be scheduled as to when they receive messages from the system to account for operators' work schedules.
 - .5 System must be configurable to send messages to an escalation list so that if the first device does not respond, the message is sent on to the next device after a configurable time has elapsed.

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- .6 Message detail shall be configurable on a per user basis.
 - .7 During a mass influx of alarms, remote notification messages shall have the ability to optimize several alarms into an individual remote notification message.
 - .8 Workstation shall have the ability to send manual messages allowing an operator to type in a message to be sent immediately.
 - .9 Workstation shall have a feature to send a heartbeat message to periodically notify users that they have communication with the system.
 - .10 Ability to configure Fire and Life Safety points for remote notification through the point editor application.
- .9 Expanded Alarm Issue Management
- .1 As optional functionality, configurable point-by-point, the system shall impose an ordered process for managing the lifecycle of an alarm. The process requires the operator to:
 - .1 Acknowledge the alarm.
 - .2 Assign the alarm issue to a contact (e.g., tradesperson or trained staff).
 - .3 Answer – an explanation of the diagnosis or solution to the alarm.
 - .4 Resolve – this happens when at least one Answer is provided and the point has returned to a stable Normal state.
 - .5 Clear – the operator may clear the alarm issue from the display.
 - .2 Each step in the lifecycle is automatically recorded for audit trail historical purposes.
- .6 Audit trail of user actions
- .1 To protect against inadvertent changes damaging critical system functions, and to enable audit-trail tracking on selected database objects, optional functionality shall be provided to configure selected objects for increased supervision. The additional supervision functionality shall allow for designation of points, control programs, trend collection reports, panels on a building level network and user account objects for detailed tracking of user modifications and deletions. Display an icon, which indicates the level of supervision for an object within specified applications.
 - .1 The minimal setting for additional supervision shall warn the user that he is attempting to modify or delete a supervised object, and will require the user to input a reason-for-change in order to proceed. The warning shall be customizable for each object.
 - .2 Additional supervision levels shall be optional to require the user to re-enter his user password, and/or require that a “supervisor” enter his user password, in order to proceed with the modification or deletion of the supervised object.
 - .3 Supervised objects shall be assigned a dedicated “revision number,” and the revision number shall be incremented automatically by the system upon each user modification. This revision number may serve as a method for tracking changes to objects.

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- .4 Point in an alarm state can have annotations added which can be viewed from the alarm display screen, graphic display screen, and anytime the point is being commanded to a new value or state. For supervised objects, the point annotation will automatically populate the reason for change field.
- .2 Audit Trail tracking of supervised objects shall record the following:
 - .1 The property of the object that was changed
 - .2 The value of the property before the change
 - .3 The value of the property after the change
 - .4 Who made the change
 - .5 The reason for change (entered by the operator)
 - .6 Who the change was authorized by (if configured for this level of supervision)

1.18 Field Devices

- .1 Room thermostats
 - .1 Provide electronic wall mounted 24 VAC with 0 to 10 Volt output. Each thermostat shall be equipped with a thermometer, and shall be tamperproof with locking cover. Provide temperature set point override and unoccupied override.
- .2 Differential pressure switches
 - .1 The differential pressure range of the switch shall be selected to suit the applications.
 - .2 The switch shall have adjustable set point and differential.
 - .3 The switch shall have SPDT contacts rated at 9 Amperes at 120V AC and CSA approved.
 - .4 The switch shall be mounted with diaphragms in a vertical plane.
- .3 Temperature sensors
 - .1 All supply air sensors and mixed air sensors shall be 1000 Ohm platinum, resistance temperature detector (RTD) type with a twenty-five foot averaging element. Accuracy of the RTD and transmitter shall be $\pm 0.3^{\circ}\text{C}$ (0.5°F) over a range of 40°C (104°F) to 116°C (241°F).
 - .2 All return air sensors shall be RTD type temperature detectors. The sensor probe shall have a minimum length of 450mm (18"). The accuracy of the sensor shall be $\pm 0.3^{\circ}\text{C}$ (0.5°F) over a range of 40°C (104°F) to 116°C (241°F).
 - .3 All space sensors shall be RTD or thermistor type temperature detectors. Sensors shall be provided with vented protective covers, mounted 1500mm (6 ft) from floor level.
 - .1 Space sensors for use in conjunction with terminal unit DDC controllers in office areas shall have override button to restore occupied set point outside of normal occupancy period and local set point adjust feature.
 - .2 Space sensors in public areas shall be the sensing-only type with no local override, display, or adjust features. These sensors shall connect to their respective controllers via a preformed cable with RJ-11 type connectors at each end. The sensor shall also contain an RJ-11 jack for connection of a laptop PC for commissioning purposes.

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- .3 Provide clear plastic or beveled metal guards for space sensors located in public corridors, entrance lobbies and washrooms where shown on the mechanical plans.
- .4 All liquid immersed sensors shall be RTD type temperature detectors. Each sensor shall be provided with a well, suitable for the working temperature and pressure of the fluid. The accuracy of the sensor shall be $\pm 0.3^{\circ}\text{C}$ (0.5°F) over a range of 40°C (104°F) to 116°C (241°F).
- .4 Humidity sensors
 - .1 The humidity sensor shall have solid state sensing element suitable for a range of 5-90% RH with an operating range of 0°C (32°F) to 60°C (140°F).
 - .2 Each sensor shall be provided with an industry standard 4-20mA transmitter, mounted at the sensor. The transmitter and sensing element shall have a combined accuracy of $\pm 2\%$ RH over the humidity range.
 - .3 Duct mounted sensors shall be mounted half way across the duct. Room mounted sensor shall be provided with vented covers.
- .5 Differential pressure sensors
 - .1 Differential pressure sensors shall be provided for water differential pressure air and static pressure applications. The differential pressure range shall be selected to match the application. Select materials suitable for the measured variable, i.e. water and air, and to withstand a minimum of twice the normal pressure.
 - .2 Each sensor shall be provided with an industry standard 4-20mA transmitter, mounted at the sensor. The transmitter and sensor shall have a combined accuracy of 0.5% of the differential pressure range.
- .6 Panels
 - .1 Control panels shall be fully enclosed cabinets. Cabinets shall have hinged door with locking latch or bolt on cover plate. All cabinet locks shall be common keyed.
 - .2 Panels shall be wall mounted or free standing and shall be as located on the mechanical drawings.
 - .3 All relays, transducers etc., shall be located within the control panels.
 - .4 Each DDC Controller enclosure shall have a standard duplex AC power receptacle located within the enclosure to provide power for test equipment, operation communication devices.
- .7 Nameplates
 - .1 Duct and pipe mounted sensors and panels shall be provided with lamacoid nameplates, clearly identifying the equipment and the zone in which it is controlling. Refer to Section 23 01 01 – Mechanical General Requirements for detail.
- .8 Automatic control valves and operators
 - .1 All characteristics of control valves shall be suitable for the required operation.
 - .2 Straight through water valves shall be single seated with equal percentage flow characteristics.

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- .3 Three-way mixing valves or combined butterfly valves shall be linear for each port giving constant total flow.
- .4 All valves shall have stainless steel stems and spring-loaded Teflon cone packing.
- .5 Valves DN50 (2") and smaller shall have screwed 1,034 kPa (150 psi) bronze bodies. Valves DN65 (2-½") and larger shall have flanged 862 kPa (125 psi) cast iron bodies.
- .6 Control valves shall be sized based on the following pressure drops:

<u>Valve Application</u>	<u>Sizing Pressure Drop</u>
2-way and 3-way modulating type	34.5 kPa (5 psi)
radiation and reheat 2 or 3-way	6.9 kPa (1 psi)
butterfly valves (two position)	line size
butterfly valves (modulating)	34.5 kPa (5 psi) at 70 degree sizing angle

- .7 Electric valve actuators shall respond to modulating 0-10 VDC control signals and shall spring return to their fail-safe positions upon power failure. Electric actuators for reheat or radiation terminal valves shall accept a 3-wire floating control signal input and may be the fail-in-place type.
- .9 Flow measuring probes
 - .1 Provide where indicated, an array of airflow traverse probes capable of continuously monitoring the fan or duct capacities (air volumes) they serve.
 - .2 Each airflow traverse probe shall contain multiple total and static pressure sensors located along the exterior surface of the cylindrical probe and internally connected to their respective averaging manifolds.
 - .3 The flow sensors shall not protrude beyond the surface of the probe(s) and shall be the offset (Fechheimer) type for static pressure and the chamfered impact type for total pressure measurement.
 - .4 Probes shall be AMCA certified and be capable of measuring the airflow rates within an accuracy of +/- 2% without the use of correction factors.
 - .5 Flow probes shall be installed in the fan inlets or supply and return ducts of VAV air handling systems as specified in the points list and within the system operational sequences.
 - .6 Standard of acceptance: Air Monitor VOLU-probe.
 - .7 Liquid flow measuring devices shall be turbine style with a rotating flow element. Standard of acceptance: Data Industrial 220B, Onicon Series F-1200.
- .10 Current sensing relays

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- .1 Provide solid-state, adjustable, current operated relay. Provide a relay, which changes switch contact state in response to an adjustable set point value of current in the monitored AC circuit.
 - .2 Adjust the relay switch point so that the relay responds to motor operation under load as an "on" state and so that the relay responds to an unloaded running motor as an "off" state. A motor with a broken belt is considered an unloaded motor.
 - .3 Provide for status device for all fans and pumps.
- .11 Control relays
- .1 Supply and install load relays capable of switching 10 Amps at 120/1/60.
- .12 Pressure sensors
- .1 Provide pressure transmitters suitable for continuous contact with the material being measured (i.e., air, water, glycol, or steam as applicable).
 - .2 Pressure transmitters shall have a linear output of 0-5V. Pressure transmitters shall have a span of not greater than twice the static pressure at maximum flow or differential pressure at shut-off as applicable.
- .13 Water flow switches
- .1 Supply paddle actuated water flow switches with snap acting S.P.D.T. contacts rated at 16 Amp 120/1/60 AC full load.
- .14 Air proving switches
- .1 Air proving and motor status shall be performed by an adjustable latch level current switch. Upon motor current rise above set point, switch shall activate and status shall be proven.

1.19 Project Management

- .1 Provide a designated project manager who will be responsible for the following:
 - .1 Construct and maintain project schedule
 - .2 On-site coordination with all applicable trades, subcontractors, and other integration vendors
 - .3 Authorized to accept and execute orders or instructions from Owner/Consultant/Architect
 - .4 Attend project meetings as necessary to avoid conflicts and delays
 - .5 Make necessary field decisions relating to this scope of work
 - .6 Coordination/Single point of contact

1.20 General Installation

- .1 Install all equipment, accessories, conduits, interconnecting wiring and pneumatic piping in a neat manner by skilled and qualified work persons using the latest standard practices of the industry.
- .2 Unless otherwise specified, meet manufacturer's latest printed instructions for materials, planned maintenance and installation methods.
- .3 Notify consultant in writing of any conflict between these specifications and manufacturer's instructions.

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- .4 Retain, at no additional cost to the owner, original equipment suppliers to provide contacts that are required on the point schedules and in the software and sequences specified. Provide the necessary relays and transformers required to interconnect equipment.
- .5 All equipment installed shall be mechanically stable and, as necessary, fixed to wall or floor. Anti-vibration mounts to be provided, if required, for the proper isolation of equipment.
- .6 Install equipment to allow for easy maintenance access. Ensure equipment does not interfere in any way with access to adjacent equipment and personal traffic in the surrounding space.
- .7 Install equipment in locations providing ventilation and ambient conditions for its specified function.
- .8 Install all electrical wiring in conformance with the requirements of the local electrical authority, provincial building code and, unless otherwise indicated, the specifications of Division 26000 – Electrical.
- .9 Install low voltage wiring in accordance with the control manufacturer's recommendations and Electrical Contractor. Run all wiring in a protective conduit in areas where exposed or where required to meet with applicable codes. Plenum rated (ft6) type cables may be used in accordance with applicable codes, in concealed, accessible locations such as ceiling spaces and wall cavities.
- .10 Shield and ground communication trunk wiring at a single end. Do not splice trunk cables.

1.21 Installation Of Controlled Devices & Sensors

- .1 Install all equipment in accordance with manufacturer's published instructions.
- .2 Supply equipment to be installed by other divisions in accordance with their work schedule.
- .3 Coordinate final location of all sensors with consultant's field representative prior to installation.
- .4 Sensor assemblies and elements must be readily accessible. Provide access doors as required to allow for easy replacement and servicing.
- .5 Support field mounted transmitters and sensors on pipe stands or channel brackets.
- .6 Locate all sensing elements to correctly sense measured variable. Isolate elements from vibrations and temperatures, which could affect measurement.
- .7 Install averaging type RTDs in serpentine configuration with adequate provision for the mechanical protection of the sensor. Support along its entire length.
- .8 Modifications to plenum and ductwork must achieve the intent of the contract documents and adhere to the following:
 - .1 Mount sensors with extension necks such that access to sensors is not restricted by insulation.
 - .2 Keep cutting to a minimum and perform in a neat and workmanlike manner.
 - .3 Provide patches and access covers of the same material and thickness as adjoining ductwork. Provide necessary reinforcing and fastening materials.
 - .4 Provide gaskets, seals and insulation to restore to, or exceed as found conditions in areas where this contractor has made modifications.
- .9 Where the point schedules indicate that auxiliary contact provision, provide all instrumentation, wiring, conduit, power supplies, and services as required to integrate these points into the BAS.

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- .10 Provide interposing and motor control relays at the local item of equipment or at the associated mcc as applicable. Provide all relays, wiring, conduit, power supplies and services as required to integrate these points into the BAS.

1.22 Electrical Wiring And Materials

- .1 Install, connect, and wire the items included under this section. This work includes providing required conduit, wire, fittings, and related wiring accessories. Unless indicated otherwise, all wiring shall be installed in conduit. Provide electrical material and installation in accordance with the appropriate sections of the current edition of the applicable local electrical codes. Install wiring in conduit or approved totally enclosed raceways. Do not use cable raceways or troughs. Ft6 rated plenum wire may be used without conduit for sensor, 24-volt power, and network communications wiring associated with terminal equipment controllers provided that the installation complies with all relevant codes.
- .2 Provide wiring between thermostats, aqua stats, and unit heater motors, all control and alarm wiring for all control and alarm devices for all sections of Mechanical specifications.
- .3 Provide 120 volt, single phase, 60 hertz emergency power to every BAS DDC controller panel, power supply, transformer, annunciator, modems, printers and to other devices as required. It is the intent that the entire building management system except terminal equipment shall be operative under emergency power conditions in the building. The power supplies are to be extended in conduit and wire from emergency circuit breakers.
- .4 Provide status function conduit and wiring for equipment covered under this section.
- .5 Provide conduit and wiring between the BAS panels and the temperature, humidity, or pressure sensing elements, including low voltage control wiring in conduit.
- .6 Provide conduit and control wiring for devices specified in this section.
- .7 Provide conduit and wiring between the pc workstation, electrical panels, metering instrumentation, indicating devices, miscellaneous alarm points, remotely operated contractors, and BAS panels, as shown on the drawings or as specified.
- .8 All wiring to be compliant to all relevant local building codes.
- .9 Provide electrical wall box and conduit sleeve for all wall-mounted devices.

1.23 Identification Of Equipment

- .1 Identify each piece of equipment, including sensors, controlled devices and control panels, with a nameplate identifying the equipment and functions with a letter and number designation.
- .2 Nameplates shall be minimum size 75mm x 25mm (3" x 1") and 3.2mm (1/8") thick laminated plastic with 6.4mm (1/4") deep engraved lettering. Nameplates shall be securely attached to the equipment. Adhere to electrical colour schedule.
- .3 Printed nametags are acceptable for cabinet mounted components providing they are securely attached.

1.24 Performance

- .1 Unless stated otherwise, control temperatures within plus or minus 1.1°C (2°F), humidity within plus or minus 3% of the set point, and static pressure within 10% of set point.

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1.25 Start-Up And Commissioning

- .1 When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. All testing, calibrating, adjusting, and final field tests shall be completed by the manufacturer. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power.
- .2 Provide any recommendation for system modification in writing to owner. Do not make any system modification, including operating parameters and control settings, without prior approval of owner.
- .3 After manufacturer has completed system start-up and commissioning. Joint commissioning of integrated system segments shall be completed.

1.26 Commissioning, Testing And Acceptance

- .1 Perform a three-phase commissioning procedure consisting of field I/O calibration and commissioning, system commissioning and integrated system program commissioning. Document all commissioning information on commissioning data sheets, which shall be submitted prior to acceptance testing. Commissioning work, which requires shutdown of system or deviation from normal function shall be performed when the operation of the system is not required. The commissioning must be coordinated with the owner, construction manager, and commissioning consultant to ensure systems are available when needed. Notify the operating personal in writing of the testing schedule so that authorized personnel from the owner and construction manager are present throughout the commissioning procedure.
- .2 Provide temporary operator workstation for exclusive use by commissioning team.
- .3 Prior to system program commissioning, verify that each control panel has been installed according to plans, specifications, and approved shop drawings. Test, calibrate and bring on line each control sensor and device. Commissioning to include, but not be limited to:
 - .1 Sensor accuracy at 10, 50 and 90% of range.
 - .2 Sensor range.
 - .3 Verify analog limit and binary alarm reporting.
 - .4 Point value reporting.
 - .5 Binary alarm and switch settings.
 - .6 Actuator ranges.
 - .7 Fail safe operation on loss of control signal, electric power, and network communications.
- .4 Provide a systems specialist to operate systems as required by the commissioning coordinator.
- .5 After control devices have been commissioned (i.e. calibrated, tested, and signed off), each bas program shall be put on line and commissioned. The contractor shall, in the presence of the owner and construction manager, demonstrate each programmed sequence of operation and compare the results in writing. In addition, each control loop shall be tested to verify proper response and stable control, within specified accuracy's. System program test results shall be recorded on commissioning data sheets and submitted for record. Any discrepancies between the specification and the actual performance will be immediately rectified and retested.
- .6 After all BAS programs have been commissioned, the contractor shall verify the overall system performance as specified. Tests shall include, but not be limited to:

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- .1 Data communication, both normal and failure modes.
- .2 Fully loaded system response time.
- .3 Impact of component failures on system performance and system operation.
- .4 Time/Date changes.
- .5 End of month/ end of year operation.
- .6 Season changeover.
- .7 Global application programs and point sharing.
- .8 System backup and reloading.
- .9 System status displays.
- .10 Diagnostic functions.
- .11 Power failure routines.
- .12 Battery backup.
- .13 Smoke Control, if required, in concert with Fire Alarm System testing.
- .14 Testing of all electrical and HVAC systems with other division of work.
- .7 Submit for approval, a detailed acceptance test procedure designed to demonstrate compliance with contractual requirements. This acceptance test procedure will take place after the commissioning procedure but before final acceptance, to verify that sensors and control devices maintain specified accuracy's and the system performance does not degrade over time.
- .8 Using the commissioning test data sheets, the contractor shall demonstrate each point. The contractor shall also demonstrate all system functions. The contractor shall demonstrate all points and system functions until all devices and functions meet specification.
- .9 The contractor shall supply all instruments for testing.
 - .1 All test instruments shall be submitted for approval.
 - .1 Test Instrument Accuracy

Temperature	0.2°C (¼°F) or ½ % full scale, whichever is less
Pressure	High Pressure (psi): 3.5 kPa (½ psi) or ½ % full scale, whichever is less Low Pressure (in w.c.): ½ % of full scale
Humidity	2% RH
Electrical	¼ % full scale
- .10 After the above tests are complete and the system is demonstrated to be functioning as specified, a thirty-day performance test period shall begin. If the system performs as specified throughout the test period, requiring only routine maintenance, the system shall be accepted. If the system fails during the test, and cannot be fully corrected within eight hours, the owner may request that performance tests be repeated.

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1.27 Training

- .1 The manufacturer shall provide factory-trained instructor to give full instruction to designated personnel in the operation of the system installed. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The manufacturer shall provide all students with a student binder containing product specific training modules for the system installed. Provide 24 hours of training. All training shall be held during normal working hours of 8:00 am to 4:30 pm weekdays.
 - .1 Explanation of drawings, operations and maintenance manuals
 - .2 Walk-through of the job to locate control components
 - .3 DDC controller and ASC operation/function
 - .4 Operator control functions including graphic generation and field panel programming
 - .5 Explanation of adjustment, calibration and replacement procedures
 - .6 Student binder with training modules
- .2 Since the owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the manufacturer. If such training is required by the owner, it will be contracted at a later date.

1.28 Warranty

- .1 Provide all services, materials, and equipment necessary for the successful operation of the entire bas system for a period of one year after beneficial use.
- .2 The adjustment, required testing, and repair of the system includes all computer equipment, transmission equipment and all sensors and control devices.
- .3 The on-line support services shall allow the local bas subcontractor to dial out over telephone lines to monitor and control the facility's building automation system. This remote connection to the facility shall be within 2 hours of the time that the problem is reported. This coverage shall be extended to include normal business hours, after business hours, weekends and holidays.
- .4 If the problem cannot be resolved on-line by the local office, the national office of the building automation system manufacturer shall have the same capabilities for remote connection to the facility. If the problem cannot be resolved with on-line support services, the bas manufacturer shall dispatch the appropriate personnel to the job site to resolve the problem within 3 hours of the time that the problem is reported.

1.29 Programming

- .1 Program, set up, and tune all control loops during initial start-up of the systems.
- .2 Create all DDC controller databases containing all real system input/output points as well as pseudo or calculated points required for global operating strategies.
- .3 Assign all points to logical system groups to permit an operator to access a specific point by calling up a dynamic display of the logical system in which the point is contained.
- .4 Assign all I/O points to the point history file function described previously in this section.
- .5 Assign all change of state activity of points, as well as operator actions, to the historical archiving program of the BAS as described previously in this section.

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- .6 Assign all change of state activity of points to the appropriate alarm and/or off-normal summary program of the BAS as described previously in this section.
- .7 Create all application programs and store as executable files on the principal BAS operator workstation bulk storage disk for automatic downloading to field DDC controllers.
- .8 For each major mechanical system, provide a dynamic system graphic incorporating all input signal values and output command values.

1.30 Control Strategies

- .1 Refer to the sequence of operation and associated control schematics for the required number of control loops. Provide all hardware and software necessary to achieve specified control.

1.31 Sequences Of Operation

- .1 Refer to mechanical drawings for control diagrams and sequences of operation.

END OF SECTION