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MECHANICAL SPECIFICATION

FOR
STERLING HALL SCHOOL
PHASE 1 – MASTER PLAN ADDITION
99 CARTWRIGHT AVE, TORONTO, ON

OUR PROJECT NUMBER:
00036.010.M.001

DATE:
2026-07-08

ISSUED / REVISION:
TENDER – REV 0

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20 00 01.00 Mechanical Supplementary Bid Form
MECHANICAL SUPPLEMENTARY BID FORM

FOR

STERLING HALL SCHOOL – PHASE 1 MASTER PLAN ADDITION
S+A PROJECT #00036.010.M.001

DATE: _____

I/we having examined the Architectural, Mechanical, Structural and Electrical Drawings, Specifications and amendments (addenda), to these documents which were issued prior to this date, along with all knowledge from site tours, site visits, and Supplemental Instructions, and I/we being aware of all conditions under which the Work/Contract will be undertaken, I/we hereby offer to furnish all materials, equipment, plant and labour necessary for the proper completion of the Mechanical Work set forth in the above mentioned Drawings, Specifications and amendments (addenda) for the stipulated sum of _____

_____ (\$ _____), in lawful money of Canada, including all prime costs, allowances and taxes.

Goods and Services Tax (GST)/Harmonized Sales Tax (HST) is not included in the above Bid price but is applicable at a value of _____

_____ (\$ _____).

This Bid price will be held open for acceptance for a period of sixty (60) days from the date of this Bid.

List of Sub-Contractors

Below are the names of the sub-contractors that will perform the respective scope of work:

Work Sublet	Name of Sub-Contractor
Plumbing and drainage	
Sheet metal	
HVAC and piping	
Fire protection	
Insulation	
Testing and balancing	
Building Automation Systems	

List of Proposed Equipment Manufacturers / Suppliers I/we herewith submit a list of manufacturers / suppliers carried in the Bid price. In the event of Contract award, I/we agree that no changes will be made to this list without prior written approval from the Consultant. (Indicate manufacturer / supplier carried for each specification section in the table below).

20 05 15.00	Variable Frequency Drives	() Danfoss () Rockwell Automation Allen-Bradley () ABB
22 11 23.29	Circulators	() Armstrong () Grundfos-Paco () Xylem Bell & Gossett () Patterson Pump Company () Taco
22 67 19.00	Domestic Water Treatment	() Culligan () BioLab
23 09 00.0X	Building Automation System (BAS)	
23 09 63.00	Laboratory Control System	() Phoenix Controls () EH Price () AirGenuity () Siemens with pressure independent venturi air valves () TSI Controls
23 21 23.00	Centrifugal Pumps	() Armstrong () Grundfos-Paco

		() Xylem Bell & Gossett, () Patterson Pump Company () Taco
23 34 73.00	Induced Flow High Plume Exhaust Fans	() Strobic () MK Plastics
23 52 16.00	Condensing Boilers	() Aerco () Viessmann () Patterson Kelley () Lochinvar () Cleaver-Brooks () Riello () Bosch () Fulton () Aerco () Cleaver-Brooks
23 52 33.14	Hot Water Dual Fired Heating Boilers (Watertube)	() Cleaver-Brooks
23 52 33.15	Steam Generators (Watertube)	() Cleaver-Brooks () Volcano () Dominion-Bridge
23 52 33.17	Hot Water Gas Fired Boilers (Flexible Tube)	() Unilux () Cleaver-Brooks () Bryan
23 52 33.20	Hot Water Gas Fired Boilers (Atmospheric)	() Laars () Raypak () Super Hot
23 52 39.19	Hot Water Gas Fired Boilers (Firetube)	() Cleaver-Brooks () Volcano () Napanee
23 52 39.20	Gas Fired Steam Boilers (Firetube)	() Volcano () Cleaver-Brooks
23 57 16.00	Heat Exchangers – Shell & Tube	() Armstrong () Taco () ITT Technologies
23 57 19.13	Heat Exchangers – Plate Type	() Xylem () Alfa-Laval () Armstrong () Tranter () APV () GEA () AIC Inc.
23 64 19.00	Reciprocating Chiller	() Daikin () Carrier () JCI York () Advance Industrial Refrigeration
23 64 29.00	Roof Mounted Air Cooled Chillers	() Daikin () JCI York () Trane () Carrier
23 64 33.00	Modular Packaged Chillers	() ModulAIR (by Advance Industrial Refrigeration) () Multistack () Daikin

		() Aermec
23 64 36.00	Chillers	() Daikin () Carrier () Trane () JCI York
23 65 43.13	Induced Draft Cooling Tower (Steel)	() Marley SPX () Baltimore Aircoil () Evapco
23 73 23.00	Custom Air Conditioning Units	() Haakon () Engineered Air () Scott Springfield () Inginia () TMI () Ventrol
23 73 23.12	Small Commercial Dedicated Outdoor Air System Packaged Units	() Oxygen8 () AuraGreen () Aldes
23 73 53.00	Compartment Units	() Haakon () Engineered Air () Racan () Ventrol
23 74 13.00	Packaged Air Conditioning Unit	() Carrier () Aaon () Daikin () JCI York
23 74 13.13	Small Packaged (Modular) Roof Mounted Air Conditioning Units	() Aaon () Daikin () Carrier () Lennox () JCI York
23 74 13.16	Roof Mounted Air Conditioning Units (High End)	() Daikin () Aaon () Engineered Air () Scott Springfield () Bousquet () Mammoth
23 74 13.19	Roof Mounted Air Conditioning Units	() JCI York () Bousquet () Daikin () Aaon
23 74 23.13	Direct Gas Fired Make-Up Air Unit	() Engineered Air () Dravo () Temprite () Reznor () Aaon () Bousquet

Cash Allowances

Include Cash Allowances in the Bid price. Include all mark ups and overhead costs in the base Bid price for these allowances. Cash Allowances are inclusive of PST where applicable, but exclude GST/HST.

Substitute Manufacturers, Material and Equipment

List any substitute equipment as a deduction from the Bid price. Acceptance of substitute equipment or material shall be at the discretion of the Owner and/or Consultant.

Item	Substitute Manufacturer	Value (Deduct)
		\$
		\$
		\$
		\$
		\$
		\$
		\$
		\$
		\$
		\$
		\$
		\$
		\$
		\$
		\$
		\$

Contractor's Suggested Deductions / Savings

We attach to this Mechanical Supplementary Bid Form a list of possible deductions from the Bid price. Describe deduction/saving in enough detail to facilitate evaluation. We fully appreciate that the acceptance of these deductions will be at the discretion of Smith + Andersen and the Owners. The Contractor is invited to study the Drawings and Specifications and submit any possible deductions to the Bid price.

Proposed Hourly Labour Cost

The hourly labour cost for providing a Journeyperson, inclusive of all charges as defined in Section 20 05 00 – General Instructions for Mechanical Sections is:

Journeyperson (Plumber)	\$	Per hour
Foreperson (Plumber)	\$	Per hour
Journeyperson (Sheet Metal Worker)	\$	Per hour
Foreperson (Sheet Metal Worker)	\$	Per hour
Journeyperson (Insulator)	\$	Per hour
Foreperson (Insulator)	\$	Per hour
Journeyperson (Sprinkler Fitter)	\$	Per hour
Foreperson (Sprinkler Fitter)	\$	Per hour
Journeyperson (Electrician)	\$	Per hour
Foreperson (Electrician)	\$	Per hour
Excavation Labour	\$	Per hour
Excavation Equipment Operator	\$	Per hour

The Owner and/or Consultant reserve the right to renegotiate the labour rate once the detailed labour rate breakdown is received.

Mechanical Bid Documents

We further confirm that we have received the following documents:

1. Mechanical Supplementary Bid Form. MECH. B.F. – 1 to MECH. B.F. – 12.
2. Mechanical Specifications – Division 20, 21, 22, and 23 consisting of the sections specified in the index at the front of the Mechanical Specification.
3. Mechanical Drawings consisting of the Drawings identified in the List of Drawings identified on the Mechanical Drawings.
4. Mechanical Amendments (addenda) listed below:

_____	Page 1 to Page _____
_____	Page 1 to Page _____
_____	Page 1 to Page _____

BID SUBMITTED BY: _____
(COMPANY)

(ADDRESS)

TELEPHONE _____

SIGNING OFFICER: _____
Print Name

SIGNING OFFICER: _____
Sign Name

Witness: _____
Print Name

Witness: _____
Sign Name

Company Seal:

END OF SECTION

20 05 00.00 General Instructions for Mechanical Sections

1. General

1.1. WORK INCLUDED

- 1.1.1. Conform to the requirements of Division 1, which applies to and forms part of all sections of the Work.
- 1.1.2. The Specification is divided into Sections which are not intended to identify contractual limits between Subcontractors nor between the Contractor and their Subcontractors. The requirements of any one Section apply to all Sections. Refer to other Divisions and Sections to ensure a complete and operational system.
- 1.1.3. Provide mechanical components and accessories which may not be specifically shown on the Drawings or stipulated in the Specifications, but are required to ensure complete and operational systems.

1.2. INTENT

- 1.2.1. Mention in the Specifications or indication on the Drawings of equipment, materials, operation and methods, requires provision of the quality noted, the quantity required, and the systems complete in every respect.
- 1.2.2. The Specifications are an integral part of the accompanying Drawings. Consider any item or subject omitted from one or the other, but which is either mentioned or reasonably implied, as properly and sufficiently specified.
- 1.2.3. Be completely responsible for the acceptable condition and operation of all systems, equipment and components forming part of the installation or directly associated with it. Promptly replace defective material, equipment and part of equipment and repair related damages.

1.3. SECTIONS AFFECTED

- 1.3.1. These instructions apply to and form a part of all Division 20, 21, 22, and 23 Sections referred herein as Mechanical.

1.4. DEFINITIONS

- 1.4.1. Where used on the Drawings or in the Specifications, the following words are given the meanings below.
 - .1 Provide: means supply, install, connect and test.
 - .2 Demolish: detach existing items and legally dispose of them off site.
 - .3 Remove and Reinstall: Detach existing items, prepare them for reuse, and reinstall them where indicated.
 - .4 Existing to Remain: existing items that are not removed and that are not otherwise indicated as being removed, removed and salvaged (turned over to Owner), or removed and reinstalled.
 - .5 Remove and Salvage: detach existing items and turn over to Owner.

1.5. REGULATIONS

- 1.5.1. Perform Work in accordance with codes, rules, regulations, by-laws and requirements of the authorities having jurisdiction.

- 1.5.2. Comply with all guidelines and standards issued by the authorities having jurisdiction.
- 1.5.3. Where names of codes and standards are referenced on the Contract Documents, comply with the latest in force edition in the jurisdiction of the Place of the Work.
- 1.5.4. Comply with regulations respecting plumbing made under the following legislation except as modified by rules, regulations and by-laws of authorities having jurisdiction:
 - .1 Ontario Water Resources Act.
 - .2 Ontario Building Code Part 7.
- 1.5.5. For natural gas systems, follow the requirements of:
 - .1 Regulations made under the Technical Standards and Safety Act
 - .2 CAN/CSA B149.1 - Natural Gas and Propane Installation Code.
- 1.5.6. Provide materials and assemblies with flame-spread ratings and smoke developed classifications in conformance with CAN/ULC-S102 "Test for Surface Burning Characteristics of Building Materials and Assemblies." Compliance with ASTM E84 "Surface Burning Characteristics of Building Materials" in lieu of CAN/ULC-S102 is not acceptable.
- 1.5.7. These Specifications are supplementary to the requirements above.
- 1.5.8. Drawings and Specifications should not conflict with the above regulations but where there are apparent discrepancies, notify the Engineer's Representative.
- 1.5.9. Where equipment utilizing refrigerants is provided, comply with regulatory refrigerant phase out requirements and dates applicable in the jurisdiction where the Project is taking place. Where equipment not meeting refrigerant phase out requirements or dates is supplied to site, provide revised unit(s) operating on a new refrigerant at no additional cost to the Owner; cover all costs of any electrical, structural, mechanical, architectural, etc. changes required to accommodate the new refrigerant.
- 1.5.10. Where equipment described in these Specifications utilizes refrigerants, provide refrigerants that have a global warming potential (GWP) of less than 700 and that are compatible with the equipment.
- 1.6. PERMITS, FEES AND INSPECTIONS
- 1.6.1. Obtain all permits, make submissions, pay all fees and arrange for all inspections required for the Work of this Division.
- 1.7. EXAMINATION OF SITE
- 1.7.1. Before submitting Bids, examine the site to determine the conditions which may affect the proposed Work. No claims for extra payment will be considered because of failure to fulfil this condition.
- 1.8. DRAWINGS, CHANGES AND INSTALLATION
- 1.8.1. The Drawings show the general character and scope of the Work and not the exact details of the installation. Install all equipment and systems complete with all accessories required for a complete and operational installation.
- 1.8.2. The location, arrangement and connection of equipment and material as shown on the Drawings represents a close approximation to the intent and requirements of the Work. The right is reserved by the Engineer's Representative to make reasonable changes required to accommodate conditions arising during the progress of the Work, at no additional cost.

- 1.8.3. In order to show more clearly the arrangement of the Work, plans and sections do not show every valve, thermometer, pressure gauge or other system accessory. Refer to the Mechanical Standard Details and to the Specifications to determine the requirements.
- 1.8.4. Install equipment in accordance with the manufacturer's written installation requirements. In the event of conflicts between the Drawings or Specifications and the manufacturer's written installation requirements, notify the Engineer's Representative for resolution.
- 1.8.5. Certain Details indicated on the Drawings are general in nature and specific labelled detail references to each and every occurrence of use are not indicated, however, such details are applicable to every occurrence.
- 1.8.6. Conceal all piping and ductwork in finished areas in ceiling spaces and shafts or furred into walls. Do not install exposed piping or ductwork in such areas unless specifically reviewed and accepted by the Engineer's Representative. Do not install piping in outside walls.
- 1.8.7. Do not install vent pipes, exhaust hoods or other mechanical equipment mounted on the roof, or housing for such equipment, closer to the edge of the roof than a distance equal to the height of the pipe, hood or equipment, unless specifically reviewed and accepted by the Engineer's Representative.
- 1.8.8. The location and size of existing services shown on the Drawings are based on the best available information. Site verify the actual location of existing services before commencing Work. Pay particular attention to underground services.
- 1.8.9. Make changes and modifications necessary to ensure co-ordination and to avoid interference and conflicts with other Trades, or to accommodate existing conditions, at no additional cost.
- 1.8.10. Leave areas clear of piping and ducts where space is indicated as reserved for future equipment and equipment for other Trades.
- 1.8.11. Coordinate piping low point drain locations so that they are not above or adjacent to electrical equipment, including junction boxes.
- 1.8.12. Allow adequate space and provisions for the removal of coils and servicing of equipment, with minimum inconvenience to the operation of systems.
- 1.8.13. Where equipment is shown to be 'roughed-in only,' obtain accurate information from the Engineer's Representative before proceeding with the Work.
- 1.8.14. Before fabricating ductwork or piping for installation, make certain that such items can be installed as shown on the Drawings without interfering with the structure or the Work of other Trades. Submit any problems that cannot be solved in agreement with the other Trades affected, for resolution. If ductwork or piping is prefabricated prior to the investigation and reaching of a solution to possible interference problems, make necessary changes in such prefabricated items at no additional cost.
- 1.8.15. Location of diffusers, grilles, registers, thermostats, sprinklers and all other equipment shown on plans is diagrammatic. Layout of each device in finished areas is critical in terms of symmetry and location. Refer to Architectural Drawings and to Supplemental Instructions in all regards. Revise any Work not installed in the correct location (at the sole discretion of the Engineer's Representative) at no additional cost. Mark-out fully co-ordinated Work with all other trades, in sufficient time for review by Engineer's Representative prior to rough-in. Precisely locate all mechanical and sprinkler services.
- 1.8.16. Prepare dimensioned layouts of each room prior to rough-in for review by the Architectural Consultant. Do not proceed with any Work until the Engineer's Representative has reviewed the layout.

1.9. INSTALLATION, INTERFERENCE AND SETTING DRAWINGS

- 1.9.1. Submit installation, interference and setting drawings dimensioned and to scale, for review by the Engineer's Representative, as may be required or requested by the Engineer's Representative to make clear the Work intended or to show its relation to adjacent Work or to the Work of other trades. When an alternative piece of equipment is substituted for equipment shown, prepare drawings of the area involved. Submit drawings in pdf format as well as in the format the Tender Drawings are prepared.
- 1.9.2. Prepare installation working drawings to 1:50 scale (1/4 in. equal to 1 ft.) for mechanical rooms showing plan and sections of the plant, services, bases, curbs, drains, motor terminals, etc.
- 1.9.3. Prepare interference drawings for shafts, ceiling spaces, typical floors and wherever there is possible conflict with the positioning of mechanical equipment, piping or ductwork and architectural or structural features or the Work of other trades.
- 1.9.4. The design of the structural framing of the mechanical rooms and pipe spaces and major pipe run supports has been based on assumed loadings supplied during the design phase. Well ahead of the construction of the affected areas, prepare and submit drawings for review by the Engineer's Representative showing the layout and weights of all finally selected mechanical equipment including details of concrete pads, concentrated pipe loads and point reactions of the equipment onto the structure.
- 1.9.5. Prepare sleeving drawings indicating the size and locations of openings required in concrete floor slabs, roof slabs/decks and walls for piping, ductwork and equipment. Bear the cost of all extra work necessary due to failure to provide information in time (i.e. before the concrete is poured).
- 1.9.6. Do not proceed with Work in areas involved until after final review of such drawings has been obtained.

1.10. BID FORM AND SUBMISSIONS OF BIDS

- 1.10.1. Submit with the bid, all information called for on the Bid Form. Bids not completed in full may, at the discretion of the Owner, be rejected.
- 1.10.2. Show alternative and unit prices for optional equipment or systems called for as additions to or deductions from the Bid amount.
- 1.10.3. Where only one name appears in the Specification, include the specified equipment in the Bid.
- 1.10.4. Where two or more names are shown in the Specifications as alternatives or equal to, this Division can select which manufacturer is to be carried, provided the choice is shown on the Bid Form. Where the choice is not indicated, supply the equipment described in the Specification or first named on the Bid Form.
- 1.10.5. Substitute equipment may be offered as a price deduction to the Bid price. Acceptance of substitute equipment is at the discretion of the Owner whose decision is final.
- 1.10.6. Provide materials and Products specified by the name of the manufacturer, the brand or trade name, or catalogue reference, as the basis of the Bid price. Provide these Products under the Contract unless substitutions are proposed and accepted in accordance with the following procedures:
 - .1 Substitution may be proposed only when the phrase, "or other approved manufacturer" is included in the Specification.
 - .2 List the proposed substitution under Substitute Equipment on the Bid Form.
 - .3 Indicate the Product name and provide a complete Product description.
 - .4 Clearly indicate the change in the Bid price for this substitution.

- 1.10.7. Only propose alternative and/or substitute equipment that is equal in performance and quality to that specified. Include the cost of all changes required to accommodate alternative and/or substitute equipment, in the price shown on the Bid Form, including but not limited to space, power, structural or any other requirements that are different from the equipment specified.
- 1.10.8. The Owner reserves the right to accept or reject any substitution without question.
- 1.11. MATERIALS AND EQUIPMENT
- 1.11.1. Make and quality of materials used in the construction of this Work are subject to the approval of the Engineer's Representative.
- 1.11.2. Manufacture in Canada wherever possible.
- 1.11.3. Labelled and/or Listed as required by the Authority Having Jurisdiction or Code.
- 1.11.4. Supply only new materials and equipment, free from defects of any kind and as shown or specified by the manufacturer's name and catalogue reference.
- 1.11.5. Where a manufacturer's equipment has been specified by name and/or model number, ensure that the performance and quality of equipment provided by an acceptable manufacturer, meets the specified equipment performance, is inclusive of all standard and specified optional features, and can be installed in the planned location with access and maintenance clearances in accordance with the manufacturer's written installation recommendations. Provide all required piping, duct and electrical connections at no additional cost.
- 1.11.6. Mechanical systems are designed and coordinated based on the manufacturer and model number and/or parameters indicated on the Equipment Schedules. Accept all costs for differences in physical properties or performance between scheduled equipment and acceptable alternative equipment manufacturers or models identified in these Specifications. Differences may include, but are not limited to, size, layout, arrangement of components, connection sizes, maintenance access, locations and/or quantity of service connections, and performance differences such as noise, power consumption, flow rates, etc.
- .1 Electrical coordination: accept all extra costs to revise the electrical provisions, including but not limited to feeder/wiring sizes, breaker sizes, fuse sizes, starters and equipment, to supply power to the non-basis of design piece of equipment.
- 1.11.7. Be responsible for all design costs associated with differences between scheduled equipment and alternate manufacturers or models identified in these Specifications.
- 1.12. CO-OPERATION WITH ENGINEER'S REPRESENTATIVE
- 1.12.1. To assist in the successful execution of the Project, the Contractor will receive an initial job report that summarizes the expectations of the Engineer's Representative and the Contractor. This job report covers topics such as progress billings, shop drawing requirements, Change Order pricing, the commissioning process, installation drawings, the Specifications, as-built drawings and operations and maintenance manuals, along with a number of other items. This job report is intended to reiterate key items from the Contract Documents and is not intended to impose new requirements.
- 1.12.2. At the appropriate time during construction, submit the applicable documentation listed below. The Engineer's Representative will review the information and identify when the information is complete. The Engineer's Representative's general review letter (required for building occupancy) will only be issued when the information requested below is submitted by the Contractor and deemed to be complete by the Engineer's Representative.
- 1.12.3. For mechanical systems occupancy, provide a PDF copy of the following documents to the Engineer's office for review:

- .1 CAN/ULC-S1001 "Standard for Integrated Systems Testing of Fire Protection and Life Safety Systems" reports for mechanical systems
- .2 Fire alarm verification certificate
- .3 Sprinkler System Engineer's letters of assurance and occupancy, signed and sealed by P.Eng.
- .4 Seismic Engineer's letters of assurance signed and sealed by P.Eng.
- .5 Contractor's letter verifying that all fire fighting access routes have been provided and are accessible
- .6 Contractor's letter confirming ventilation supply air and return air available for each room
- .7 Report confirming sanitary and lab exhaust systems operational
- .8 Stair pressurization start-up report
- .9 Fuel oil system completion certificates, including authority having jurisdiction inspection certificates
- .10 Contractor's letter verifying fire stops and smoke seals installed in accordance with Mechanical Specification
- .11 Contractor's letter verifying fire damper, smoke damper, and / or combination smoke / fire damper installations are in accordance with their listings and the Mechanical Specification, and fire damper test confirmation letter
- .12 Contractor's letter verifying smoke control system is installed, operational and commissioned per Mechanical Contract Documents and Building Code requirements
- .13 Contractor's letter verifying smoke control venting to aid firefighting is installed, operational and commissioned per Mechanical Contract Documents and Building Code requirements
- .14 Contractor's letter verifying carbon monoxide detection and exhaust system is installed, operational and commissioned per Mechanical Contract Documents and Building Code requirements
- .15 Start up report(s) for heating systems, air handling unit(s), heating boiler(s), fan coil unit(s), heat pump(s), fan(s), etc.
- .16 Contractor's letter confirming that emergency power generation ventilation system is installed, operational and commissioned
- .17 Start up report(s) for ventilation systems, air handling unit(s), fan coil unit(s), heat pump(s), fan(s), exhaust fan(s), etc.
- .18 Start up report(s) for cooling systems including chillers, cooling towers, air handling unit(s), fan coil unit(s), heat pump(s), split a/c unit(s), etc.
- .19 Plumbing system pressure testing, flushing, water quality test, and chlorination report(s)
- .20 Final plumbing inspection certificate
- .21 Pressure test report on all piping systems
- .22 Contractor's letter verifying that all plumbing fixtures are installed and operational
- .23 Test reports and certificates from local building inspection authority confirming that the following items are installed, pressure tested and operational: building drains, sanitary and storm building sewers, drainage system and venting system, pipes, fittings, fixtures, etc.
- .24 Backflow preventer test reports
- .25 Contractor's letter verifying grease interceptor(s) installed and tested in accordance with Mechanical Contract Documents and Building Code

- .26 Contractor's letter verifying oil interceptor(s) installed and tested in accordance with Mechanical Contract Documents and Building Code
 - .27 Contractor's letter verifying acid neutralization system installed and commissioned in accordance with Mechanical Contract Documents and Building Code
 - .28 Contractor verification of accessibility of the fire dampers, fixtures, cleanouts, valves, plumbing appliances, devices and equipment
 - .29 Cyber Security Report Letter
 - .30 Air balancing report
 - .31 Hydronic (Piping) balancing report
 - .32 Pressure testing of refrigerant systems report
 - .33 Where the Owner has hired a third-party commissioning agent, all documentation and completion of the commissioning process submitted up to the initial BAS commissioning stage where the system is ready for season performance testing, where relevant.
 - .34 Letter from the expansion joint and anchor manufacturer: confirming that the systems have been installed in accordance with design requirements and manufacturer's installation instructions, or stating that expansion compensation is not required for the Project.
- 1.12.4. For mechanical systems financial close, provide the following additional documents to the Engineer's office for review:
- .1 Copies of as-built drawings
 - .2 Operating and maintenance manual
 - .3 Warranty letter
- 1.13. SUBSTANTIAL PERFORMANCE
- 1.13.1. The Owner will not deem the Project "ready for use" as defined in the provincial or territorial lien legislation until the following minimum items are complete:
- .1 Everything required in the clauses above for occupancy.
 - .2 All mechanical items commissioned and accepted by Engineer's Representative as noted in Specification Section 20 08 00.00 – COMMISSIONING.
 - .3 Submission of final, reviewed Operating and Maintenance Manuals including final reviewed Shop Drawings turned over to the Engineer's Representative and Owner as outlined in Section 20 08 03.00 – OPERATING AND MAINTENANCE INSTRUCTIONS.
 - .4 Submission of final, reviewed as-built documentation to the Engineer's Representative and Owner, as outlined in Specification Section 20 05 02.00 – AS-BUILT DRAWINGS. Note that this includes all final balancing reports.
- 1.14. CO-OPERATION WITH OTHER DIVISIONS
- 1.14.1. Pay particular attention to the proximity of electrical conduit and cable to mechanical piping and equipment.
- 1.14.2. Maintain at least 150 mm (6 in.) separation between pipes transporting hot fluids and pipes carrying cold fluids, unless approval from the Engineer's Representative is obtained.
- 1.14.3. Do not allow Electrical conduits to touch or be supported from piping or ductwork.

- 1.14.4. Install all materials in the spaces shown without encroaching upon space for materials installed under other Sections or Divisions. Where the space allocated to another Section or Division is encroached upon, relocate the materials to their proper space allocation in such a manner to complete the Work using space allocated to the various Sections and Divisions. Relocate materials and Work involved at no additional cost.
- 1.14.5. Supply all items to be built in ample time for rapid progress of the Work. Schedule and proceed with Work as required to satisfy the construction schedule.
- 1.14.6. Confirm the available voltage for all single phase and three phase motors or other similar electrically driven equipment with the Electrical Division prior to ordering the equipment. Report any discrepancy between the requirements identified within the Contract Documents and those of the Electrical Division to the Engineer's Representative and supply equipment to suit the appropriate power requirements. Bear all costs associated with failure to perform this coordination prior to ordering of the motors or equipment.
- 1.15. TEMPORARY USE OF EQUIPMENT
 - 1.15.1. Where systems, or a part thereof, are operated during construction, maintain the system and equipment in proper operating condition.
 - 1.15.2. Prior to application for Substantial Performance of the Work as certified by the Engineer's Representative, return the systems and/or equipment to new condition by replacing all consumables such as air or water filters, belts in belt driven equipment, etc. with new components. Clean the air side of all coils in the air handling systems, lubricate all bearings according to manufacturer's written factory standards and adjust the thermostatic control system according to Specifications. Clean all duct systems to NADCA Standards.
- 1.16. EXISTING SERVICES AND EQUIPMENT
 - 1.16.1. All changes and connections to existing services shall be made only in a manner and at a time approved by the Engineer's Representative so as to avoid any interruption of such services during normal working hours. If necessary, make changes and connections to existing services outside of normal working hours, without additional cost.
 - 1.16.2. Whenever existing services or equipment are to be removed, remove all associated piping and ducts back to the main, nearest pipe or duct and securely cap or plug open ends in an approved manner. If necessary to facilitate installation of new Work, remove existing services and equipment and then replace without additional cost.
 - 1.16.3. Whenever it becomes necessary to relocate existing piping, ducts or equipment to make possible installation of the Work under this Contract, make such relocation without additional cost.
 - 1.16.4. Where connections are made to existing services, replace and make good existing insulation.
- 1.17. INTERRUPTION OF SERVICES
 - 1.17.1. Schedule interruptions of the mechanical services to any part of the building at a time agreeable to the Owner's Representative. Make all necessary arrangements with those concerned and include for any overtime required to ensure that the interruption is held to a minimum.
 - 1.17.2. Obtain approval from the Engineer's Representative for testing and operation of major equipment to avoid excessive utility charges. Such testing is to be generally carried out after normal working hours or on weekends.
 - 1.17.3. Perform all such overtime Work at no additional cost.

1.18. METRIC CONVERSIONS

- 1.18.1. Take particular care with imperial versus SI metric conversions. This applies to all services including, but not limited to, equipment, pipes, ductwork and site services in both new and existing installations.
- 1.18.2. Conform to CAN/CSA-Z234.1 "Metric Practice Guide."

1.19. ALTERNATIVE AND IDENTIFIED PRICES

- 1.19.1. If alternative and unit prices have been requested, include on the Bid Form. Prices not on the Bid Form at time of submission will not be accepted. Refer to the Specifications and the Drawings for details.

1.20. PREPURCHASED EQUIPMENT

- 1.20.1. The Owner has given a letter of intent for pre-purchased equipment to the successful manufacturer.
- 1.20.2. Assume the Contract with the manufacturer. Take responsibility for this equipment under the same terms and conditions as all other equipment supplied by this Division as part of the Contract.
- 1.20.3. The following equipment has been pre-purchased:

Equipment	PURCHASE PRICE
	\$
	\$
	\$
	\$

1.21. DEMOLITION

- 1.21.1. The Drawings show the general scope of the demolition and not exact details or total extent. For exact details and total extent each service must be carefully checked on site. Before removing services, follow the service through to ensure other areas of the building are not affected. Open shafts, walls and ceilings as required to examine the services.
- 1.21.2. If there are no isolating valves readily available to isolate sections of pipe that requires removal, add valves as required. The cost of these valves will be paid for from the Cash Allowance Section. Co-ordinate with the Engineer's Representative to shut-down the system. Install caps on all services. Add caps to all valves at the termination point of existing services.
- 1.21.3. Where valves are removed, remove valve tags, revise existing charts and hand tags over to Owner.

1.22. SCHEDULE, ACCESS, PROTECTION AND CLEAN-UP

- 1.22.1. The construction schedule places restrictions on the duration of construction within areas and the duration of shut-down of equipment. Refer to the General Conditions for all requirements.
- 1.22.2. There may be access restrictions to the site (location, time of day, days of week). Refer to Front End Specifications for more information and conform to all requirements stated within.
- 1.22.3. Refer to the security and protection requirements in the General Conditions and conform to all requirements. In particular:
- .1 No open flames without prior written approval of the Owner.
 - .2 No smoking.

- .3 Keep the site clean at all times.
- 1.23. HOUSEKEEPING PADS, CURBS AND SUPPORT PIERS
 - 1.23.1. Provide dimensioned drawings for final sizes and locations for housekeeping pads, support piers, and curbs around all floor penetrations for pipes and ducts. Submit for review by Division 3 and the Engineer's Representative. Extend edge of equipment housekeeping pad 100 mm (4 in.) beyond equipment frame and hold down bolts. Refer to the Drawings and Details for additional information.
 - .1 Mechanical Division shall furnish and install curbs and housekeeping pads.
 - .2 Mechanical Division shall furnish and install equipment support piers.
 - 1.23.2. Provide housekeeping pad and curb heights as follows:
 - .1 Air handling equipment with cooling coils: 150 mm (6 in.).
 - .2 Air handling equipment with heat wheels: 200 mm (8 in.).
 - .3 Condensing boilers / condensing water heaters: 150 mm (6 in.), or as required by the manufacturer's written instructions.
 - .4 All other equipment: 100 mm (4 in.).
 - .5 Curbs around floor penetrations: 50 mm (2 in.).
- 1.24. ASHRAE 90.1
 - 1.24.1. Provide mechanical equipment that complies with the minimum efficiency standards set out in ASHRAE 90.1 "Energy Standard for Buildings Except Low-rise Residential Buildings" and the National Energy Code of Canada for Buildings. Submit all necessary information to substantiate conformance.
- 1.25. HOISTING FACILITIES
 - 1.25.1. Provide hoisting facilities for the Work of this Division.
 - 1.25.2. Hoisting facilities provided by the General Contractor may be available for Subcontractor's use. If the General Contractor's hoisting facilities are inadequate, provide hoisting facilities for the Work of this Division. Coordinate requirements with the General Contractor prior to submission of Bid.
- 1.26. ENCLOSURES
 - 1.26.1. Where VFDs, pump control panels, fan control panels, or disconnect switches supplied by Mechanical are installed in parking garages, bike storage spaces, or spaces accessible to the public or general building occupants, install the aforementioned items inside a secured, lockable, naturally ventilated, see through tamperproof cover. Ensure tamperproof cover is such that Electrical Code "working space around electrical equipment" with secure footing requirements are complied with.
- 1.27. INTELLECTUAL PROPERTY
 - 1.27.1. The Contractor acknowledges, represents, warrants and agrees that the Owner, its Consultants, and the Engineer's Representative are not responsible, and are hereby indemnified against any action as a result of patent infringement made through the review, acceptance, or receipt of materials, equipment, Work, etc. provided by the Contractor or any of their Suppliers or manufacturers in the execution of this Contract.

1.28. CYBER SECURITY

1.28.1. Coordinate with Owner's Information Technology representatives, obtain a copy of Owner's cyber security policy and provide all applicable cyber security configurations.

1.28.2. Definitions

- .1 Cyber Assets: Systems (including hardware, software, and data) and communication networks (including hardware, software, and data).
- .2 Critical Cyber Assets: Cyber assets that perform critical system functions. The loss or compromise of these cyber assets would adversely affect the operational reliability of the system.
- .3 Cyber Attack: The use of electronic means to interrupt, manipulate, destroy, or gain unauthorized access to a computer system, network, or device.
- .4 Cybercrime: Any crime where cyber – the internet and information technologies, such as software, firmware, computers, tablets, personal digital assistants or mobile devices – has a substantial role in the commission of a criminal offence.
- .5 Cyber Hygiene: Practices and steps that users of computers and other devices take to maintain system health and improve online security. These practices are often part of a routine to ensure the safety of identity and other details that could be stolen or corrupted.
- .6 Cyber Incident: Any unauthorized attempt, whether successful or not, to gain access to, modify, destroy, delete, or render unavailable any computer network or system resource.
- .7 Cyber Security: Technologies, processes, and practices designed to protect networks, devices, programs, and data from attack, damage, or unauthorized access.
- .8 Cyber Threat or Cyber Security Threat: Malicious act that seeks to damage data, steal data, or disrupt digital life in general. Cyber threats include computer viruses, data breaches, Denial of Service (DDoS / DoS) attacks and other attack vectors.
- .9 Cyber Threat Actors: Broad term for any states, groups, or individuals who, with malicious intent, aim to take advantage of vulnerabilities, low cyber Security awareness, and technological developments to gain unauthorized access to information systems in order to access or otherwise affect victims' data, devices, systems and networks.
- .10 IP Multicast: Technique for one-to-many and many-to-many real-time communication over an IP Infrastructure network.
- .11 Endpoint: Remote computing device that communicates back and forth with a network to which it is connected. Such as a server, desktop, or laptop.
- .12 Network Certificates: Also known as a Digital Certificates, which are an electronic "password" that allows a person or organization to exchange data securely over the internet using the public key infrastructure (PKI). Digital Certificates are also known as a public key certificate or identity certificate. There are 3 Main types of certificates:
 - .1 Secure Socket Layer Certificate (SSL) Digi-SSL
 - .2 Software Signing (Code Signing Certificate) Digi-Code
 - .3 Client Certificate (Digital ID) Digi-ID
- .13 Social Engineering: Exploitation methods that target human vulnerabilities, such as carelessness and trust.
- .14 Technical Vulnerabilities: Weaknesses or flaws in the design, implementation, operation, or management of an information technology system, device, or service.

1.28.3. Cyber Security Measures

- .1 Implement at minimum the following multi-layered Cyber Security measures to limit and / or reduce the Owner's potential risk from a cyber threat event; such as a Cyber Security data breach or Cyber Security attack.
- .2 Password Management
 - .1 Employ password management best practices such as:
 - .1 Do not use default passwords.
 - .2 Use strong and unique passwords for all applications. Use a minimum of 8 characters where there is no password policy inherent in the software; use a mixture of uppercase and lowercase letters, numbers, and include at least one special character (! @ # ?]).
 - .3 Reset passwords at regular intervals.
 - .4 Configure two-factor authentication for all accounts where possible in the system software.
 - .5 Do not use System Admin logins for simple tasks; create separate User accounts with rights levels appropriate for the job function. Create and define user accounts as appropriate such as Role based, Individual logins or assigned roles.
 - .6 Use different passwords for every account.
 - .7 Enforce secure password policies within the business environment.
 - .8 Have interface lock after a predefined # of failed login attempts for a predetermined time interval.
- .3 Port and Interface Management
 - .1 Employ Port Management techniques such as:
 - .1 Restrict access on network switch ports to assigned devices addresses.
 - .2 Lock down all open, unused and unsecure ports on the networking devices such as switches, routers, and firewalls.
 - .3 Shut off all unused communication services and hardware interfaces.
 - .4 Advise Owner on use of 3rd party port security monitoring.
- .4 Physical and Virtual Networks
 - .1 Provide a dedicated VLAN for network connected systems where a dedicated LAN has not been provided.
- .5 Encryption
 - .1 Use minimum TLS 1.2 for all network attached equipment and use TLS 1.3 where available.
- .6 Network Certificates
 - .1 Ensure Network Certificates are up to date and not expired for all equipment and systems.
- .7 Firmware & Software Update Management
 - .1 Use the latest stable Firmware / Software version on all devices / equipment as well as implement a Firmware / Software Update management process and procedure.
- .8 Manufacturer's System Hardening Guides
 - .1 Provide the Manufacturer's System hardening guides for the equipment being installed and implement as many recommendations / features as possible.
- .9 External Memory

- .1 Restrict the use of external memory. Restrict or eliminate the use of devices such as external USB Thumb drives unless expressly allowed by the Owner's Information Technology representatives.
- .10 Log Off
 - .1 Enable auto-log off timer for all software, websites and logins. Set auto-log off timer on local Workstation(s) being used to access the equipment with a reasonable timer in the case that an employee leaves the workstation unattended.
- .11 Anti-Virus Software
 - .1 Enable and configure anti-virus software on PC endpoints in accordance with the Owner's Information Technology requirements, unless it is to be installed and configured by the Owner.
- .12 Filtering Techniques
 - .1 Apply filtering techniques including the types listed below where possible:
 - .1 Web Filtering: A Web filter adds another layer to anti-phishing defences by blocking the web-based component of phishing and malware attacks.
 - .2 Multicast Message Filtering: Filters the packets sent to multicast groups users are not subscribed to.
 - .3 Content Filtering: Is the use of a program to screen and / or exclude access to web pages or email deemed objectionable. A content filter will then block access to this content.
- .13 Back up Regularly
 - 1. Provide backup schedule in the closeout submittals and configure system for automatic backups wherever possible.
 - 2. Identify files that require manual backup and the backup procedure. This helps to protect against many types of data loss, especially if a Cyber Threat Actor gains access.
- 1.28.4. IT Devices and Systems
 - .1 Apply the Cyber security measures listed in the clauses above in part or in full, as possible, to a wide range of Information Technology (IT) Devices including:
 - .1 Firewalls
 - .2 Routers
 - .3 Network switches (Core and Edge Devices)
 - .4 Servers and databases
 - .5 Workstation computers
 - .6 Network connected system devices and controllers
 - .7 Wireless Access Points and wireless controllers
 - .8 Mobile phones and tablets
 - .9 Any IT System or endpoint connected to the network
- 1.28.5. Operational Technology (OT) Devices and Systems
 - .1 Apply the Cyber security measures listed in the clauses above, in part or in full, as possible, to a wide range of OT Network devices including:
 - .1 Industrial Control Systems such as:

- .1 (PLC's) Programmable Logic Controllers are an industrial digital computer which has been ruggedized and adapted for the control of manufacturing processes, such as assembly lines, or robotic devices.
 - .2 (SCADA) Supervisory Control and Data Acquisition is a control system architecture comprising of computers, networked data communications and graphical user interfaces (GUI) for high level process supervisory management.
 - .3 (DCS) Distributed Control System is a computerized control system for a process or plant usually with many control loops, in which autonomous controllers are distributed throughout the system.
 - .4 (CNC) Computer numerical Control is the automated control of machining tools (Drills, boring tools, lathes) and 3D printers by means of a computer.
 - .2 Building Management Systems (BMS) and Building Automation Systems (BAS)
 - .3 HVAC equipment
 - .4 Lighting controls for both internal and external applications
 - .5 Energy monitoring and metering equipment
 - .6 Transportation and parking systems
 - .7 Scientific equipment
 - .8 Any other OT System or endpoint that can be connected to the network
- 1.28.6. Report Cybercrime
- .1 Advise the Owner and / or their representatives of any indication of a Cyber Incident of a criminal nature when performing any work on a network connected system.
- 1.28.7. Cyber Security Report Letter
- .1 Provide a Cyber Security Report Letter in the closeout documents to the client stating which Cyber Security measures have been implemented, when implementing any and / or all of the Cyber Security Measures mentioned in this Specification.
- 1.29. WARRANTY
- 1.29.1. Except where longer warranty periods are required by other specification sections, provide a one (1) year warranty for the Work, starting at Substantial Performance of the Work.
- 1.29.2. Coordinate the extension of manufacturer warranties to comply with the clause above, based on the duration of construction.
- 1.30. LIFE SAFETY INTEGRATION TESTING
- 1.30.1. Provide testing of the integration of all life safety and fire protection systems.
- 1.30.2. The Integrated Testing Coordinator (ITC) will complete an Integration Testing Plan (ITP). Carry out the testing as described by the ITC in the ITP, and in accordance with CAN/ULC-S1001 "Integrated Systems Testing of Fire Protection and Life Safety Systems" as it relates to any mechanical systems.
- 1.30.3. The ITC and development of the ITP are not the responsibility of this Contractor.
- 1.30.4. The testing of the integrated systems shall include, but not be limited to the following systems and all associated components:
- .1 Fire Alarm (e.g. mechanical systems integrated with or controlled by fire alarm system – dampers, fan start up, fan shut down, make up air, pressurization, etc.)
 - .2 Elevators

- .3 Emergency Generators and/or Inverters (e.g. combustion air, cooling air, cooling, dampers, fuel, alarms, etc.)
- .4 Sprinkler Systems
- .5 Standpipe Systems
- .6 Fire Pumps
- .7 Water Supplies
- .8 Water Supply Control Valves
- .9 Heat Tracing for Life Safety Systems
- .10 Fixed Fire Suppression Systems
- .11 Cooking Equipment Fire Suppression Systems
- .12 Automatic Door Operators for Stair Relief
- .13 Hold-Open Devices (e.g. smoke control system integration)
- .14 Smoke Control Systems (Passive and / or Active)
- .15 Venting to Aid Firefighting
- .16 Hazardous Protection Monitoring
- .17 Gas / CO Detection Systems
- .18 Prevention of Smoke Recirculation (AHUs)
- 1.30.5. Coordinate with all other trades to carry out the appropriate testing.
- 1.30.6. Be responsible for carrying out and coordinating the testing Work associated with the ITP. Coordinate all Work with the ITC and include but not be limited to the following:
 - .1 Perform functional testing of the integration of all life safety and fire protection systems as a whole to ensure the proper operation and interconnection between the systems.
 - .2 Testing of the integrated life safety systems must be done as a complete installed assembly; individual component testing or partially installed assembly testing is not acceptable.
 - .3 Follow the testing methodology for verifying and documentation of operation as outlined in the ITP and in accordance with CAN/ULC-S1001.
 - .4 Provide all other documentation requested by the ITC as it relates to the mechanical systems in conformance with CAN/ULC-S1001.
- 1.31. VALUATION OF CHANGES
- 1.31.1. Further to Contract requirements, use the following method in determining the value of a change to the Work, by either Change Order or Change Directive:
 - .1 Estimate and acceptance in a lump sum, unless the Engineer's Representative otherwise determines that the method shall be unit prices set out in the Contract.
- 1.31.2. Provide the Engineer's Representative with a detailed cost analysis of the proposed change including:
 - .1 Quantity of each material.
 - .2 Unit cost of each material.
 - .3 Labour units based on Mechanical Contractors Association of America (MCAA) Labour Estimating Manual.
 - .4 Labour (hours) involved.

- .5 Suppliers' quotation or credit memo for equipment noted in proposed change, with detailed breakdown.
 - .6 Sub-trade quotations including a complete cost breakdown of the proposed change meeting the requirements of this section.
 - .7 Sub-trade's suppliers' quotation or credit memo for equipment noted in proposed change, with detailed breakdown.
 - .8 Mark-ups, if applicable.
 - .9 Value of GST or HST, as applicable.
 - .10 Proposed change in contract time, if any.
 - .11 S+A proposed change number in every quotation to facilitate record keeping.
- 1.31.3. Comply with requirements of Contract Documents for all materials included in quotations for proposed changes.
- 1.31.4. List material and labour separately for each item/clause of the proposed change, on the detailed cost breakdown.
- 1.31.5. Not be entitled to any additional compensation arising out of changes to the Work other than the amounts determined and agreed to under CCDC 2-2020 GC 6.2.
- 1.31.6. Inform the Surety Company or Companies who have issued any bonds for this Contract, and any Insurers who have insured any part of the Work or operations or who have an interest in this Contract, of all changes in the Contract. Pay all costs of any changes in bonds or insurances required to maintain bonds or insurances in conformance with the requirements of the Contract Documents. Provide Owner immediately with any revised bonds or insurances.
- 1.31.7. Charge special equipment rental rates at cost. Provide an official quotation of the equipment rental with the proposed change quotation as backup, otherwise special equipment rentals will not be accepted by the Owner/Consultant.
- 1.31.8. The maximum percentage fee for mark-ups is as stated in the Division 0/1 specifications or Contract Supplementary Conditions.
- 1.31.9. All changes, change notices, proposed changes, revisions to contract, Supplemental Instructions, Change Directives or any additional costs or deletes to the stipulated lump sum Contract Price are subject to review and scrutiny by a qualified third party or individual.
- 1.31.10. Use material costs based on a discount to nationally available pricing guides (i.e. Trade Service, Allpriser, etc.) to reflect a value with a fair and reasonable markup to the actual cost of the materials purchased from distributors. The Owner and/or Engineer's Representative reserve the right to negotiate material pricing to a value that is fair and reasonable to the Owner. Indicate on the Bid Form or Supplementary Bid Form: which pricing guide is proposed to be used and discount rate compared to list price.
- 1.31.11. Base the hourly labour rate for all changes on a Journeyperson rate as listed on the Bid Form and/or Supplementary Bid Form. The Owner and/or Engineer's Representative reserve the right to renegotiate the labour rate. The hourly labour rate will be inclusive of overhead, markup and profit.
- 1.31.12. At the request of the Owner or the Engineer's Representative, submit a detailed labour cost breakdown showing a breakdown of all adders to the base wage rate to show how the Contractor has come to the proposed hourly rate. The Owner and the Engineer's Representative reserve the right to negotiate the hourly labour rate with the Contractor.
- 1.31.13. When pricing additional work for proposed changes, only price new materials that are required for the proposed change. Where existing materials and/or infrastructure can be re-used for the proposed change, utilize these items in the valuation of the change at no extra cost.

- 1.31.14. Where a proposed change includes both credits and extras, overhead and permitted mark-ups apply to the net extra or credits, if any, of the entire change.
- 1.31.15. When pricing proposed changes containing both additions and credits, and where no work and/or materials have been installed on site, only price the net new materials and net new labour that are required for the proposed change. Utilize equal per unit labour and material costs for credits and additions.
- 1.31.16. Utilize equal per unit labour and material costs for credits and additions.
- 1.32. STATEMENT OF PRICES
 - 1.32.1. To form a basis for progress payments, submit a sample progress draw for the various portions of the work. Provide sample progress draw format matching that shown in the example progress draw below. As part of the sample progress draw, include a breakdown which illustrates all categories shown on the example progress draw which are relevant to the project. Break down the categories to clearly illustrate the value of the material being supplied as the first subcategory and the value of the labour being supplied as the second subcategory, as shown on the example progress draw. Provide further material and labour breakdowns by floor, area, or phase if the project sequencing or schedule focuses on distinct areas, one at a time. The Engineer's Representative reserves the right to request that additional categories be added to the progress draw if the Engineer's Representative feels that doing so will aid in assessing the Contractor's progress on site, thereby expediting Contractor payment. Progress draws not including the categories shown on the example progress draw where relevant to the project and / or not providing separate labour value and separate material value subcategories will be rejected.
 - 1.32.2. Ensure that the total price of all portions of the work equals the total price of the work covered under the Mechanical Division. Present cost for as-built drawings and O&M manuals as separate line items as shown below. Present line items from Section 20 08 00.00 – COMMISSIONING as shown below.
 - 1.32.3. List and track each of the approved changes on separate lines on the progress draw.
 - 1.32.4. Provide progress draw where the amount claimed is for the value, proportionate to the amount of the Contract, of Work performed and Products delivered to the Place of the Work as of the last day of the payment period. Do not include items on the progress draw which don't meet these conditions.
 - 1.32.5. Amortize costs of temporary facilities and utilities over the duration of the Work. Claims for 'mobilization,' 'bidding costs,' or similar lump sums at or before start of Work are not acceptable.

EXAMPLE PROGRESS DRAW
Mechanical Contractor Name
Billing Application Mechanical Division
Project Name

Application Number – xx

Date – xxxx to xxxx

<u>Description</u>	<u>Contract Value</u>	<u>%</u>	<u>Billed To Date</u>	<u>%</u>	<u>Prev. Billed</u>	<u>%</u>	<u>This Billing</u>	<u>Balance to Complete</u>
Permits	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Demolition & removals	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Plumbing piping – Materials	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Plumbing piping – Labour	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Plumbing fixtures – Materials	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Plumbing fixtures – Labour	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Plumbing equipment – Materials	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Plumbing equipment – Labour	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Drainage piping – Materials	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Drainage piping – Labour	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Drainage pumps – Materials	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Drainage pumps – Labour	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Fire protection piping – Materials	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Fire protection piping – Labour	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Fire protection valves / equipment – Materials	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Fire protection valves / equipment – Labour	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
HVAC piping – Materials	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
HVAC piping – Labour	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
HVAC ductwork – Materials	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
HVAC ductwork – Labour	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
HVAC equipment – Materials	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
HVAC equipment – Labour	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Building Automation System raceways and wiring – Materials	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Building Automation System raceways and wiring – Labour	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Building Automation System equipment – Materials	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Building Automation System equipment – Labour	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Heat tracing – Materials	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Heat tracing – Labour	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Gas service – Materials	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx

Gas service – Labour	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Gas piping – Materials	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Gas piping – Labour	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Water service – Materials	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Water service – Labour	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Fuel oil system – Materials	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Fuel oil system – Labour	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Excavation and backfill – Materials	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Excavation and backfill – Labour	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Balancing Contractor walk-through of site with Mechanical Contractor to confirm that all valves, appurtenances, dampers, and balancing devices to fully balance and test the systems are available and accessible	x,xxx.xx	xxx	x,xxx.xx	xxx	x,xxx.xx	xxx	x,xxx.xx	x,xxx.xx
Shop Drawings (0.5 % of contract value)	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Installation review and equipment verification (0.5 % of contract value)	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Plumbing and drainage system testing (0.5 % of contract value)	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Testing of piping systems (0.5 % of contract value)	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Assistance with Independent Contractor balancing of piping systems (0.25 % of contract value)	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Testing of air systems (0.5 % of contract value)	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Assistance with Independent Contractor balancing of air systems (0.25 % of contract value)	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
System start-up (0.5 % of contract value)	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Commissioning / Testing (3% of contract value)	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Operating & Maintenance Manuals (0.5 % of contract value)	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Training (0.5 % of contract value)	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
As-Built Drawings (0.5 % of contract value)	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Demobilization / Clean-up	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	Xxx	xxx,xxx.xx	xxx,xxx.xx
Subtotal	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Additions to Contract								
CO # / PC # / CCN #	xx,xxx.xx	xxx	xx,xxx.xx	xxx	xx,xxx.xx	xxx	xx,xxx.xx	xx,xxx.xx

Cash Allowance #	xx,xxx.xx	xxx	xx,xxx.xx	xxx	xx,xxx.xx	xxx	xx,xxx.xx	xx,xxx.xx
-----	-----	-----	-----	-----	-----	-----	-----	-----
Subtotal	xx,xxx.xx	xxx	xx,xxx.xx	xxx	xx,xxx.xx	xxx	xx,xxx.xx	xx,xxx.xx
-----	-----	-----	-----	-----	-----	-----	-----	-----
Total Contract	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx	xxx,xxx.xx	xxx,xxx.xx
Less Holdback			xxx,xxx.xx		xxx,xxx.xx		xxx,xxx.xx	
-----	-----	-----	-----	-----	-----	-----	-----	-----
Total			xxx,xxx.xx		xxx,xxx.xx		xxx,xxx.xx	

2. Products

2.1. NOT USED

3. Execution

3.1. NOT USED

END OF SECTION

20 05 01.00 Abbreviations

1. General

1.1. ABBREVIATIONS

- 1.1.1. The following list of common abbreviations and acronyms may be utilized in the Contract Documents or in the execution of the Work. The list is considered general in nature and all abbreviations or acronyms identified may not apply to the specific Work required to be completed. The list is not exhaustive and some abbreviations or acronyms may be the same however represent different denotation (e.g. BHP - Boiler Horsepower and BHP - Brake Horsepower) and must be read in the context of the Section the abbreviation or acronym is written in. A Section may define alternative abbreviations or acronyms that take precedence in the execution of the Work of that Section.

AABC	- Associated Air Balance Council
AAP	- Alarm Annunciator Panel
ABMA	- American Boiler Manufacturers Association
ABSA	Alberta Boilers Safety Association
AC	- Alternating Current
ACO	- Acid Resistant Cleanout
AD	- Acid Resistant Drains
AFD	- Acid Resistant Floor Drain
AFF	- Above Finished Floor
AGA	- American Gas Association
AMCA	- Air Movement and Control Association
ANSI	- American National Standards Institute
AHRI	- Air-Conditioning, Heating and Refrigeration Institute
ASCE	- American Society of Civil Engineers
ASHRAE	- American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME	- American Society of Mechanical Engineers
ASTM	- American Society for Testing and Materials
AV	- Acid Resistant Vent
AWG	- American Wire Gauge
AWS	- American Welding Society
AWWA	- American Water Works Association
BHP	- Boiler Horsepower or Brake Horsepower
Btu/hr	- British Thermal Units per Hour
BWG	- British Wire Gauge
CAD	- Computer Aided Drafting
CAFV	- Controllable Air Flow Venturis
CAP	- College of American Pathologists
CBC	- California Building Code
CCA	- Chromated Copper Arsenate
CEMA	- Canadian Electrical Manufacturer's Association
CEMS	- Central Energy Management System

CCF	- Central Computer Facility
CCMC	- Canadian Construction Materials Centre
cfm	- Cubic Feet per Minute
CGA	- Canadian Gas Association
CGSB	- Canadian General Standards Board
CI	- Cast Iron
CIMJ	- Cast Iron Mechanical Joint
CPU	- Central Processing Unit
CRN	- Canadian Registration Number
CSA	- Canadian Standards Association
cu.ft.	- Cubic Feet
cu.m.	- Cubic Meter
c/w	- Complete with
db.	- Dry Bulb
dB	- Decibel
dBA	- A-weighted Decibel
DC	- Direct Current
DDC	- Direct Digital Control
DegC	- Degrees Celsius
DegF	- Degree Fahrenheit
dia.	- Diameter
DPDT	- Double Pull Double Throw
DPTX	- Differential Pressure Transmitters
EAP	- Excess Exhaust Alarm Panel
EDR	- Equivalent Direct Radiation
EF	- Exhaust Fan
EEMAC	- Electrical Equipment Manufacturers Association of Canada
EEPROM	- Electrically Erasable Programmable Read-Only Memory
EMT	- Electrical Metallic Tubing
EP	- Electric Pneumatic
EPDM	- Ethylene Propylene Diene-Rubber
EPROM	- Electrically Programmable Read Only Memory
ERW	- Electric Resistance Welded
FACP	- Fire Alarm Control Panel
FDA	- Food and Drug Administration
FHC	- Fume Hood Controller or Firehose Cabinet
FLA	- Full Load Amps
fpm	- Feet per Minute
fps	- Feet per Second
FM	- Factory Mutual
ft.	- Foot or Feet
ga	- Gauge
gal	- Gallons

GFD	- Gallons per Square Feet per Day
GPD	- Gallons per Day
GPH	- Gallons per Hour
GPM	- Gallons per Minute
GS	- Galvanized Steel
GSG	- Galvanized Sheet Gauge
GSS	- Galvanized Sheet Steel
h-cu.ft.	- Hour-cubic footHCFCs - Hydrochlorofluorocarbons
HEPA	- High Efficiency Particulate Air
HOA	- Hand/Off/Auto
HOT	- Hand Held Operator Terminal
HSS	- Hollow Steel Sections or Hollow Structural Sections
HTK	- Hood Termination Kit
hp	- High Pressure or Motor Horsepower
Hz	- Hertz
IAO	- Insurers' Advisory Organization
IAOC	- Insurers' Advisory Organization of Canada
IBC	- International Building Code
ICU	- Intensive Care Unit
(I)GPH	- (Imperial) Gallons per Hour
(I)GPM	- (Imperial) Gallons per Minute
in.	- Inch or Inches
in. WG	- Inches of Water Gauge
IRMA	- Inverted Roof Membrane Assembly
kg	- Kilogram
kg/cu.m.	- Kilogram per cubic meter
kPa	- Kilopascals
kVa	- Kilovolt-amps
kW	- Kilowatts
lbs/cu.ft.	- Pounds per cubic foot
lbs/hr.	- Pounds per Hour
L	- Litre
L/s	- Litres per Second
LFC	- Laminar Flow Cabinets
LEDs	- Light Emitting Diodes
LCP	- Laboratory Control Panel
LTF	- Linear foot
LM	- Linear meter
mA	- Milliamps
MAC	- Make-up Air Controller
mADC	- Milliamps Direct Circuit
MBH	- 1000 British Thermal Units per Hour
MCC	- Motor Control Centre

mm	-	Millimetre
m	-	Metre
m/s	-	Metres per Second
mL	-	Millilitre
MCP	-	Motor Control Panel
MJ	-	Mechanical Joint
MOV	-	Motor Overvoltage
mPa	-	Millipascals
MSC	-	Master Summing Controller
MSG	-	Manufacturers' Standard Gauge
NADCA	-	National Air Duct Cleaners Association
NBS	-	National Bureau of Standards
NC	-	Noise Criterion as Defined by Graph in ASHRAE
NCCLS	-	National Committee for Clinical Laboratory Standard
NEMA	-	National Electrical Manufacturers Association
NFPA	-	National Fire Protection Association
NIM	-	Network Interface Module
NIST	-	National Institute of Standards and Technology
NIOSH	-	National Institute of Occupancy Safety and Health
NPS	-	American National Standard Straight Pipe Thread
NPSH	-	Net Positive Suction Head
NPT	-	American National Standard Taper Pipe Thread
No.	-	Number
NST	-	National Standard Thread
NVLAP	-	National Voluntary Laboratory Accreditation Program
OAT	-	Outside Air Temperature
OC	-	On Centre
OCP	-	Operator Control Panel
OPSS	-	Ontario Provincial Standard Specification
OS&Y	-	Outside Screw and Yoke
OWRA	-	Ontario Water Resources Act
oz.	-	Ounce or Ounces
PCU	-	Personal Computer Unit
PE	-	Pneumatic Electric
PIT	-	Portable Interface Terminal
ph	-	Hydrogen Ion Concentration
ppm	-	Part per Million
psf	-	Pounds per Square Foot
psi	-	Pounds per Square Inch
psia	-	Pounds per Square Inch Absolute
psig	-	Pounds per Square Inch Gauge
PWM	-	Pulse Width Modulation
PVC	-	Polyvinyl Chloride

qt.	- Quart
RAH	- Return Air Humidity
RH	- Relative Humidity
RO	- Reverse Osmosis
rpm	- Revolutions per Minute
RPU	- Remote Processing Unit
RPU-TU	- Remote Processing Unit for Terminal Units
SCFH	- Standard Cubic Feet per Hour
SCMH	- Standard Cubic Meters per Hour
SCR	- Silicone Controlled Rectifier
SI	- International System of Units
SMACNA	- Sheet Metal and Air Conditioning Contractors' National Association
sp. in. wg.	- Static Pressure, Inches Water Gauge
SPDT	- Single Pull Double Throw
SPS	- Sash Position Sensor
SS	- Stainless Steel
SF	- Supply Fan
SPWM	- Sine-Coded Pulse Width Modulated
SSPC	- Steel Structures Painting Council (The Society of Protective Coatings)
sq.m.	- Square Meter
STC	- Supply/Exhaust Tracking Controller or Sound Transmission Class
SWS	- Sidewall Velocity Sensors
TDS	- Totally Dissolved Solids
TEFC	- Totally Enclosed Fan Cooled
TIG	- Tungsten Inert Gas
TKV-TWA	- Threshold Limit Value - Time Weighted Average
UACU	- Unitary Air Conditioning Units
UL	- Underwriter's Laboratories
ULC	- Underwriter's Laboratories of Canada
Ohm	- Ohm
USP	- United States Pharmacopeia
USG	- United States Gallons
USGPH	- United States Gallons per Hour
USGPM	- United States Gallons per Minute
UV	- Ultraviolet
VAC	- Volts Alternating Current
VDC	- Volts Direct Current
VFD	- Variable Frequency Drive
VSC	- Variable Speed Controllers
VSCFH	- Closed Loop Variable Frequency Drives For Dedicated Exhaust Hoods
VSD	- Variable Speed Drives
W	- Watt
W/cu.m.	- Watts per Cubic Meter

W/ft.	- Watts per Foot
W/m	- Watts per Meter
W/sq.in.	- Watts per Square Inch
W/sq.m.	- Watts per Square Meter
WC	- Water Closet
wb	- Wet Bulb
wg	- Water Gauge
WHMIS	- Workplace Hazardous Material Information System
WSP	- Working Steam Pressure
WOG	- Water, Oil, Gas

2. Products

2.1. NOT USED

3. Execution

3.1. NOT USED

END OF SECTION

20 05 02.00 As-built drawings

1. General
 - 1.1. WORK INCLUDED
 - 1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
 - 1.2. RELATED WORK SPECIFIED ELSEWHERE
 - 1.2.1. Refer to as-built drawings in Section 01 70 00.00 (01 72 29.00) - CLOSEOUT SUBMITTALS.
 - 1.3. RECORD OF REVISIONS ON SITE
 - 1.3.1. Print and maintain two complete sets of white prints to mark the Project progress, changes and deviations.
 - 1.3.2. Maintain an updated copy of plans and schematics in the digital format for which the Project is provided (i.e. AutoCAD or Autodesk Revit MEP) and be capable to produce documents in Adobe PDF upon request.
 - 1.4. SUBMITTALS
 - 1.4.1. Submit as-built drawings in Revit/CAD format and PDF format for underground services for review prior to slab pour.
 - 1.4.2. Submit as-built drawings in Revit/CAD format and PDF format for all other areas of the building prior to request for occupancy.
 - 1.4.3. Comply with Section 20 05 03.00 - SHOP DRAWINGS for all submittals.
 - 1.5. WARRANTY
 - 1.5.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
2. Products
 - 2.1. NOT USED
3. Execution
 - 3.1. DOCUMENTATION REQUIREMENTS
 - 3.1.1. As the Project progresses record all changes and deviations.
 - 3.1.2. Maintain an accurate dimensional record of revisions. Specifically record:
 - .1 Underground piping invert elevations and pipe locations dimensioned to column lines after review and acceptance by the Authority Having Jurisdiction.
 - .2 Inverts of underground piping at building exit and entry, below floor slab at each branch connection, riser base, and change in direction as well as a least 3 points on long straight runs.

- .3 Above ground piping revisions.
- .4 Duct revisions.
- .5 Equipment revisions.
- .6 Locations of access doors and panels. Identify the equipment and components they serve.
- .7 Locations of valves.
- 3.1.3. Keep revisions up-to-date during construction including Change Orders, Change Directives, and Supplemental Instructions. Make documentation available for review at all times.
- 3.1.4. Final as-built documents shall not contain markings or corrections electronically or by hand (i.e. marker, pen, pencil, etc.). Drawings submitted that contain mark-ups will not be accepted.
- 3.2. SUBMISSION REQUIREMENTS
 - 3.2.1. On completion of the Work, submit the draft documentation indicating all such changes and deviations for review by the Engineer's Representative. Submit all documents in PDF format.
 - 3.2.2. Upon return of the "Reviewed" draft submittal, transfer "as-built" information and any additional submittal comments to the final software submission requirement (i.e. Autodesk AutoCAD or Autodesk Revit MEP).
 - .1 Request the acceptable version(s) of the software that may be used. Owner shall confirm the acceptable software version upon receipt of request. If the Owner has no preference, the latest published version shall apply.
 - .2 Conform to the Owner/Engineer's Representative's standards.
 - .3 The Mechanical Contractor may request from the Engineer's Representative the most current electronic documentation (Mechanical Drawings) in AutoCAD. Documents to be forwarded via a secure file transfer. The Engineer's Representative will provide the Drawings one time at no charge. Where the Drawings are requested more than one time throughout the course of the project, a nominal charge of \$500.00 will apply to the second and subsequent requests.
 - .4 Clearly label electronic files with Engineer's Representative and Owner, Contract number, file names and the Drawing number.
 - 3.2.3. Submit the documents in PDF along with the submission of the completed electronic source software documentation on an approved electronic storage device for review by the Engineer's Representative.
 - 3.2.4. If required, the Engineer's Representative will provide a quotation to this Contractor to transfer "as-built" information from the mark-up documentation to the acceptable software.
 - .1 Include a cost of \$400.00 per sheet for the transfer of marked up "as-built" information to AutoCAD and forwarding of the mechanical information by the Engineer's Representative to the Owner.
 - 3.2.5. The Project will remain incomplete and monies retained until a satisfactory as-built submission is provided.
- 3.3. AUTOCAD SPECIFIC SUBMISSION REQUIREMENTS
 - 3.3.1. Submit a complete list of layer names and brief description of each layer's use with all files.
 - 3.3.2. Submit a complete list of symbol (block) names with a description of each symbol.
 - 3.3.3. Make special effort to ensure that drafting is accurate, i.e. appropriate lines are indeed horizontal and vertical; lines that should intersect do but not over-intersect and that entities are placed on correct layers.

- 3.3.4. Use the standard fonts available in the software. Do not use custom fonts, shape files, etc.
- 3.3.5. Provide all drawings in the same scale of measurement and units as issued on Bid Documents.

END OF SECTION

20 05 03.00 Shop Drawings

1. General
 - 1.1. WORK INCLUDED
 - 1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
 - 1.2. RELATED WORK SPECIFIED ELSEWHERE
 - 1.2.1. Comply with Section 01 33 00.00 (01 33 23.00) for Submittals except as amended below.
2. Products
 - 2.1. SHOP DRAWINGS
 - 2.1.1. Submit Shop Drawings organized by Specification Section. Ensure Shop Drawing package for a given Specification Section is complete, including all equipment, products, materials, and systems to be used as part of that Specification Section, and submit as a single shop drawing package. Do not submit numerous separate Shop Drawings for the same Specification Section. Do not combine more than one Specification Section into one submission. Incorrect submissions will be returned without review.
 - 2.1.2. Within three (3) weeks of Project award, submit the following as the first Shop Drawing/Submittal:
 - .1 A list of the Shop Drawings/Submittals that are proposed to be submitted for the Project, taking into account the organizational requirements of the clause above. Order the list based on Specification Section number, from lowest to highest. Follow the format shown in the example below and use the headings shown to produce a table.
 - .2 State expected equipment lead times.
 - .3 State estimated submission date for Shop Drawings/Submittals.

Example Proposed Shop Drawing List

Mechanical Contractor Name

Project Name

<u>Specification Section #</u>	<u>Specification Section Name</u>	<u>Item</u>	<u>Expected Equipment Lead Time</u>	<u>Estimated Submission Date</u>

- 2.1.3. Do NOT submit all Shop Drawings/Submittals for the Project at the same time. If large quantities of Shop Drawing/Submittals are received at the same time, the Consultant will not be able to review them all within the normal time frame and will require the Contractor to identify the priority order in which submissions should be reviewed.
- 2.1.4. Submit Shop Drawings electronically, by email, in PDF format. Submissions that are not electronic without prior approval from the Engineer's Representative shall be returned as not reviewed. Provide the following information in the email submission:
 - .1 S+A Project number and Contractor Shop Drawing Identifier in Subject Line

- .2 Attachments shall be limited to 20 MB
- .3 Provide FTP hyperlink for all attachments in excess of 20 MB with appropriate information for downloading the file (as required)
- .4 Shop Drawing Submission to the following email address:
 - .1 ContractAdmin.Toronto@smithandandersen.com
- 2.1.5. Shop drawings submitted directly to Smith + Andersen personnel (and not copied to the email address provided above) without advanced permission will not be processed nor considered as received.
- 2.1.6. Shop Drawings shall indicate clearly the materials and/or equipment actually being supplied, all details of construction, accurate dimensions, capacity, operating characteristics and performance. Each Shop Drawing shall give the identifying number as noted in the documents of the specific pump, fan, etc. for which it was prepared.
- 2.1.7. Each Shop Drawing for non-catalogue items shall be prepared specifically for this Project. Shop Drawings and brochures for catalogue items shall be marked clearly to show the items being supplied.
- 2.1.8. When requested, Shop Drawings shall be supplemented by data explaining the theory of operation. The Engineer's Representative may also request that this information be added to the maintenance and operating manual.
- 2.1.9. Provide a cover sheet with the Project name, issue date, issue number, Specification section number, title of section and with space for Shop Drawing review stamps for the Contractor and Engineer's Representative.
- 2.2. ENVIRONMENTAL PRODUCT DECLARATIONS (EPD)
 - 2.2.1. Where EPDs are available for Products, submit them for review.
 - 2.2.2. Follow Product Category Rules (PCRs) for Life Cycle Assessment (LCA) presented on EPDs.
 - 2.2.3. Where multiple EPDs are available for the same Product, the order of preference is as follows:
 - .1 Product Specific, Facility Specific EPD: a Product and manufacturer specific EPD, where the environmental impacts are unique to the specific manufacturing facility.
 - .2 Product Specific EPD: a Product and manufacturer specific EPD where the environmental impacts are considered across multiple manufacturing facilities (i.e. an average of the different facilities in which the Product is manufactured).
 - .3 Industry Average EPD: an EPD for a type of Product, representing the typical environmental impacts averaged across a number of different manufacturers.
- 3. Execution
 - 3.1. SUBMISSIONS
 - 3.1.1. Each Shop Drawing or catalogue sheet shall be in original PDF format stamped and signed by the Contractor to indicate that they have checked the submission for conformance with all requirements of the Drawings and Specifications, that they have co-ordinated this equipment with other equipment to which it is attached and/or connected and that they have verified all dimensions to ensure the proper installation of equipment within the available space and without interference with the Work of other trades. Ensure that electrical co-ordination is complete before submitting Shop Drawings for review.
 - 3.1.2. Scanned PDF versions are not acceptable.

- 3.1.3. Manufacturing of equipment, installation of equipment or connecting services shall not start until after final review of Shop Drawings by the Engineer's Representative has been completed.
- 3.1.4. Should equipment or materials that arrive on site differ from those shown on the Shop Drawings, bear all costs for:
 - .1 Revising the equipment and materials.
 - .2 Revising the Work of other Contractors impacted.

END OF SECTION

20 05 05.00 Selective Demolition for Mechanical Services

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.1.2. These Specifications are an integral part of the Contract Documents and apply to all Division 20, 21, 22 and 23 Sections.

1.1.3. Provide labour, materials, products, equipment and services required to complete the decommissioning and/or demolition Work specified herein.

1.1.4. Refer to Drawings for extent of decommissioning and/or demolition Work. The Drawings indicate the approximate locations of services as far as these are known. The Drawings do not necessarily represent the full extent of the installed service(s) to be removed and are inferred to include decommissioning of all pipes, valves, fittings, appurtenances, etc. except where a service or component is explicitly identified to remain as an abandoned service.

.1 For decommissioning and demolition of all services within a floor or identified area, refer to as-built drawings for reference for additional detail as required.

.2 Where full removal of services or equipment is required and existing as-built drawings are not available, review the service locations on site, plan the removal to avoid disruption or accidental discharge from services, and mark all services for demolition with colour coding as required for phased removal.

1.1.5. Dispose of all debris offsite in accordance with the jurisdictional authorities.

1.1.6. Remove and pay for the disposal of refrigerants, oils, glycol, or similar materials in accordance with all municipal by-law or code requirements.

1.1.7. Remove and store salvageable items as directed herein or indicated on Drawings.

1.1.8. Mechanical decommissioning and/or demolition Work associated with this building is indicated on the Mechanical Drawings and generally consists of the following:

.1 HVAC systems including all ducts, pipes, controls, and appurtenances.

.2 Plumbing and drainage including all sanitary, storm, venting, water distribution, natural gas distribution, specialty piping such as compressed air, fuel oil, etc.

.3 All fire protection systems including sprinkler systems, standpipe systems, fire hose cabinets and all appurtenances.

.4 Remove services in a staged or phased approach to allow for immediate repair or service replacement where required to temporarily maintain the integrity of the building envelope against weather, etc.

1.2. REFERENCE STANDARDS

1.2.1. Meet the requirements of all Municipal, Provincial and Federal By-laws and Ordinances for the Province and Municipality for the Place of the Work.

1.2.2. Execute this Work in accordance with the latest or in force edition of the following codes and standards:

.1 Ontario Building Code.

.3 Occupational Health and Safety Act.

.4 Regulations for Construction Projects.

- .5 Ontario Fire Code.
- .6 National Fire Code of Canada.
- .8 Regulations under Fire Protection and Prevention Act.
- .9 Technical Standards and Safety Authority (TSSA).

1.3. SUBMITTALS

- 1.3.1. Submit Shop Drawings as requested by the Engineer's Representative, indicating demolition sequence, cutting and patching, bracing and protection of existing services designated to remain.
- 1.3.2. Comply with Section 01 33 00.00 (01 33 23.00) for Submittals except as amended below.
- 1.3.3. Comply with Section 20 05 03.00 – SHOP DRAWINGS.

1.4. QUALITY ASSURANCE

- 1.4.1. Provide adequate equipment and skilled labour with appropriate certifications suitable to the demolition task.
- 1.4.2. Remove from site and dispose of debris, refrigerants, oils, etc. in accordance with the requirements of the Authority Having Jurisdiction.
- 1.4.3. Arrange and pay for all permits, notices and inspections necessary for the proper execution and completion of the demolition Work.
- 1.4.4. Decommissioning of special equipment, where noted on the Mechanical Drawings, must be provided by the equipment manufacturer.
- 1.4.5. Review and sign off on all demolition Work prior to demobilization of demolition trades. Any associated costs due to failure to review and sign off on demolition Work will be the responsibility of the Mechanical Contractor.

2. Products

2.1. DISPOSAL OF MATERIALS

- 2.1.1. Except as required by Law for disposal, the Contractor may claim ownership of all materials which have not been designated for salvage from the demolition. Remove all material and debris from the site as quickly as possible and dispose of in a legal manner. Properly remove and dispose of all refrigerant and other toxic or hazardous materials. Burning of debris or selling of materials on site is not permitted. The Contractor is responsible for all future use (or misuse) of items once they have been removed from the installed location.
- 2.1.2. Conform to the requirements of the Municipality regarding disposal of waste materials.
- 2.1.3. Materials prohibited from municipality waste management facilities shall be removed from site and disposed to recycling companies specializing in recyclable materials.

2.2. SALVAGEABLE ITEMS TO BE REMOVED AND STORED

- 2.2.1. The following is a list of salvageable items to be carefully disconnected, removed and turned over for storage for future use:
 - .1 NONE.

3. Execution

3.1. GENERAL INSTRUCTIONS

- 3.1.1. At the end of each Work shift, leave Work in a safe condition.
- 3.1.2. Demolish Work into sections of practical size for removal without alteration or damage to existing building structure or finishes that are indicated to remain.
- 3.1.3. Demolish Work in sections, replacing with new materials as required, for services to remain in operation during the demolition and construction process. This may include, but is not limited to systems such as storm drainage, sanitary drainage, etc.

3.2. STORAGE OF MATERIALS

- 3.2.1. Store materials only in areas designated and as permitted by the local jurisdictional authorities.
- 3.2.2. Do not stack materials and debris in the building to the extent that overloading of any part of the structure will occur.

3.3. PROTECTION OF PREMISES

- 3.3.1. Adhere strictly to the Owner's requirements.
- 3.3.2. Adhere strictly to the requirements for heritage preservation.
- 3.3.3. Adhere to an agreed upon schedule for dust and noise control prior to commencing Work in or adjacent to existing facilities where such Work might affect other facilities or their occupants.
- 3.3.4. Execute Work with least possible interference or disturbance to the building occupants, public, and normal use of adjacent premises.
- 3.3.5. Provide temporary means to maintain security when security has been reduced by this Contractor.
- 3.3.6. Utilize only elevators, dumbwaiters, conveyors or escalators assigned for Contractor's use for moving workers and material within the building. Protect walls of passenger elevators prior to use. Accept liability for damage, safety of equipment and overloading of existing equipment.
- 3.3.7. Provide temporary dust screens, barriers, warning signs in locations where renovations and alteration Work is adjacent to public areas which will be operative during Work.
- 3.3.8. Protect all heritage or other mechanical systems indicated to remain against damage.
- 3.3.9. Provide and maintain ready access to firefighting equipment at all times.
- 3.3.10. Provide and maintain proper and suitable fire extinguishers throughout the duration of the Work.
- 3.3.11. The Drawings indicate the approximate locations of services, as far as these are known. Should any mechanical or electrical service that is anticipated to remain in place (i.e. storm drainage) be broken or disrupted by operations specified under this contract, repair the service and make good all damage. Temporarily remove and replace all services or parts of services to permit the full removal of services identified.
- 3.3.12. The existing Drawings and/or as-built drawings indicate the approximate locations of services as far as these are known. Where specific services are identified for removal within an area of Work, immediately advise the Engineer's Representative in writing when unknown or unexpected services are encountered. Investigate and clearly document these services back to their source, as required, to facilitate further direction regarding removal.
- 3.3.13. Accept liability for costs incurred by the Owner in repairing and cleaning equipment, etc., resulting from failure to comply with the above requirements.

3.4. RESTRICTIONS REGARDING USE OF PREMISES

- 3.4.1. Use only those existing entrances and stairs designated for access to and egress from the existing buildings and various floors where Work of this contract is to be carried out. No traffic through other areas of the building will be permitted without the prior consent of the Owner.
- 3.4.2. Keep stairs and corridors clear and open as required for exit purposes in case of fire, and as required for use by the Contractor's personnel.

3.5. PREPARATION

- 3.5.1. Prior to commencing this Work, arrange to have the appropriate trades present to disconnect all utility services where required.
- 3.5.2. Drain completely all gravity or pressurized water services to avoid damage or hazard due to accidental discharge. Where sections of the installed services cannot be drained fully utilizing existing valves, drain connections, etc., open the service and control the discharge of water appropriately to avoid discharge during service removal.
- 3.5.3. Identify and protect all existing services designated to remain.

3.6. INTERRUPTION OF EXISTING SERVICES TO REMAIN

- 3.6.1. Arrange, schedule and perform Work to mitigate disturbance to existing facilities and services.
- 3.6.2. Submit a complete master schedule of anticipated service interruptions and changeovers with approximate dates required, durations and times of day, for approval by the Owner before proceeding with any Work. Update and submit the schedule on a weekly basis during construction.
- 3.6.3. Notify the Owner in writing at least 36 hours in advance (unless specified elsewhere) of the planned interruption of existing services that are to remain.
- 3.6.4. Interruption of services must occur at the times and for the duration stipulated by the Owner.
- 3.6.5. Keep service interruption duration to an absolute minimum. Carry out all preparatory Work, measurements, etc., without interruption of existing services where possible.
- 3.6.6. The following service interruptions are required to be performed after business hours or on weekends, etc. Include all required costs to complete the Work during this time:
 - .1 Sprinkler Work

3.7. PARTIAL REMOVAL OF A SERVICE

- 3.7.1. Remove services back to the main (service pipe or duct) or nearest branch (pipe or duct) serving other areas to remain. Cap services tight to the main or branch.
- 3.7.2. Do not abandon unused services in the ceiling space, furred walls, shafts, etc. unless expressly permitted by the Engineer's Representative or Owner.
- 3.7.3. Where an unused service is indicated or permitted to remain, mark the abandoned services clearly including the service type (i.e. Do Not Connect - Abandoned Chilled Water).

END OF SECTION

20 05 13.00 Electric Motors

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.1.2. Provide electric motors for all driven equipment supplied by this Division.

1.2. SUBMITTALS

1.2.1. Provide Shop Drawings for all electrical motors in accordance with Section 20 05 03.00 - SHOP DRAWINGS and incorporate the following information:

- .1 Horsepower
- .2 Voltage
- .3 Frequency
- .4 Speed
- .5 Starting current and torque characteristics
- .6 Full load current
- .7 Class of insulation
- .8 Enclosure type
- .9 Service factor
- .10 Ambient temperature reference
- .11 Type of bearings
- .12 Locations of connection box
- .13 Manufacturer
- .14 Motor starting times

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Motors:

- .1 Efficiency:
 - .1 Meet or exceed requirements of ASHRAE 90.1 “Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings,” CSA C390 “Test method, marking requirements, and energy efficiency levels for three-phase induction motors,” and Government of Canada Electric Motors Energy Efficiency Regulations.

- .2 High efficiency motors: T frame, AC, three phase, meeting or exceeding the CSA C390 "Test Methods, Marking Requirements, and Energy Efficiency Levels for Three-phase Induction Motors" Table 3 Premium Efficiency levels and approved under the Canadian Electrical Code:
 - .1 Provide high efficiency motors for all fans and pumps having motors 0.75 kW (1 hp) or larger.
 - .2 Squirrel cage induction type with standard drip proof enclosure.
 - .3 Conform to NEMA and CSA standards for electrical motors.
 - .4 Canadian manufacturer where possible.
 - .5 1750 nominal rpm unless specified otherwise.
 - .6 Class F Insulation system.
 - .7 For motors controlled by variable speed drives, provide a class F insulation system and comply with NEMA MG 1 "Motors and Generators" Part 31 "Definite Purpose Inverter-fed Polyphase Motors."
 - .8 Starting current-torque characteristics in accordance with NEMA, Design B unless otherwise specified or unless load characteristics dictate otherwise.
 - .9 Starting times: start and accelerate to full speed within 10 seconds.
 - .10 Motor horsepowers indicated in the Specifications, Schedules, or Drawings are minimums.
 - .11 Designed for continuous operation at 40 deg. C. (104 deg. F.).
- 2.1.2. Motors controlled from Variable Speed Drives:
- .1 Maintenance free, conductive microfiber, shaft grounding ring.
 - .1 AEGIS SGR for low voltage motors up to 500 hp.
 - .2 AEGIS Pro Series for medium and low voltage motors over 500 hp.
 - .3 Where explosion proof motors are required, locate shaft grounding rings within explosion proof enclosure in accordance with IEEE Standard 303 "IEEE Recommended Practice for Auxiliary Devices for Rotating Electrical Machines in Class I, Division 2 and Zone 2 Locations" or inside the explosion proof motor. Install in accordance with manufacturer's recommendations.
- 2.1.3. Locate motor connection boxes on side of motor most easily accessible for maintenance and remote from belts, gears or driven equipment. If boxes are factory installed on wrong side of motor, relocate as required.
- 2.1.4. Motor characteristics unless noted otherwise in equipment schedules:
- .1 For 0.375 kW (1/2 hp) and larger 575 volt, 3 phase, 60 cycle.
 - .2 For 0.25 kW (1/3 hp) and smaller 120 volt, 1 phase, 60 cycle.
- 2.1.5. Single phase motors 0.25 kW (1/3 hp) and smaller: capacitor start.
- 2.1.6. Provide motors 22.4 kW (30 hp) and larger with heat detector protection embedded in the windings for connection into the motor control circuit.
- 2.1.7. Motors 74.6 kW (100 hp) and larger: suitable for reduced voltage starting, delta-wye.
- 2.1.8. Motor enclosures as follows:
- .1 If protected from the weather and entraining moisture, use open drip-proof, service factor 1.15.
 - .2 Motors located in air streams: suitable for satisfactory operation at maximum temperature and moisture levels of surrounding air.

- .3 For all other locations, use totally-enclosed fan-cooled (TEFC), service factor 1.0.
 - .4 Use explosion proof motors where scheduled.
- 2.1.9. Nameplate: minimum of 2 mm (3/32 in.) thick laminated phenolic plastic 100 mm (4 in.) long x 50 mm (2 in.) wide with black face and white centre, 5 mm (7/32 in.) high letters engraved through to the white lamination, securely fastened in a conspicuous place on the motor. Include the following information on the nameplate:
 - .1 Motor No.
 - .2 Mechanical Equipment Driven
 - .3 Circuit No.
 - .4 Panel No.
 - .5 Panel Location
- 2.1.10. Manufacturer nameplate: include the nominal full load motor efficiency.
- 2.1.11. Manufacturers:
 - .1 Canadian General Electric
 - .2 TECO Westinghouse
 - .3 Lincoln
 - .4 US Motors
 - .5 Weg
 - .6 ABB Baldor
- 3. Execution
- 3.1. INSTALLATION
- 3.1.1. Install protective guards over all moving parts. Include tachometer holes for each shaft.
- 3.1.2. Check that all motors are rotating in the correct direction. Where they are not, work with the Electrical Contractor to resolve the motor rotation issue.

END OF SECTION

20 05 14.00 Wiring and Starters

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.1.2. All power and control wiring from starters and fused and non-fused disconnect switches, whether mounted in MCCs or individually, to all mechanical devices and equipment shall be provided by this Division except where shown and specified under the Electrical Division.

1.1.3. All starters for devices supplied by this Division shall be provided by this Division except where shown and specified under the Electrical Division.

1.2. RELATED WORK SPECIFIED ELSEWHERE

1.2.1. All power wiring and starters for devices supplied by this Division shall be provided by the Electrical Division except where shown and specified under this Division. All control wiring shall be provided by this Division.

1.2.2. Where starters for skid mounted, packaged equipment are provided by this division they shall meet the requirements of the Electrical Division.

1.3. REFERENCES

1.3.1. IEC 60947-4-1 "Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters" latest edition.

1.3.2. CSA C22.2 No. 60947-4-1 "Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters (Bi-national standard with UL 60947-4-1)" latest edition.

1.3.3. CSA C22.2 No. 4 "Enclosed and dead-front switches (Tri-national standard with NMX-J-162-ANCE-2016 and UL 98)" latest edition.

1.3.4. CSA C22.2 No. 39 "Fuseholder assemblies" latest edition.

1.4. SUBMITTALS

1.4.1. Further to the requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS and Section 20 05 03.00 - SHOP DRAWINGS, submit Shop Drawings of the following for Individual Starters:

- .1 Submit an overload thermal element list with all supporting data for review prior to installation of the elements.
- .2 Submit samples of nameplates for review before manufacturing.
- .3 Mounting method and dimensions.
- .4 Starter size and type.
- .5 Layout of identified internal and front panel components.
- .6 Enclosure types.
- .7 Wiring diagram for each type of starter.
- .8 Interconnection diagrams.

- 1.4.2. Further to the requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS and Section 20 05 03.00 - SHOP DRAWINGS, submit Shop Drawings of the following for Motor Control Centre:
- .1 Outline dimensions.
 - .2 Configuration of identified compartments.
 - .3 Floor anchoring method and dimensioned foundation template.
 - .4 Cable entry and exit locations.
 - .5 Dimensioned, position and size of busbars and details of provision for future extension.
 - .6 Schematic and wiring diagrams.
 - .7 Size, capacity and labeling of all starters.
 - .8 Electrical ratings of MCC.
- 1.5. WARRANTY
- 1.5.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
2. Products
- 2.1. DISCONNECT SWITCHES
- 2.1.1. Fusible, horsepower rated disconnect switch in CSA Type 3R enclosure, size as indicated.
- 2.1.2. Provision for padlocking in on-off switch position by three locks.
- 2.1.3. Mechanically interlocked door to prevent opening when handle in ON position.
- 2.1.4. Fuses: size as indicated, class J, current limiting, in accordance with Section 26 28 14.00 - FUSES - LOW VOLTAGE.
- 2.1.5. Fuse-holders: suitable without adaptors, for type and size of fuse indicated.
- 2.1.6. Quick-make, quick-break action.
- 2.1.7. ON-OFF switch position indication on switch enclosure cover.
- 2.1.8. Equipment identification
- .1 Provide equipment identification in accordance with Section 26 05 53.00 - IDENTIFICATION.
 - .2 Indicate name of load controlled on nameplate.
 - .3 Provide a lamacoid nameplate that indicates the replacement fuse size as well as the maximum allowable fuse size for that disconnect switch based upon the sizing of the feeder.
- 2.1.9. MANUFACTURERS
- .1 Schneider Electric.
 - .2 Eaton Cutler-Hammer.
 - .3 Siemens.
- 2.2. MOTOR CONTROL CENTRE
- 2.2.1. SUPPLY CHARACTERISTICS
- .1 600 V, 60 Hz, wye connected, 3 phase, 3 wire, plus bonding conductor.

2.2.2. GENERAL DESCRIPTION

- .1 Compartmentalized vertical sections with common power busbars.
- .2 Floor mounting, free standing, metal enclosed dead front enclosure.
- .3 Indoor CSA Type 1 with drip hood, sprinkler proof enclosure suitable for front mounting.
- .4 Class I Type C wiring.

2.2.3. VERTICAL SECTION CONSTRUCTION

- .1 Independent vertical sections fabricated from rolled flat steel sheets bolted together to form a rigid, completely enclosed assembly.
- .2 Each vertical section shall be divided into compartment units.
- .3 Each unit to have complete top and bottom steel plate for isolation.
- .4 Horizontal wireways, equipped with cable supports, across top and bottom, extending full width of motor control centre, isolated from busbars by steel barriers.
- .5 Vertical wireways c/w doors for load and control conductors extending full height of vertical sections, and equipped with cable tie supports. Installation wiring to units accessible with doors open and units in place.
- .6 Openings, with removable cover plates, in side of vertical sections for horizontal wiring between sections.
- .7 Incoming cables to enter at top or bottom as indicated on Drawings.
- .8 Provision for outgoing cables to exit via top or bottom with terminals.
- .9 Removable lifting means.
- .10 Provision for future extension of both ends of motor control centre including busbars without need for further drilling, cutting or preparation in field.
- .11 Divide assembly for shipment to site, as required complete with hardware and instructions for re-assembly.

2.2.4. SILLS

- .1 Continuous 50 mm channel iron floor sills for mounting bases with 19 mm diameter holes for bolts.

2.2.5. BUSBARS

- .1 Main horizontal and branch vertical, three phase high conductivity tin plated copper busbars in separate compartment bare self-cooled, extending entire width and height of motor control centre, supported on insulators and rated:
 - .1 Main horizontal busbars rated as specified on MCC schedules, but no less than 600 A.
 - .2 Branch vertical busbars as required to meet the connected load and 20% spare capacity (300 A minimum).
- .2 Branch vertical busbars for distribution of power to units in vertical sections.
- .3 No other cables, wires, equipment in main and branch busbar compartments.
- .4 Brace buswork to withstand effects of short-circuit current of 65 kA RMS symmetrical.
- .5 Bus supports: with high dielectric strength, low moisture absorption, high impact material and long creepage surface designed to discourage collection of dust.

2.2.6. GROUND BUS

- .1 Copper ground bus extending entire width of motor control centre.
- .2 Vertical ground bus strap, full height of section, tied to horizontal ground bus, engaged by plug-in unit ground stab.

2.2.7. MOTOR STARTERS AND DEVICES

- .1 Refer to Section 26 29 00.00 - MOTOR STARTERS TO 600 V and to Motor Control Schedule.

2.2.8. STARTER UNIT COMPARTMENTS

- .1 Units NEMA size 5 and smaller, circuit breaker units 225 A and smaller, plug-in type with self-disconnect. Guide rail supports for units to ensure that stabs make positive contact with vertical bus. Provision for units to be installed or removed, off load, while buses energized.
- .2 Unit mounting:
 - .1 Engaged position - unit stabbed into vertical bus.
 - .2 Withdrawn position - unit isolated from vertical bus but supported by structure. Terminal block accessible for electrical testing of starter.
 - .3 Provision for positive latching in either engaged or withdrawn position and padlocking in withdrawn position.
 - .4 Stab-on connectors free floating tin plated clips, self-aligning, backed up with steel springs.
- .3 External operating handle of circuit switch interlocked with door to prevent door opening with switch in "on" position. Provision for 3 padlocks to lock operating handle in "off" position and lock door closed.
- .4 Hinge unit doors on same side.
- .5 Overload relays manually reset from front with door closed.
- .6 Pushbuttons and indicating lights mounted on door front.
- .7 Devices and components by one manufacturer to facilitate maintenance.
- .8 Pull-apart terminal blocks for power and control to allow removal of starter units without removal of field wiring.

2.2.9. FINISHES

- .1 Equipment to be painted: baked grey enamel.

2.2.10. MANUFACTURERS

- .1 Schneider.
- .2 Eaton.
- .3 Siemens.
- .4 Rockwell Automation Allen-Bradley.

- 2.2.11. Provide an engraved lamaroid nameplate for the motor control centre and each individual starter within the motor control centre. MCC identification shall be 50 mm (2 in.) high letters. All other identification shall be 6 mm (1/4 in.) high letters.

Typical Identification Plate for Motor Control Centre

First Line	- MCC #1
Second Line	- Voltage/Phase/# of Wires
Third Line	- Fed from main secondary switchboard
Fourth Line	- In main electrical room

Typical Identification Plate for Individual Starters

First Line	- Supply Fan SF-1

Second Line - Voltage/Phase/# of Wires

2.2.12. All nameplates shall be fastened with self-tapping screws.

2.3. MATERIALS

2.3.1. Starters: to IEC 60947-4-1 with AC4 utilization category.

2.4. EQUIPMENT

2.4.1. All starters (with the exception of manual motor starters) are to be combination starters with fusible disconnect switches.

.1 All fusible disconnects are:

- .1 To be of the quick make and quick break type.
- .2 To have an operating handle on the outside of the enclosure.
- .3 To have fuse clips suitable for HRC type J fuses.

.2 The operating handle of the fusible disconnect switch must be:

- .1 Capable of being locked in the "OFF" position.
- .2 Have provisions of accepting 3 pad locks.
- .3 Have provision for preventing switching to "ON" position while enclosure door is open.

2.4.2. All starters, with the exception of manual motor starters, are to be provided with a single phase, dry type control circuit transformer with:

- .1 A fused secondary.
- .2 Primary voltage as indicated.
- .3 120 V secondary.
- .4 Secondary fusing.

2.4.3. Size the control transformer for control circuit load plus 20 % spare capacity, minimum capacity 150 VA.

2.4.4. All starters shall be equipped with indicating lamps that are long life cluster LED style.

2.4.5. All starters shall be provided with 3 phase bimetallic overload relays which are adjustable and are ambient temperature compensated. Manual resets for the overload relays are to be mounted on the enclosure door such that they can be reset from outside of the enclosure and have externally visible trip indication.

2.4.6. All starters shall have identification for each wire and terminal for external connection, within starter, with permanent number marking identical to diagram.

2.5. MANUAL MOTOR STARTERS

2.5.1. Single or three phase manual motor starters of size, type, rating, and enclosure type as indicated, with components as follows:

- .1 Switching mechanism, quick make and break.
- .2 One overload heater per phase, manual reset, trip indicating handle.

2.5.2. Accessories:

- .1 Toggle switch: heavy duty oil tight labeled as indicated on the Starter Schedule.
- .2 Indicating light: oil tight type and colour as indicated on the Starter Schedule.

- .3 Locking tab to permit padlocking in "ON" or "OFF" position.

2.6. FULL VOLTAGE MAGNETIC STARTERS

- 2.6.1. Magnetic and combination magnetic starters of size, type, rating and enclosure type as indicated with components as follows:

- .1 Contactor solenoid operated rapid action type.
- .2 Motor overload bimetallic protective relay.
- .3 Wiring and schematic diagram inside starter enclosure in a visible location.

- 2.6.2. Accessories:

- .1 Pushbuttons or Selector switches: heavy duty oil tight labeled as indicated on the Starter Schedule.
- .2 Indicating lights: oil tight type and color as indicated on the Starter Schedule.
- .3 2-N/C and 2 N/O spare auxiliary contacts unless otherwise indicated on the Starter Schedule.

2.7. FULL VOLTAGE REVERSING MAGNETIC STARTERS

- 2.7.1. Full voltage reversing magnetic starters of size, type, rating and enclosure type as indicated with components as follows:

- .1 Two - 3 pole magnetic contactors mounted on a common base.
- .2 Mechanical and electrical interlocks to prevent both contactors from operating at same time.
- .3 Motor overload bimetallic protective relay.
- .4 Wiring and schematic diagram inside starter enclosure in a visible location.

- 2.7.2. Accessories

- .1 Pushbuttons or Selector switches: heavy duty oil tight labeled as indicated on the Starter Schedule.
- .2 Indicating lights: heavy duty oil tight type and color as indicated on the Starter Schedule.
- .3 Auxiliary control devices as indicated on the Starter Schedule.

2.8. MULTI-SPEED STARTERS

- 2.8.1. (2) Speed starters of size, type, rating and enclosure type as indicated. Starter suitable for variable torque type motor, unless otherwise indicated, and with components as follows:

- .1 One 3-pole contactor for each winding for separate winding motors.
- .2 One 3-pole and one 5-pole contactor for each re-connectable winding for consequent pole type motors.
- .3 Three overload relays.

- 2.8.2. Accessories:

- .1 Pushbuttons or Selector switches: heavy duty oil tight labeled as indicated on the Starter Schedule.
- .2 Indicating lights: heavy duty oil tight, type and color as indicated on the Starter Schedule.
- .3 Auxiliary control devices as indicated on the Starter Schedule.

- .4 Low speed compelling relay and automatic sequence accelerating, decelerating relays for each speed.

2.9. MAGNETIC STARTER, REDUCED VOLTAGE, AUTO-TRANSFORMER

2.9.1. Auto-transformer starter closed circuit transition type, of size, type, rating and enclosure type as indicated and with following components:

- .1 Three 3-pole contactors.
- .2 Auto-transformer with 50 %, 65 % and 80 % taps.
- .3 One adjustable pneumatic timing relay.
- .4 One 3-pole manual reset overload device.
- .5 Thermal overload protection of auto-transformers.

2.9.2. Accessories:

- .1 Pushbuttons or Selector switches: heavy duty oil tight labeled as indicated on the Starter Schedule.
- .2 Indicating lights: heavy duty oil tight type and color as indicated on the Starter Schedule.
- .3 Auxiliary control devices as indicated on the Starter Schedule.

2.10. MAGNETIC STARTER REDUCED VOLTAGE STAR-DELTA

2.10.1. Reduced voltage star-delta open transition starter, of size, type, rating and enclosure type as indicated, with components as follows:

- .1 Two 3-pole delta contactors with auxiliary relays and interlocks.
- .2 One 3-pole star contactor with auxiliary relays and interlocks.
- .3 Mechanical interlock to interlock one delta contactor and the star contactor.
- .4 One timing relay.
- .5 Three overload relays.

2.10.2. Reduced voltage star-delta closed transition starter, of size, type, rating and enclosure type as indicated, with components as follows:

- .1 Two 3-pole delta contactors with auxiliary relays and interlocks.
- .2 One 3-pole star contactor with auxiliary relay and interlocks.
- .3 One 3-pole transition contactor.
- .4 One set of transition resistors.
- .5 Mechanical interlock, to interlock one delta contactor and the star contactor.
- .6 One timing relay.
- .7 Three overload relays.

2.10.3. Accessories:

- .1 Pushbuttons or Selector switches: heavy duty oil tight labeled as indicated on the Starter Schedule.
- .2 Indicating lights: heavy duty oil tight, type and color as indicated on the Starter Schedule.
- .3 Auxiliary control devices as indicated on the Starter Schedule.

2.11. MAGNETIC STARTER REDUCED VOLTAGE PART WINDING

2.11.1. Two-step reduced voltage, part winding starter of size, type, rating and enclosure type as indicated, with components as follows:

- .1 Two 3-pole contactors.
- .2 Adjustable pneumatic timer.
- .3 Six manual reset overload relays.

2.11.2. Three step reduced voltage part winding starter of size, type, rating and enclosure type as indicated, with the following components:

- .1 Three 3-pole contactors.
- .2 One set starting resistors.
- .3 Six overload relays.

2.11.3. Accessories:

- .1 Pushbuttons or Selector switches: heavy duty oil tight labeled as indicated on the Starter Schedule.
- .2 Indicating lights: heavy duty oil tight type and color as indicated on the Starter Schedule.
- .3 Auxiliary control devices as indicated on the Starter Schedule.

2.12. THREE PHASE MANUAL REVERSING STARTER

2.12.1. Three phase manual reversing starter of size, type, rating and enclosure type as indicated, with components as follows:

- .1 Two 3-pole manual motor starters, quick make and break.
- .2 Six overload relays and manual reset.
- .3 Mechanical interlock to prevent both switches from closing at same time.

2.12.2. Accessories

- .1 Pushbuttons or Selector switches: heavy duty oil tight labeled as indicated on the Starter Schedule.
- .2 Indicating lights: heavy duty oil tight type and colour as indicated on the Starter Schedule.

2.13. THREE PHASE MANUAL TWO SPEED SEPARATE WINDING STARTERS

2.13.1. Three phase manual two speed separate winding starters of size, type, rating and enclosure type as indicated with components as follows:

- .1 Two 3-pole manual motor starters, quick make and break.
- .2 Six overload relays and manual reset.
- .3 Mechanical interlock to prevent both switches from closing at same time.

2.13.2. Accessories:

- .1 Pushbuttons or Selector switches: heavy duty oil tight labeled as indicated on the Starter Schedule.
- .2 Indicating lights: heavy duty oil tight type and colour as indicated on the Starter Schedule.

2.14. ENCLOSURE

- 2.14.1. Starter to come in a CSA Type 3R enclosure, size as indicated.
- 2.14.2. Equipment to be painted: baked grey enamel.
- 2.14.3. Provide an engraved lamacoid nameplate for each individual starter. Identification shall be 6 mm (1/4 in.) high letters.

Typical Identification Plate

- First Line - Exhaust Fan EF-1
- Second Line - 208 V/3 ph./3 W
- Third Line - Fed from splitter #1

3. Execution

3.1. INSTALLATION

- 3.1.1. Install starters, connect power to starter and provide wiring from starter to motor through a manual disconnecting device if required by code.
- 3.1.2. Connect controls to starters and connect power to controls.
- 3.1.3. Ensure correct fuses and overload devices elements installed.
- 3.1.4. All wiring and starters provided by this Division shall comply with the requirements of the Electrical Division of the Specifications.
- 3.1.5. This Division shall review the Shop Drawings for the motor starters submitted by the Electrical Division to ensure that all field connections are shown, the motor horsepower are correct and that the motor control schematics reflect all requirements.
- 3.1.6. Install disconnect switches in accessible locations which meet the electrical code requirements for working space with secure footing. Working space clearance envelope to be 1 m deep in front of disconnect switch, 1 m or disconnect switch width wide, whichever is greater, and 2.2 m high.
- 3.1.7. Ensure slack is provided in control wiring connections to control valves, dampers, differential pressure sensors, or other equipment with moving parts.
- 3.1.8. Ensure slack is provided in power wiring connections to control valves, dampers, differential pressure sensors, or other equipment with moving parts.

3.2. FIELD QUALITY CONTROL

- 3.2.1. Perform tests in accordance with Section 26 08 01.00 - TECHNICAL SERVICES DIVISION START-UP SERVICE and manufacturer's written instructions. Contractor to oversee all testing and correct any deficiencies noted.
- 3.2.2. Operate switches, contactors to verify correct functioning.
- 3.2.3. Perform starting and stopping sequences of contactors and relays.
- 3.2.4. Check that sequence controls, interlocking with other separate related starters, equipment, control devices, operate as indicated.

END OF SECTION

20 05 15.00 Variable Frequency Drives

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. QUALITY ASSURANCE

1.2.1. The Variable Frequency Drive (VFD) manufacturing facility shall be ISO 9001 "Quality Management Systems - Requirements" certified. The VFD shall be UL listed, Canadian UL listed and CSA listed.

1.2.2. Provide a minimum 100,000 hours mean time between failure (MTBF).

1.2.3. The term Variable Frequency Drive (VFD) shall be synonymous with Variable Speed Drives (VSD) and Adjustable Frequency Drives (AFD).

1.2.4. All Variable Frequency Drives for this Project shall be of a single manufacturer for all fan and pump systems, including all components that require VFDs for air handling equipment, cooling towers, fluid coolers, pumps, etc. except where specifically identified as part of a packaged system in these Specifications.

1.3. RELATED WORK

1.3.1. For motors connected to Variable Frequency Drives, refer to requirements of Section 20 05 13.00 - ELECTRIC MOTORS.

1.4. SUBMITTALS

1.4.1. Submit Shop Drawings of all items supplied in accordance with requirements of Section 20 05 03.00 - SHOP DRAWINGS.

1.4.2. Ensure Shop Drawings include VFD Short Circuit Current Rating (SCCR).

1.5. WARRANTY

1.5.1. Provide 24-month warranty starting at the date of Substantial Performance of the Work. Provide warranty that includes on-site parts and labour.

2. Products

2.1. GENERAL REQUIREMENTS

2.1.1. Variable Frequency Drives (VFD) shall be Danfoss VLT HVAC Drive FC102, Rockwell Automation Allen-Bradley PowerFlex 700, and ABB ACH580 as specified herein for the fans, pumps, heat recovery wheels, and cooling tower fans designated on the schedules or in the respective sections to be variable speed.

2.1.2. All standard and optional features shall be included within the VFD enclosure, unless otherwise specified. The VFD's UL listing shall allow it to be mounted in a plenum or other air handling compartments.

- 2.1.3. For indoor applications, the VFD shall be housed in a CSA Type 1 with drip hood, sprinkler proof enclosure.
- 2.1.4. For outdoor and humid (>70 % relative humidity) applications, the VFD shall be housed in a CSA Type 3R enclosure.
- 2.1.5. The VFD shall be a digitally controlled drive, using Pulse Width Modulation (PWM) technology with sensorless vector control. It shall utilize IGBTs in its inverter section.
- 2.1.6. The VFD shall allow the motor to produce full rated power at rated amps, RMS fundamental volts, and speed without using the motor's service factor when the motor's rated voltage is applied to the VFD input.
- 2.1.7. The VFD shall include an integral disconnect switch on the line side of the drive.
- 2.1.8. VFD shall bear a minimum Short Circuit Current Rating (SCCR) listed by a Nationally Recognized Testing Lab, acceptable to the local Authority Having Jurisdiction, and shall be **10,000 A** Lower SCCR listed units implying the use of current limiting fuses ahead of them in the field, in lieu of an actual appropriate SCCR rating, are not acceptable.
- 2.1.9. The VFD including all specified options shall be assembled by the ANSI/UL Standard 508 "Industrial Control Equipment" certified manufacturer for the building and assembly of option panels and the complete unit shall be tested to ANSI/UL Standard 508. Assembly of the option panels by a third-party panel shop shall not be acceptable. Where the components are separate, the appropriate CSA or C-UL stickers shall be applied to both the VFD and option panel. Both the VFD and option panel shall be manufactured in ISO 9001 "Quality Management Systems - Requirements" certified facilities.
- 2.1.10. Provide harmonic filters for VFDs in accordance with Section 20 35 26.00 – HARMONIC FILTERS.
- 2.1.11. The VFD's full load amp rating shall meet or exceed Canadian Electrical Code Table 44 "Three-phase ac motors." The VFD shall be able to provide full rated output current continuously, 110 % of rated current for 60 seconds and 160 % of rated current for up to 0.5 second while starting.
- 2.1.12. The VFD shall be able to provide full torque at any selected frequency from 28 Hz to base speed to allow driving direct drive fans without derating.
- 2.1.13. Input and output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD. Switching rate may be up to 1 time per minute on the input and unlimited on the output. Disconnect switches located between the drive and the motor shall be interlocked into the VFD's safety circuitry.
- 2.1.14. An automatic motor adaptation test algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to run the test.
- 2.1.15. VFD power components shall be designed for 600 V AC where intended for 575/600 V service. Components designed for 480 V AC installed on 575/600 V service shall not be acceptable.
- 2.1.16. VFD shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD efficiencies while reducing motor noise.
- 2.1.17. VFD's output switching shall be maintained within the requirements of NEMA Standard MG 1 "Motors and Generators" Part 30. VFD's with output exceeding 1000 V shall employ dV/dT output filters.

2.2. PROTECTIVE FEATURES

- 2.2.1. A minimum of Class 20 I²t electronic motor overload protection for single motor applications and thermal-mechanical overloads for multiple motor applications shall be provided.
- 2.2.2. Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over-voltage, under-voltage, VFD over-temperature and motor over-temperature. The VFD shall display all faults in plain English. Codes shall not be acceptable.
- 2.2.3. Where the Electrical Drawings indicate that the VFDs are to be used on a high resistance grounded (HRG) power distribution system, as is common in hospitals, data centres, and industrial facilities, ensure that VFD surge protection devices are of the delta connected type, and ensure that metal oxide varistor (MOV) maximum continuous operating voltage (MCOV) is selected for a HRG power distribution system of the voltage shown on the Electrical Drawings. Ensure that MOVs will not fail when a sustained line-to-ground fault occurs on the HRG system and the two unfaulted phases see their line-to-ground voltage rise to the line-to-line voltage until the Owner undertakes a scheduled shutdown at a later time. Ensure that the remainder of the VFD components are selected for proper application on a HRG system.
- 2.2.4. Protect the VFD from sustained power or phase loss. The VFD shall provide full rated output with an input voltage as low as 90 % of the nominal.
- 2.2.5. The VFD assembly including all required options shall be rated for 100,000 A interrupting capacity (AIC).
- 2.2.6. The VFD shall have built-in or externally mounted EMI electromagnetic filters to limit the EMI and RFI output from the VFD, designed to meet standard EN/IEC 61800-3 "Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods."
- 2.2.7. The VFD shall have a wide operating supply power range and shall continue to operate without faulting or tripping until the input voltage reaches at least 701 V AC on 600 V systems and 300 V AC on 208/230 V systems and 539 V AC on 460 V systems.

2.3. INTERFACE FEATURES

- 2.3.1. Each VFD shall have the same operator's keypad, including digital display with Hand/Start, Off/Stop, Auto/Start, and Help selector switches or buttons that shall be provided to start and stop the VFD and determine the speed reference. The keypad shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings. The keypad shall include a built-in real time clock with date function. Speed Transfer between Hand and Auto shall be "bumpless."
- 2.3.2. Each VFD shall include an open system communication protocol interface, BACnet as defined by ANSI/ASHRAE Standard 135 "BACnet™--A Data Communication Protocol for Building Automation and Control Networks" for seamless integration with Section 23 09 00.00 - BUILDING AUTOMATION SYSTEM (BAS).
- 2.3.3. Run permissive circuit shall be provided to accept a "system ready" signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of sending an output signal as a start command to actuate external equipment before allowing the VFD to start.
- 2.3.4. The VFD shall be able to be programmed to sense the loss of load and signal a no load/broken belt warning or fault.
- 2.3.5. If the temperature of the VFD's heat sink rises to 80 Deg. C. (176 Deg. C.), the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. If the temperature of the heat sink continues to rise the VFD shall automatically reduce its output frequency to the motor. As the VFD's heat sink temperature returns to normal, the VFD shall automatically increase the output frequency to the motor and return the carrier frequency to its normal switching speed.

- 2.3.6. At least six programmable digital inputs shall be provided for interfacing with the system's control and safety interlock circuitry.
- 2.3.7. As a minimum, the following hardware points shall be available for direct connection to Section 23 09 00.00 - BUILDING AUTOMATION SYSTEM (BAS):
- .1 VFD Start/Stop
 - .2 VFD Speed Control
 - .3 VFD Speed Feedback
- 2.3.8. Under smoke control or special fire mode conditions, the VFD shall be able to be programmed to automatically default to a preset speed or bypass, and be capable of accepting a start and stop signal from the building's fire alarm system.
- 2.4. SERVICE CONDITIONS
- 2.4.1. Ambient temperature, -10 Deg. C. to 40 Deg. C. (14 Deg. F. to 104 Deg. F.) without derating.
- 2.4.2. 0 to 95 % relative humidity, non-condensing.
- 2.4.3. Elevation to 1005 m (3300 ft.) without derating.
- 2.4.4. AC line voltage variation, -10 to +10% of nominal with full output.
- 2.4.5. No side clearance shall be required for cooling of any units. All power and control wiring shall be done from the bottom.
- 2.5. BYPASS
- 2.5.1. Supply either a manual 3 contactor bypass as per Article 2.5.2 or supply an electronic bypass system as per Article 2.5.3 and all respective Sub-Articles.
- 2.5.2. Provide a manual 3-contactor bypass, were indicated in schedules or specified, consisting of a door interlocked main fused disconnect switch padlockable in the off position, a built-in motor starter and a four position DRIVE/OFF/BYPASS/TEST switch controlling three contactors. In the DRIVE position, the motor is operated at an adjustable speed from the VFD. In the OFF position, the motor and VFD are disconnected. In the BYPASS position, the motor is operated at full speed from the AC power line and power is disconnected from the VFD so that service can be performed. In the TEST position, the motor is operated at full speed from the AC line power while power is applied to the input of the VFD. This allows the VFD to be given an operational test while continuing to run the motor at full speed in bypass. In case of an external safety fault, a customer supplied normally closed dry contact shall be able to stop the motor whether in DRIVE or BYPASS mode. Supply VFD specific only fuses.
- .1 Service personnel shall be able to defeat the main power disconnect switch and open the bypass enclosure without disconnecting power. This shall be accomplished through the use of a specially designed tool and mechanism while meeting all local and national code requirements for safety.
- 2.5.3. Provide a complete factory wired and tested electronic bypass system, consisting of an output contactor and bypass contactor. Overload protection shall be provided in both drive and bypass modes.
- .1 Include a door interlocked, padlockable circuit breaker or disconnect switch to disconnect all input power to the drive and bypass system.
 - .2 Supply fast acting fuses exclusive to and in front of the VFD only.
 - .3 The electronic bypass shall have its own keypad with, Drive, Bypass, Hand, Off, Auto, Reset operator keys.

- .4 The keypad shall also have the following LED indication: Ready, Enable, Drive running, Bypass running, Drive fault, Bypass fault, Bypass H-O-A mode, Auto transfer to bypass selected, Drive selected, Bypass selected.
 - .5 All external safety interlocks shall remain fully functional whether the system is in Hand, Auto or Bypass modes.
 - .6 The electronic bypass shall be fully operable from the Serial Communications system which shall have capability to monitor the VFD/Bypass mode, check status of H-O-A, Bypass fault, and Override and also force the motor into Bypass mode.
- 2.5.4. Bypass shall be provided on the systems:
- .1
3. Execution
- 3.1. INSTALLATION
- 3.1.1. Comply with manufacturer's installation instructions.
 - 3.1.2. Provide a disconnect switch at the motor where required by the authorities having jurisdiction. Where such a disconnect switch is installed, provide an auxiliary contact or switch at the disconnect switch, mounted to open when the disconnect switch is opened and wired to a terminal strip in the VFD such that opening the disconnect switch initiates a drive shut down and prevents the drive from starting in either Line or Drive positions.
 - 3.1.3. Locate and mount VFD panels in Mechanical Rooms and/or where shown on the Drawings.
 - 3.1.4. Where VFDs are shown on the Drawings in locations away from building walls or need to be installed away from building walls, install them in accordance with the Execution requirements of Section 20 05 29.00 – HANGERS AND SUPPORTS.
 - 3.1.5. Arrange for manufacturer's technical representative or local qualified representative to:
 - .1 Inspect the installation of the drives and to start-up.
 - .2 Test and commission the drives. The VFD shall operate a dynamometer at full load and speed and shall be cycled during the test.
 - .3 Be present during testing and commissioning performed under Section 23 09 00.00 - BUILDING AUTOMATION SYSTEM (BAS).
 - 3.1.6. Measure the distortion of each phase at the load terminals of the branch breaker and report the results to the Engineer's Representative. Any deficiency shall be corrected and re-evaluated.
 - 3.1.7. Implement a communication protocol for remote interface to match the communication protocol under Section 23 09 00.00 - BUILDING AUTOMATION SYSTEM (BAS).
 - 3.1.8. BAS connection to drives provided under Section 23 09 00.00 - BUILDING AUTOMATION SYSTEM (BAS).

END OF SECTION

20 05 19.00 Indicating Instruments

1. General
 - 1.1. WORK INCLUDED
 - 1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
 - 1.2. SUBMITTALS
 - 1.2.1. Shop Drawings: Further to requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS and Section 20 05 03.00 - SHOP DRAWINGS, submit working ranges of thermometers and gauges with Shop Drawings.
 - 1.3. WARRANTY
 - 1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
2. Products
 - 2.1. MATERIALS
 - 2.1.1. Pipeline thermometers shall be complete with:
 - .1 Dust-tight stainless case and stem with 127 mm (5 in.) dial.
 - .2 Bi-metal type.
 - .3 White face with black lettering.
 - .4 Range normally 0 to 115 deg. C. (32 to 240 deg. F.) for hot water and -17 to 49 deg. C. (0 to 120 deg. F.) for chilled water but range shall suit maximum and minimum temperatures of location and be shown on Shop Drawings.
 - .5 Temperature marking in 1 deg. C. (2 deg. F.) increments in both imperial and metric scales.
 - .6 External recalibration adjustment.
 - .7 Separable socket with extension neck as required for insulated pipe.
 - .8 Universal adjustable hinge.
 - .9 Wells shall be registered with the provincial Boiler and Pressure Vessel Safety Branch and have a CRN.
 - 2.1.2. For ducts up to 750 mm (30 in.) in the largest dimension, thermometers shall be similar to pipeline thermometers but with an additional perforated bulb guard and shall be flanged for mounting on ducts.
 - 2.1.3. For ducts over 750 mm (30 in.) in largest dimension, thermometer shall be complete with:
 - .1 115 mm (4½ in.) diameter, cast aluminum case construction.
 - .2 Black pointer.
 - .3 White face with black lettering.
 - .4 Range normally 0 to 115 deg. C. (32 to 240 deg. F.) for heated supply air, 0 to 80 deg. C. (32 to 175 deg. F.) for cooled supply, mixed and return air and -40 to 90 deg. C. (-40

- to 195 deg. F.) for outside air but range shall suit maximum and minimum temperature of location and shall be shown on Shop Drawings.
- .5 Temperature marking in 1 deg. C. (2 deg. F.) increments in both imperial and metric scales.
 - .6 Vapour filled.
 - .7 1500 mm (60 in.) minimum length copper averaging bulb with bronze braided armour.
 - .8 Flanged for mounting on ducts.
 - .9 For insulated ducts or plenums, provide a bracket for mounting thermometer clear of insulation.
- 2.1.4. Thermometers for remote reading shall be similar to duct thermometers specified above but with armoured extension capillary and bulb with separable well for pipelines or flanged duct connection for averaging bulb, as required.
- 2.1.5. Pressure gauges shall be complete with:
- .1 Dust-tight nominal 115 mm (4½ in.) dia. case, solid front complete with back blow-out to ASME B40.100 "Pressure Gauges and Gauge Attachments", ASME B40.1 "Gauges: Pressure Indicating Dial Type — Elastic Element" Grade 2A Level Standards.
 - .2 Back-flanged where required.
 - .3 Black pointer.
 - .4 White dial with black markings.
 - .5 Dial range to cover twice the average working pressure of the equipment and shall be compound gauges on pump suction for all open systems.
 - .6 Clear lens.
 - .7 Phosphor bronze bourdon tube, silver soldered.
 - .8 Brass or stainless steel movement, bronze or nylon brushed, scale and movement mounted independent of the case.
 - .9 Brass socket.
 - .10 kPa and psi scales.
 - .11 Provincial Boiler and Pressure Vessel Safety Branches registration number.
 - .12 All wetted parts in contact with potable water systems shall be lead free.
- 2.1.6. Pressure and temperature test port:
- .1 Continuous operating temperature range of -40 Deg. C. (-40 Deg. F.) to 65.6 Deg. C. (150 Deg. F.).
 - .2 Dual self closing Nordel valves for 135 Deg. C (275 Deg. F.) intermittent maximum operating temperature.
 - .3 2758 kPa (400 psig) maximum operating pressure.
 - .4 Threaded brass or 316 stainless steel body to suit service material.
 - .5 Screwed cap and gasket with retaining strap.
 - .6 Temperature and pressure test kit in protective carrying case with 2 thermometers, 1 pressure gauge and 2 adaptors for full range of service temperatures and pressures.
- 2.1.7. Manometers shall be Magnehelic gauge type in dust free case with black pointer. Gauge range shall be 2½ times the maximum filter resistance. Case shall be suitable for duct or plenum mounting. Provide bracket for mounting gauge on insulated ducts or plenums.
- 2.1.8. Pressure and temperature test ports shall be Pete's Plug II.
- 2.1.9. Thermometers shall be Terice, Taylor, Weksler, Winters or Ashcroft.

2.1.10. Pressure gauges shall be Trerice, Ashcroft, Morrison, Winters or Weksler.

3. Execution

3.1. INSTALLATION

3.1.1. Locate all thermometers and pressure gauges so as to assure easy reading from the floor or platform.

3.1.2. Where direct reading instruments cannot be satisfactorily located use a remote instrument.

3.1.3. Locate remote instruments next to the point of the reading, on wall or structure.

3.1.4. Each remote or panel mounted instrument shall have an engraved lamacoid nameplate identifying the system and service.

3.1.5. Insert pipeline thermometer and/or pressure gauges into tanks, equipment tappings or in pipeline using screwed tees or forged steel couplings, welded into the pipe.

3.1.6. Duct thermometers shall be attached to duct using sheet metal screws through thermometer flange.

3.1.7. Provide thermometers in the following locations in pipelines:

- .1 In and out of each water coil or other coil, handling liquid, except individual reheat coils in ductwork
- .2 On each branch of 3 port control valves, excluding valves on fan coil, induction units, or individual reheat coils in ductwork
- .3 In and out of each heat exchanger, condenser, cooler or type of other heat exchanger
- .4 Each heating water return and each heating water supply for each main system
- .5 Each hot or cold water storage tank
- .6 and where specifically shown

3.1.8. As an alternative to thermometers and pressure gauges on pipeline systems, provide temperature and pressure ports in locations identified or shown on Standard Details.

3.1.9. When a common supply header provides the same temperature water to more than one coil or zone, provide a thermometer on the common header only.

3.1.10. For control valves with by-pass, locate thermometer in common pipe to allow for manual temperature control.

3.1.11. Provide thermometers in the following locations in ducts or plenums:

- .1 Upstream and downstream from each coil, spray or humidifier, except individual reheat coils in ductwork.
- .2 On each of 3 ducts or plenums at mixing dampers.
- .3 Return air from each zone.
- .4 Outside air entering air handling units.
- .5 and where specifically shown.

3.1.12. Where a common duct or plenum provides the same temperature air to many zones, provide a thermometer on the common duct only, rather than at each branch of a zone.

3.1.13. Provide test wells for thermometers where shown. Test wells shall be compatible with the thermometers used. Wells shall be registered with the applicable Provincial Authority Having Jurisdiction and have a CRN.

- 3.1.14. Provide a ball valve on the inlet to each gauge. Install a pressure snubber on any gauge installed near a pump or in any location where damping is required to prevent rapid oscillation of the pointer. When the equipment is subject to vibration, mount the gauge on adjacent wall or on a mounting plate, supported from the floor.
- 3.1.15. Provide pressure gauges in the following areas (not permitted to be pressure and temperature test ports):
- .1 City (potable) water line where it enters the building
 - .2 In and out of each pump
 - .3 In and out of all pressure reducing valves
 - .4 Each fire standpipe at highest fire hose cabinet
 - .5 and where specifically shown
- 3.1.16. Provide pressure gauges or pressure and temperature test ports in the following areas:
- .1 On each hot water supply and hot water return header
 - .2 Air cushion tank or expansion tank
 - .3 City (potable) water make-up line
 - .4 In and out of each heat exchanger, condenser, cooler or type of other heat exchanger
 - .5 and where specifically shown
- 3.1.17. Provide valved and capped connections for pressure gauges on each side of coils where pressure and temperature test ports are not provided.
- 3.1.18. Install manometer at each bank of filters to show the resistance to air flow through the filters. Where prefilters and final filters are mounted in a common frame it is only necessary to provide a single manometer to show the resistance across the total filter assembly. Where filters are separately mounted in individual frames provide a manometer for each set of filters.

END OF SECTION

20 05 29.00 Hangers and Supports

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.1.2. For piping and equipment provided under the Mechanical Division, provide complete with all necessary supports and hangers required for a safe and professional installation.

1.1.3. Hangers, supports, anchors, guides, and restraints shall be selected to withstand all static and dynamic loading conditions which act upon the piping system and associated equipment.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings in accordance with Section 20 05 03.00 – SHOP DRAWINGS.

1.2.2. The Mechanical Division shall prepare detailed Shop Drawings showing all anchors and guides for all systems with the potential for thermal expansion/contraction and/or loads due to weight or thrust. The drawings shall bear the signed seal of a Professional Engineer licensed to practice in the appropriate discipline and Place of the Work. The drawings shall include all details of construction, static and dynamic forces at points of attachment, etc. necessary for review and acceptance by the Project Structural Engineer's Representative. Make adjustments as necessary to satisfy the requirements of the Structural Division. No anchor points shall be permitted without reviewed Shop Drawings and, where installed prior to review, shall be removed and replaced to the satisfaction of the Engineer's Representative.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Provide hangers and supports manufactured by Anvil ASC Engineered Solutions, Taylor Pipe Supports, or E. Myatt & Co.

2.1.2. All pipe hangers and supports shall be manufactured to the latest requirements of ANSI MSS-SP-58 "Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation." Where applicable, design and manufacture of hangers and supports shall also conform to ANSI/ASME B31 "Code for Pressure Piping."

2.1.3. Pipe rolls shall have cast iron rollers, shaped to accept the outside diameter of the insulated pipe. Roll shall either rotate on a steel shaft mounted on a cast iron stand or shall roll on a cast iron bed plate.

2.1.4. Pipe slide assembly shall be manufactured to the latest requirements of ANSI MSS-SP-58. Assembly shall be complete with Carbon steel structural or fabricated tee, 100 % virgin PTFE bonded slide plates and carbon steel base.

- .1 For cold services such as cooling systems (e.g. chilled water, chilled glycol, brine, refrigerant, etc.), domestic cold water, and dual temperature systems (cooling systems and heating systems (e.g. heating glycol, heating, etc.)) to maintain the integrity of the

- insulation and vapour barrier and where slides cannot be directly welded to the pipe, provide a plain carbon steel pipe clamp to be welded to the tee support. Clamp shall be full length of tee support and shall be minimum 150 mm (6 in.) or as recommended by manufacturer for the specific pipe size.
- .2 For hot services such as heating systems (e.g. steam, steam condensate, heating glycol, heating, etc.), domestic hot water, etc. where the piping is 50 mm (2 in.) and larger, use a standard catalogue protection saddle tack welded to the pipe, which provides a space between the pipe and tee equal to the thickness of the insulation. Weld the tee to the protection saddle.
 - .3 For longitudinal movement only provide hold down lugs.
 - .4 For free movement in all directions width of slide plate base shall be sufficient for full travel.
 - .5 As an alternative to the above, for compact installations, tees may be welded to the pipe directly provided that the temperature is suitable, extended structural or fabricated tees are used, and the tee is vapour sealed at the insulation and completely insulated to prevent condensation for cold services. Provide details and obtain approval from the Engineer's Representative prior to proceeding with this arrangement.
- 2.1.6. For pipe and duct runs on the roof of the building, provide roof supports by Trikon Systems, MIRO Industries (Unistrut), Advanced Support Products Inc., or Portable Pipe Hangers Inc.
- 2.1.7. For pipe and duct runs on the roof of the building, anchor pipes and ducts to the building structure using supports by Thaler Roof Specialties or equal.
- 2.1.8. As an alternative to pipe and duct runs on the roof of the building being anchored to the building structure, provide support system design taking into account wind load review, stamped and signed by a Professional Engineer registered in the location of the Project. Provide roof supports by Trikon Systems, MIRO Industries (Unistrut), Advanced Support Products Inc., or Portable Pipe Hangers Inc.
- 2.1.9. All hangers, supports, brackets and other devices installed exterior to the building or in corrosive environments (pool mechanical rooms, pools, pool change rooms, etc.) shall be galvanized to prevent failure from environmental corrosion. If galvanized components cannot be used submit samples of proposed substitute for review prior to installation.
- 2.1.10. Provide supplemental support to minimize the risk of joint separation under high thrust conditions for large diameter no-hub cast iron fittings over 102 mm (4 in.) in accordance with the Standard Details and manufacturer's recommended installation instructions.
- .1 As an alternative to the above field devised methods and materials, provide engineered pipe and fitting restraints designed and manufactured for the specific purpose of restraining no hub cast iron pipe and fittings against separation under thrust forces equivalent to 145 kPa (50 ft) head pressure. Equal to Holdrite #117.
- 2.2. CONSTANT SUPPORT HANGERS
- 2.2.1. For piping at hanger locations where the vertical movement of the piping is 12 mm (1/2 in.) or more or where necessary to avoid the transfer of load to adjacent hangers or connected equipment, pipe hangers shall be constant support design.
- 2.2.2. The total travel for constant support hangers shall be equal to travel plus 20 %. In no case shall the difference between the actual and total travel be less than 25 mm (1 in.). The constant support hanger shall have travel scales on both sides of the support frame for inspection purposes.
- 2.2.3. Each constant support hanger shall be individually calibrated prior to shipment to support the exact loads specified.

- 2.2.4. Alloy springs shall meet the requirements of ASTM A125 "Standard Specification for Steel Springs, Helical, Heat-Treated" and shall be shot peened and examined by magnetic particle. The spring rate tolerance shall be +/- 5 %.
- 2.2.5. Constant supports shall have a wide range of load adjustability. No less than 10 % of this adjustability shall be provided either side of the calibrated load for plus or minus field adjustment. Load adjustment scale shall be provided to aid the field in accurate adjustment of loads and load adjustment shall be possible without the use of special tools and shall not impact the travel capabilities of the supports.
- 2.2.6. Constant supports shall be furnished with travel stops to prevent upward and downward movement of the hanger. The travel stops shall be factory installed so that the hanger level is at the cold position. The travel stops shall be designed to permit future re-engagement.
- 3. Execution
 - 3.1. INSTALLATION
 - 3.1.1. Pipe hangers shall be capable of supporting the pipe in all conditions of operation. They shall allow free expansion and contraction of the piping, and prevent undue stress to building structural components.
 - 3.1.2. Piping shall be supported from walls, beams, columns, and slabs using approved structural attachments. In situations where approved attachments cannot be used, alternative attachments or substructure assemblies shall receive approval prior to installation. Prior approval shall be given for any cutting or drilling of building structural steel. Damage or modification to the structure through welding, cutting, or drilling shall not be permitted if it reduces the integrity of the building structure as deemed by the Structural Engineer's Representative. It shall be the responsibility of the Mechanical Division to supply anchor bolts and base diagrams for equipment and pipe supports showing exact location of attachments.
 - 3.1.3. All drilling for hangers, rod inserts and Work of similar nature shall be done by this Division.
 - 3.1.4. Auxiliary structural members shall be provided under the Mechanical Section concerned where piping, ducts or equipment must be suspended between the joists or beams of the structure, or where required to replace individual hanger to allow for installation on new services. Auxiliary structural members shall be the same material and finish as the primary structure (i.e. prime painted, galvanized, etc.). Submit details for review as requested.
 - 3.1.5. Depending on the type of structure, hangers shall be either clamped to steel beams or joists, or attached to approved concrete inserts. Submit proposed hanger details for review and acceptance by the Structural Engineer's Representative. Make adjustments as necessary to satisfy the requirements of the Structural Division.
 - 3.1.6. For precast concrete construction, hanger rods shall pass between slabs and be supported on the slab within the topping by a 100 mm x 100 mm x 3 mm (4 in. x 4 in. x 1/8 in.) steel plate welded to the hanger rod. A lock nut threaded to the hanger rod together with a 50 mm (2 in.) minimum dia. washer shall be applied tight against the under surface of the deck to prevent rising of the hanger.
 - 3.1.7. Approved type expansion shields and bolts may be used for pipe up to 100 mm (4 in.) diameter where the presetting of concrete inserts is not practical. Submit proposed hanger details for review and acceptance by the Structural Engineer's Representative. Make adjustments as necessary to satisfy the requirements of the Structural Division.
 - 3.1.8. Suspension from metal deck shall not be allowed unless specifically accepted by the Engineer's Representative. Drawings of the proposed method of suspension must be submitted for review.

3.1.9. Hangers, hanger rods and inserts in all parking and ramp areas shall meet the requirements of CSA S413 "Parking Structures" and shall be of corrosion-resistant material or have an effective, durable corrosion resistant coating. Submit samples for approval.

3.1.10. Hanger rods shall be subject to tensile loading only. Suspended piping shall be supported by adjustable hanger rods sized as follows:

Pipe Size	Hanger Rod Diameter
50 mm (2 in.) and under	9 mm (3/8 in.)
65 mm (2-1/2 in.) and 75 mm (3 in.)	12 mm (1/2 in.)
100 mm (4 in.) and 125 mm (5 in.)	16 mm (5/8 in.)
150 mm (6 in.) to 200 mm (8 in.)	19 mm (3/4 in.)
250 mm (8 in.) to 300 mm (12 in.)	22 mm (7/8 in.)

3.1.11. Unless otherwise specified or shown, hanger spacing for all services shall be as follows:

Nominal Pipe Diameter	Maximum Span
Up to and including 38 mm (1-1/2 in.)	2.1 m (7 ft.)
50 mm (2 in.) to 125 mm (5 in.)	3 m (10 ft.)
150 mm (6 in.) and larger	4.6 m (15 ft.)

.1 For all steel piping connected to the geothermal field including all piping from the field to the heat exchangers in the Energy Transfer Stations:

Nominal Pipe Diameter	Maximum Span
Up to and including 38 mm (1-1/2 in.)	2.1 m (7 ft.)
50 mm (2 in.) to 125 mm (5 in.)	3 m (10 ft.)
150 mm (6 in.) and larger	3.5 m (11.5 ft.)

3.1.12. In addition, provide a hanger within 600 mm (2 ft.) on each side of valves, fitting or tees on pipes 38 mm (1½ in.) diameter and larger.

3.1.13. Hanger spacing for plumbing and drainage services shall be in accordance with the plumbing code or municipal by-laws as applicable.

3.1.14. Hanger spacing for fire protection services shall be in accordance with the NFPA codes.

3.1.15. All horizontal piping 50 mm (2 in.) diameter and larger shall be supported by adjustable wrought iron clevis type hangers. Smaller piping shall be supported by adjustable split ring hangers or clevis type hangers.

3.1.16. Suspending one hanger from another shall not be permitted.

3.1.17. For all heating systems piping (e.g. steam, steam condensate, heating glycol, heating, etc.) and domestic hot water piping, 50 mm (2 in.) and larger, use a standard catalogue protection saddle tack welded to the pipe, which provides a space between the pipe and hanger equal to the thickness of the insulation.

3.1.18. For all heating systems piping (e.g. steam, steam condensate, heating glycol, heating, etc.) and domestic hot water piping, 38 mm (1-1/2 in.) and smaller, use line size hangers.

- 3.1.19. For all cooling systems (e.g. chilled water, chilled glycol, brine, refrigerant, etc.) piping, domestic cold water piping, or dual cooling systems and heating systems (heating glycol, heating, etc.) piping, 25 mm (1 in.) and smaller, install a section of high density insulation complete with continuous vapour barrier between the pipe and the hanger. Refer to Section 20 07 00.00 - INSULATION.
- 3.1.20. For all cooling systems (e.g. chilled water, chilled glycol, brine, refrigerant, etc.) piping, domestic cold water piping, or dual cooling systems and heating systems (e.g. heating glycol, heating, etc.) piping, larger than 25 mm (1 in.), use a galvanized steel shield between the insulation and the hanger. Between the shield and the pipe, install a section of high density insulation complete with continuous vapour barrier. Refer to Section 20 07 00.00 - INSULATION.
- 3.1.21. For insulated ducts, ensure supports are on the outside of the insulation so as to not be directly connected to the duct creating a vapour barrier issue. Provide high density insulation in the area of the supports and spread the load.
- 3.1.22. The shield width shall be minimum 1/4 of the pipe circumference. The length and gauge shall be as follows:
- .1 150 mm (6 in.) long and 14 US gauge for pipe larger than 25 mm (1 in.) up to 50 mm (2 in.) diameter
 - .2 250 mm (10 in.) long and 12 US gauge for pipes 65 mm (2-1/2 in.) to 300 mm (12 in.) diameter
 - .3 300 mm (12 in.) long and 10 US gauge for pipes 350 mm (14 in.) to 400 mm (16 in.) diameter
- 3.1.23. Hangers and riser clamps in contact with copper pipe shall be copper coated construction or plastic coated. Taped hangers and riser clamps shall not be accepted.
- 3.1.24. Unless otherwise specified or shown, all pipes supported from below shall be mounted on pipe rolls or pipe slides.
- 3.1.25. Provide constant support hangers where shown for horizontal or vertical pipes which require vertical movement for expansion. Vertical movement shown for these hangers shall be movement either up or down. Provide hangers to allow for movement in both directions.
- 3.1.26. Unless otherwise specified or shown, vertical pipes shall be supported at least every fourth floor or every 12 m (40 ft.) maximum.
- 3.1.27. Pipe slides shall be pre-engineered type. Structural or fabricated tees shall be welded to the pipe or to the protection saddle.
- 3.1.28. Install resilient hangers in accordance with Section 20 05 48.00 - VIBRATION AND NOISE CONTROL.
- 1.1.1. Install additional seismic supports in accordance with Section 23 05 49.00 - SEISMIC FORCE RESISTING SYSTEMS.
- 3.1.29. Other means of support shall be as shown or as specified hereunder.
- 3.1.30. Provide minimum clear height of 203 mm (8 in.) under roof-mounted piping, with insulation in place, to facilitate proper roof drainage and access to roof membrane.
- 3.1.31. Provide minimum clear height under roof-mounted ductwork, with insulation in place, in compliance with SMACNA "HVAC Duct Construction Standards Metal and Flexible" Rooftop Equipment Installation section figures and Smith + Andersen Mechanical Standard Details, to facilitate proper roof drainage and access to roof membrane.

- 3.1.32. For special equipment supports refer to equipment sections. Where no support method is identified, secure wall mounted equipment to metal framing or masonry, with steel toggle or expansion fasteners, machine screws or sheet metal screws as applicable. Plastic, fibre or soft metal inserts shall not be acceptable. Wall mounted equipment shall not exceed 45.5 kg (100 lbs) in weight or 250 mm (10 in.) in depth unless reviewed or detailed by the Engineer's Representative. Where framing does not permit direct attachment, provide metal strut sub-framing or minimum 19 mm (3/4 in.) fire retardant treated plywood backboards, unpainted, attached to the framing. Provide attachments for backboards at 600 mm (24 in.) on centres with no less than 4 attachments.
- 3.1.33. Where equipment control panels, VFDs, and similar equipment are shown on the Drawings in locations away from building walls or need to be installed away from building walls, provide suitably sized, galvanized, strut channel, frame walls, securely fixed to the floor, for mounting the equipment.

END OF SECTION

20 05 33.00 Electric Tracing

1. General
 - 1.1. WORK INCLUDED
 - 1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
 - 1.1.2. Conform to Section 26 05 01.00 - GENERAL INSTRUCTIONS FOR ELECTRICAL SECTIONS.
 - 1.2. SUBMITTALS
 - 1.2.1. Submit detailed Shop Drawings for all Products being supplied and include electric tracing cable layouts, calculations, power requirements, connection quantities and locations, and control information. Demonstrate compliance with Specification.
 - 1.2.2. Submit Shop Drawings in accordance with Section 20 05 03.00 - SHOP DRAWINGS.
 - 1.3. WARRANTY
 - 1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
2. Products
 - 2.1. MATERIALS
 - 2.1.1. Electric tracing cable shall be nVent Raychem or Thermon, for 208 volt, 1 phase supply.
 - 2.1.2. Tracing cable shall be self-regulating type to CSA Standard C22.2 No. 130 "Requirements for electrical resistance trace heating and heating device sets."
 - 2.1.3. Thermostat shall be minimum 20 amp rating with fixed control point set at 4.4 deg. C. (40 deg. F.).
 - 2.1.4. Thermostat shall be minimum 20 amp rating with adjustable control from 0 deg. C. (32 deg. F.) to 49 deg. C. (120 deg. F.) with remote bulb, 3 m (10 ft.) of copper capillary. Where thermostat is mounted in conditioned areas, enclosure shall be dust and moisture resistant and where mounted in non-conditioned areas, enclosure shall be weather-proof. Thermostat shall have CSA Type 4X enclosure.
 - 2.1.5. Provide electronic controller with an alarm contact for any fire protection or life safety systems to monitor cables and de-energize cables fully during periods when ambient temperatures exceed set point. Controllers for single circuit with features as follows:
 - .1 LED window digital display of measured temperature, set points, and alarm conditions;
 - .2 LED status indicators;
 - .3 integral 30 mA ground fault protection;
 - .4 programmable temperature settings;
 - .5 current rating up to 30 A;
 - .6 alarm contacts and LED indicator;
 - .7 CSA Type 4X enclosure; and

- .8 thermistor sensor.
- 2.1.6. Provide electronic controller with an alarm contact for any gutter tracing or rain water leader applications to monitor cables and de-energize cables fully during periods when ambient temperatures exceed set point or when no precipitation is occurring. Controllers for single circuit with features as follows:
 - .1 LED window digital display of measured temperature, set points, and alarm conditions;
 - .2 LED status indicators;
 - .3 integral 30 mA ground fault protection;
 - .4 programmable temperature settings;
 - .5 remote precipitation sensor(s);
 - .6 programmable time delay to control how long heating cable remains energized after end of precipitation event;
 - .7 current rating up to 30 A;
 - .8 alarm contacts and LED indicator;
 - .9 CSA Type 4X enclosure; and
 - .10 thermistor sensor.
- 2.1.7. Contactors, where required, shall be with 120 V coil and pilot light in cover. Provide control transformer as required.
- 2.1.8. The following minimum watts/linear foot shall be maintained for pipe freeze protection applications. The table below is based on a -29 Deg. C. (-20 Deg. F.) minimum ambient temperature.

Up to and including 75 mm (3 in.) pipe	=	5 watts/ft. nominal
100 - 150 mm (4-6 in.) pipe	=	8 watts/ft. nominal
200 mm (8 in.) and 250 mm (10 in.) pipe	=	12 watts/ft. nominal
Larger than 250 mm (10 in.) pipe	=	XX watts/ft. nominal per cable and XX runs of cable
- 2.1.9. For soffit and slab heating systems, provide isometric drawings for every circuit for a complete heat tracing system.
- 2.1.10. Provide thermal insulation for pipes as specified in Section 20 07 00.00 – INSULATION.
- 2.1.11. On non-metallic (plastic) pipes the cable shall be installed using aluminum tape (AT180/AL-20L). The cable shall have an outer braid of tinned copper and an outer jacket of modified polyolefin.
- 2.1.12. Electric tracing cable for sprinkler systems shall be listed for this use. Where electric tracing cable protects branch lines, it shall be specifically listed for use on branch lines.
- 2.1.13. Include the following accessories:
 - .1 power connection and end seal kits
 - .2 splice, and tee kits
 - .3 "Electric Traced" caution labels
 - .4 aluminum tape for plastic pipe (where required)
 - .5 glass cloth adhesive tape
 - .6 contactors, relays, power distribution components

- .7 mounting clips/hardware for installation of the cables on the bottom of the slab
- 2.1.14. Internal tracing for gutters or canopy rain water leaders shall be self-regulating roof and gutter de-icing cable. Cable jacket shall be ultraviolet stabilized and weather proof. All cable components shall be UL Listed and CSA Certified for use as part of the system for keeping water drainage paths clear and to avoid ice dams. Component enclosures shall be CSA Type 4 rated. Cable shall have a nominal wattage of 5 watts/ft with a power output of 12 watts/ft in snow and ice.
3. Execution
- 3.1. INSTALLATION
- 3.1.1. Completely cover the pipe with cable for the full length shown, and without gaps. Ensure that valve body and bonnet are completely protected.
- 3.1.2. Install heating cables after pipe installation and testing is complete. Attach cable as recommended by the manufacturer with pipe straps, ensuring cables do not touch or cross.
- 3.1.3. For slab and soffit heating installations, install the cable tight to the bottom of the slab as per the manufacturer's written installation instructions using equipment supplied by the manufacturer.
- 3.1.4. Install soffit and slab heating cables at a maximum spacing of 375 mm (15 in.) between the runs of cable unless otherwise specified by the manufacturer to suit the required outside air design temperature. Spacing to be confirmed through the Shop Drawings.
- 3.1.5. Strap thermostat bulb to pipe clear of cable, and mount thermostat on wall or roof with brackets. Hang capillary on straps.
- 3.1.6. For slab and soffit heating applications, install thermostat remote bulb (temperature sensor) in between two runs of heating cable and in capped rigid galvanized steel conduit, either within the concrete slab or attached to the bottom of it. Conduit to allow sensor to be replaced easily should it fail. Also install in accordance with manufacturer's written instructions and mount thermostat in accessible location allowing for ease of access.
- 3.1.7. Retain the services of the manufacturer to inspect and approve the entire installation before the pipe or slab/soffit is concealed and/or insulated. Check for breaks with a 2500 volt DC megger. Provide report for inclusion in the operating manuals. The cost of inspection shall be included in the Contract Price. This Contractor shall provide pre-commissioning and final commissioning.
- 3.1.8. The installation by this Section shall be complete requiring power supply only by the Electrical Division. Provide all wiring between the electric tracing and the electrical junction box and make final connections.

END OF SECTION

20 05 48.00 Vibration and Noise Control

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. RELATED WORK SPECIFIED ELSEWHERE

1.2.1. Concrete Work on grade or cast integrally with a floor is provided under Division 3.

1.2.2. Sound isolated concrete floors – under Division 13.

1.3. SUBMITTALS

1.3.1. Shop Drawings: Supply Shop Drawings of the vibration and noise control equipment being supplied in accordance with Section 20 05 03.00 - SHOP DRAWINGS. Provide Shop Drawings showing completely the various acoustic assemblies. Include on the Shop Drawings the equipment weight at each isolator and the isolator proposed to be used complete with its weight rating. Submit Shop Drawings after all major equipment (e.g. chillers, cooling towers, etc.) has been reviewed and isolators have been coordinated.

1.4. PERFORMANCE REQUIREMENTS

1.4.1. Adequately isolate all equipment to maintain acceptable noise levels in the occupied area of the building as specified below. Take noise measurements over the complete audible frequency range in each of the occupied zones under, above and beside Mechanical Equipment Rooms, and where indicated by the Engineer's Representative. Noise levels due to mechanical equipment, ductwork, grilles, registers, terminal devices, diffusers, etc., shall not exceed sound pressure levels in all 8 octave bands corresponding to the NC levels per ASHRAE handbook as indicated.

1.4.2. AREAS NC LEVELS

Residential Suites	30 NC
General offices	35 NC
Meeting Rooms	35 NC
Corridor and Lobbies	35 NC
Storage Rooms	40 NC
Entrance Halls	40 NC
Amenity Space	35 NC
Fitness	40 NC
Pool	40 NC
Outdoors	45 dBA

1.5. WARRANTY

1.5.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

- 2.1.1. All equipment provided for vibration isolation or noise control shall be new and manufactured specifically for the purpose intended.
- 2.1.2. All vibration isolation devices shall be Vibro-Acoustics, Kinetics Noise Control, VMC Amber Booth, Isotech, or Mason Industries and shall be one manufacturer throughout the Project.
- 2.1.3. All factory built silencers and acoustic plenums shall be Vibro-Acoustics, Kinetics Noise Control/Vibron, VAW Systems or EH Price and shall be one manufacturer throughout the Project.
- 2.1.4. Provide vibration isolation devices for all motorized or electrical equipment. Static deflection of isolators shall be as given in the Vibration Isolation Schedule and/or as specified below. The Vibration Isolation Schedule shall take precedence.
- 2.1.5. Provide silencers in accordance with the Silencer Schedule and/or as shown on Drawings to maintain acceptable noise levels.
- 1.1.2. Provide vibration isolation with integral seismic resisting for equipment intended to provide resisting from seismic and wind forces. Housings shall be capable of withstanding the applicable design forces for the specific installation. Installation shall be in accordance with Section 23 05 49.00 – SEISMIC FORCE RESISTING SYSTEMS.

2.2. VIBRATION ISOLATION

- 2.2.1. Type EP (Elastomeric Pad) - Vibro-Acoustics Model N, Kinetics Model NPD, Mason Industries Model W or Super W, or ISOTECH Model IR or ISOPAD.
 - .1 Type EP shall be 8 mm thick ribbed or waffle neoprene pads. Isolator pads shall be selected for less than 80 % maximum rated load.
 - .2 If the isolator is bolted to the structure, a neoprene vibration isolation washer and sleeve (Uniroyal Type 602/660 or as approved) shall be installed under the bolt head between the steel washer and the base plate.
- 2.2.2. Type MEP (Metal and Elastomeric Sandwich Pad) - Vibro-Acoustics Model NSN, Kinetics Model RSP, Mason Industries Model WSW, or ISOTECH Model IRMR or IPMP.
 - .1 Type MEP shall consist of two 8 mm thick ribbed or waffle neoprene pads bonded to each side of a 16-gauge stainless or galvanized steel shim plate. Isolator pads shall be selected for less than 80 % maximum rated load.
 - .2 If the isolator is bolted to the structure, a neoprene vibration isolation washer and sleeve (Uniroyal Type 602/660 or as approved) shall be installed under the bolt head between the steel washer and the base plate.
- 2.2.3. Type DDNM (Double Deflection Neoprene Mounts) - Vibro-Acoustics Model RDM, Kinetics Model RD, Mason Industries Model ND, or ISOTECH Model IDR.
 - .1 Type DDNM shall be laterally stable, double deflecting, molded neoprene isolators. All metal surfaces shall be covered with neoprene. The top and bottom surfaces shall be ribbed and bolt holes shall be provided in the base. The mounts shall have leveling bolts rigidly secured to the equipment.
 - .2 DDNM mounts shall be selected for a static deflection of 9.5 mm unless specified otherwise.
- 2.2.4. Type DDNH (Double Deflection Neoprene Hangers) - Vibro-Acoustics Model RHD, Kinetics Model RH, Mason Industries Model HD, or ISOTECH Model IHND.

- .1 Type DDNH shall consist of a molded neoprene isolating element in a steel hanger box. A neoprene sleeve shall be provided where the lower hanger rod passes through the steel hanger box, such that the hanger rod cannot contact the steel. The diameter of the clear hole in the hanger box shall be at least 19 mm larger than the diameter of the hanger rod and permit the hanger rod to swing through a 30 degree arc. When installed the hanger box shall be allowed to rotate through a full 360 degrees without encountering an obstruction.
- .2 Unless otherwise specified the static deflection of DDNH hangers shall be 8 mm.
- 2.2.5. Type SPNM (Spring and Neoprene Mounts) - Vibro-Acoustics Model FS, Kinetics Model FDS, Mason Industries Model SLFSW, or ISOTECH Model IOSB.
 - .1 Type SPNM shall have a free standing and laterally stable steel spring without any housing, and two type WP isolation pads sandwiching a 16 gauge stainless or galvanized steel separator plate shall be bonded to the isolator base plate. Springs shall be designed so that the ratio of the horizontal to vertical spring constant is between one and two. The spring diameter shall not be less than 80 % of the compressed height of the spring at rated load. Loaded springs shall have a minimum additional travel to solid equal to 50 % of the specified static deflection.
 - .2 Unless otherwise specified the minimum static deflection of SPNM isolators under actual load conditions for equipment mounted on grade slabs shall be 25 mm (1 in.), and 50 mm (2 in.) for equipment mounted elsewhere.
 - .3 Unless otherwise specified, isolators need not be bolted to the floor for indoor installations. If base plates are bolted to the structure, a neoprene vibration isolation washer and sleeve (Uniroyal Type 602/660 or as approved) shall be installed under the bolt head between the steel washer and the base plate.
- 1.1.3. Type SPNMS (Spring and Neoprene Mounts - Seismic Restrained) - Vibro-Acoustics Model SFS, Kinetics Model FHS, Mason Industries Model SSLFH, or ISOTECH Model IHSS or IPSSA.
 - .4 Type SPNMS shall be laterally stable restrained steel spring type. Springs shall be designed so that the ratio of the horizontal to vertical spring constant is between one and two. The spring diameter shall not be less than 80 % of the compressed height of the spring at rated load. Loaded springs shall have a minimum additional travel to solid equal to 50 % of the specified static deflection.
 - .5 Unless otherwise specified the minimum static deflection of SPNMS isolators under actual load conditions for equipment mounted on grade slabs shall be 25 mm (1 in.), and 50 mm (2 in.) for equipment mounted elsewhere.
 - .6 Isolators shall be bolted to the floor and equipment. A neoprene vibration isolation washer and sleeve (Uniroyal Type 602/660 or as approved) shall be installed under the bolt head between the steel washer and the base plate.
- 2.2.6. Type SPH (Spring Hangers) - Vibro-Acoustics Model SH, Kinetics Model SH, Mason Industries Model 30, or ISOTECH Model IHS, IHA or IHB.
 - .1 Type SPH shall consist of a steel spring and welded steel housing. Spring diameter and hanger box hole shall be large enough to permit the hanger rod to swing through a 30 degree arc. A neoprene sleeve shall be provided where the lower hanger rod passes through the steel hanger box, such that the hanger rod cannot contact the steel hanger. The diameter of the clear hole in the hanger box shall be at least 19 mm (3/4 in.) larger than the diameter of the hanger rod. When installed, the spring element shall not be cocked, and the hanger box shall be allowed to rotate through a full 360 degree arc without encountering any obstructions.
 - .2 Unless otherwise specified, the static deflection of SPH hangers under actual load conditions shall be 50 mm (2 in.).

- 2.2.7. Type SPNH (Spring and Neoprene Hangers) - Vibro-Acoustics Model SHR, Kinetics Model SRH, Mason Industries Model 30N, or ISOTECH Model IHSE, IHAE or IHBE.
- .1 Type SPNH shall consist of a steel spring and welded steel housing. Spring diameter and hanger box hole shall be large enough to permit the hanger rod to swing through a 30 degree arc. A neoprene sleeve shall be provided where the lower hanger rod passes through the steel hanger box, such that the hanger rod cannot contact the steel hanger. The diameter of the clear hole in the hanger box shall be at least 19 mm (3/4 in.) larger than the diameter of the hanger rod. When installed, the spring element shall not be cocked, and the hanger box shall be allowed to rotate through a full 360 degree arc without encountering any obstructions.
 - .2 Type SPNH shall include the addition of a neoprene element in series with the spring. The neoprene element shall have a deflection of not less than 9 mm with a strain not exceeding 15 %. Unless otherwise specified, the static deflection of SPNH hangers under actual load conditions shall be 50 mm (2 in.).
- 2.2.8. Type CSNM (Constrained Spring and Neoprene Mounts) - Vibro-Acoustics Model CSR, Kinetics Model FLS, Mason Industries Model SLR, or ISOTECH Model ICSN.
- .1 Type CSNM shall be a spring and neoprene mount that incorporates a housing which contains unrestrained stable springs with built-in leveling device and resilient vertical limit stops to prevent spring elongation when partial load is removed and limits the movement of equipment when it is subjected to wind loading.
 - .2 A minimum clearance of 25 mm (1 in.) shall be maintained around the restraining bolts and between the housing and the spring so as not to interfere with the spring operation. Limit stops shall provide minimum 6 mm (1/4 in.) clearance under normal operation, and a neoprene washer shall be installed beneath the bolt head/washer used to restrain the isolator.
 - .3 For installations subject to wind load, provide tapped hole in top and bottom plates for bolting to equipment and the roof or supporting structure with a neoprene sleeve.
 - .4 Provide minimum 6 mm thick neoprene acoustical base pad on the underside of the mount unless designated otherwise.
 - .5 Mount shall be capable of supporting equipment at a fixed elevation during equipment erection. Installed and operating heights shall be identical.
 - .6 Unless specified otherwise, the minimum static deflection for Type CSNM mounts under actual load conditions shall be 50 mm (2 in.).
- 1.1.4. Type SCSNM (Constrained Spring and Neoprene Mounts - Seismic Restrained) - Vibro-Acoustics Model SCSR, Kinetics Model FLSS, Mason Industries Model SLRS, or ISOTECH Model ISCSA.
- .7 Type SCSNM shall be a spring and neoprene mount that incorporates welded steel housings and heavy top plates containing laterally stable restrained springs with built-in leveling device and vertically restraining limit stops to prevent spring elongation when partial load is removed and limits the movement of equipment when it is subjected to wind or seismic loading.
 - .8 A maximum clearance of 6 mm (1/4 in.) shall be maintained around the restraining bolts and between the housing and the spring so as not to interfere with the spring operation. Top plate and restraining bolts shall be out of contact with the housing during normal operation.
 - .9 Provide tapped hole in top and bottom plates for bolting to equipment and the roof or supporting structure with a neoprene sleeve.
 - .10 Provide minimum 6 mm thick neoprene acoustical base pad on the underside of the mount unless designated otherwise.

- .11 Mount shall be capable of supporting equipment at a fixed elevation during equipment erection. Installed and operating heights shall be identical.
- .12 Unless specified otherwise, the minimum static deflection for Type SCSNM mounts under actual load conditions shall be 50 mm (2 in.).
- 2.2.9. Type RTIC (Rooftop Isolation Curb) - Vibro-Acoustics Model RTR, Kinetics Model KSR, Mason Industries Model RSC, or ISOTECH Model IVC.
 - .1 Type RTIC shall be curb type rail with integral isolators which is designed to fit over the roof curb and under the isolated equipment. The top and bottom members shall contain weather resistant springs having a minimum 25 mm (1 in.) deflection with 50% additional travel to solid. Spring diameter shall not be less than 80% of the compressed height of the spring.
 - .2 Wind resistance shall be provided by means of resilient snubbers with a minimum clearance or 6 mm (1/4 in.) so as not to interfere with the spring action except in high winds.
 - .3 The weather seal shall consist of continuous closed cell sponge materials both above and below the base and a waterproof, flexible neoprene connection joining the outside perimeter of the upper and lower members.
 - .4 The curb shall be manufactured as a single assembly.
- 2.2.10. Type SB (Steel Base) - Vibro-Acoustics Model S, Kinetics Model SFB, Mason Industries Type MSLSFW, or ISOTECH Model ISB.
 - .1 Type SB base which shall be a structural steel base frame with clearance holes located to correspond to the mounting bolt holes of the equipment mounted on the base. Fan bases shall have built-in motor slide rails, and shall be reinforced as necessary to withstand belt pull without drive misalignment or base distortion.
 - .2 The bases shall be constructed with deep angle steel sections with a minimum vertical angle leg of 100 mm (4 in.) for motors of 7.5 hp or less, 125 mm (5 in.) for motors between 7.5 hp and 20 hp, and 150 mm (6 in.) for motors over 20 hp.
 - .3 Structural steel base frames shall be galvanized.
- 2.2.11. Type CB (Concrete Base) - Vibro-Acoustics Model C, Kinetics Model CIB-L, Mason Industries Type KSLFSW, or ISOTECH Model ICIB
 - .1 Type CB inertia base shall have an integral rectangular structural steel form to which concrete is poured.
 - .2 Perimeter members shall be beams of depth equal to 10% of the longest span of the base, but not more than 300 mm (12 in.) or less than 150 mm (6 in.) deep. Forms shall include motor slide base and all reinforcing steel. Where anchor bolt locations fall in concrete, the reinforcing steel shall include drilled members with sleeves welded below the steel to accept the anchor bolts. Height saving steel brackets shall be used in all mounting locations.
 - .3 When the concrete base is T-shaped, isolators shall be located under the projections as well as under the main body in order to prevent cantilever distortion.
 - .4 Inertia bases for pumps shall be of sufficient size to accommodate supports for pipe elbows at pump suction and discharge connections.
 - .5 Height saving brackets or welded steel pockets shall be incorporated in ensure a 50 mm (2 in.) minimum clearance under each inertia base.
 - .6 The weight of each inertia base shall be sufficient to lower the centre of gravity to or below the isolator support plane.
 - .7 The structural perimeter frame, mounting templates, height saving brackets, and spring system shall be provided as an assembly by the vibration control vendor.

- .8 Structural perimeter frames shall be galvanized.
- 2.2.12. All spring mounts shall be complete with levelling devices 6 mm (1/4 in.) thick ribbed neoprene sound pads and completely colour coded stable springs.
- 2.2.13. Where steel spring isolation systems are described in the Specifications, the mounting assemblies shall utilize bare springs with the spring diameter not less than 80 % of the loaded operating height of the spring. Each spring isolator shall be designed and installed so that the ends of the spring remain parallel during and after spring installation.
- 2.2.14. All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves shall be furnished by the manufacturer, and must be linear over a deflection range of not less than 50 % above the design deflection.
- 2.2.15. All vibration isolators shall have either known undeflected heights of calibration markings to that, after adjustment, verified, thus determining that the load is within the proper range of the device and that the correct degree of vibration isolation is being provided according to design.
- 2.2.16. All mounts installed outdoors or exposed to high humidity conditions shall have two coats of rust resisting paint and springs shall be cadmium plated and neoprene coated. Nuts and bolts shall be cadmium plated. All metal parts of mountings (except springs and hardware) shall be hot dip galvanized.
- 2.2.17. Flexible spherical expansion joints shall be constructed of EPDM in the covers, liners and with Kevlar tire cord frictioning.
 - .1 Solid steel rings shall be used within the raised face rubber flanged ends to prevent pullout. Flexible cable bead wire is not permitted.
 - .2 19 mm (3/4 in.) to 38 mm (1-1/2 in.) shall have threaded two piece bolted flange assemblies, one sphere and cable retention.
 - .3 50 mm (2 in.) and larger shall have two spheres reinforced with a ductile iron external ring between spheres.
 - .4 400 mm (16 in.) to 600 mm (24 in.) shall be single sphere.
 - .5 Flanges shall be split ductile iron or steel with hooked or similar interlocks.
 - .6 Connectors shall be rated at 1.72 MPa (250 psi) up to 77 Deg. C. (170 Deg. F.) with a uniform drop in allowable pressure to 1.48 MPa (215 psi) at 121 Deg. C. (250 Deg. F.) in sizes through 350 mm (14 in.). 400 mm (16 in.) through 600 mm (24 in.) single sphere minimum ratings shall be 1.24 MPa (180 psi) at 77 Deg. C. (170 Deg. F.) and 1.03 MPa (150 psi) at 121 Deg. C. (250 Deg. F.).
 - .7 Higher rated connectors shall be used to accommodate service conditions where required.
 - .8 Factory test all expansion joints to 150 % of the rated pressure. Safety factors to burst and flange pullout shall be a minimum of 3/1.
- 2.2.18. Neoprene mounting sleeves for hold down applications of equipment with vibration isolators shall be Uniroyal Type 620/660 or as approved.
- 2.2.19. Grout: Non-shrink, self-levelling grout having ability to withstand thermal, vibratory and impact stresses.
- 2.2.20. Acoustic Sealant: Non-hardening, non-skinning permanently flexible, to CAN/CGSB-19.21 "Sealing and Bedding Compound, Acoustical." Tremco, CGC Acoustic Sealant or approved equivalent.
- 2.3. INTERNAL ACOUSTIC DUCT LINING
 - 2.3.1. Fiberglass duct lining manufacturer: Certainteed, Owens-Corning, Knauf Insulation, or Johns Manville.

- 2.3.2. Natural fibre duct lining manufacturer: Bonded Logic.
- 2.3.3. Provide acoustic duct lining with a minimum density of 24 kg/m³ (1.5 lbs/ft³).
- 2.3.4. Provide acoustic duct lining that complies with the requirements of NFPA 90A "Standard for the Installation of Air-Conditioning and Ventilation Systems" and the "Duct Liner Materials Standard" of the Thermal Insulation Manufacturer's Association.
- 2.3.5. Provide internal acoustic duct lining that incorporates means to prevent fiber entrainment in the air stream, such as airstream surface and long edges complete with acrylic polymer surface coating.
- 2.4. ACOUSTICAL DUCT AND PIPE LAGGING
 - 2.4.1. Acoustical duct and pipe lagging shall be Kinetics Model KNM-100ALQ.
 - 2.4.2. The barrier shall be constructed of a 2 mm (1/16 in.) thick barium sulphate loaded limp vinyl sheet bonded to a thin layer of reinforced aluminum foil on one side. The barrier shall have a nominal density of 4.8 kg/m² (1 lbs/ft²) and shall have a minimum STC rating of 28.
 - 2.4.3. The barrier shall have a minimum thermal conductivity "K" value of 0.29 and a rated service temperature range of -40 Deg. C. (-40 Deg. F.) to 105 Deg. C. (220 Deg. F.).
 - 2.4.4. The barrier shall have a Flame Spread Index of no more than 25 and a Smoke Development Index of no more than 50 when tested for Surface Burning Characteristics per ASTM E84 "Standard Test Method for Surface Burning Characteristics of Building Materials."
 - 2.4.5. The decoupling layer shall be a combination of 25 mm (1 in.) or 50 mm (2 in.) as shown, fibreglass batting, non woven porous scrim-coated glass cloth, quilted together in a matrix of diamond stitch pattern which encapsulates the glass fibres. The composite material shall be fabricated to include a nominal 152 mm (6 in.) wide barrier overlap tab extending beyond the quilted fibreglass to facilitate a leak-tight seal around field joints.
- 2.5. SILENCERS
 - 2.5.1. Provide factory-built silencers completely pre-fabricated of incombustible materials and bearing a minimum insertion loss and a maximum air pressure drop as shown in Silencer Schedule. Include all system effects in the installed position shown on the Drawings in the silencer performance. Conform to ASTM E477 "Standard Test Method for Laboratory Measurements of Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers" for submitted silencer performance.
 - 2.5.2. Media filled silencers shall contain acoustic media type as indicated on the Silencer Schedule, either acoustic quality, shot free glass fibre insulation with long, resilient fibres bonded with a thermosetting resin, or 100% natural cotton fibres treated with an EPA registered, non-toxic borate solution, "flash dried" to provide resistance to mould, mildew and fungi. Media shall not cause or accelerate corrosion of aluminum or steel. Glass fibre, and rockwool will not be permitted as a substitute for cotton fibre media.
 - 2.5.3. Acoustic media in media filled silencers shall have density as required to provide specified performance, packed under 15 percent compression and protected from air erosion by perforated sheet metal, gauge as specified below.
 - 2.5.4. Acoustic media filled silencers with internal air velocities above 22.9 m/s (4500 fpm) shall have acoustic media wrapped with glass fibre cloth for additional erosion protection.
 - 2.5.5. Silencers shall have acoustic media wrapped in Tedlar film liner to help prevent shedding, erosion and impregnation of the acoustic media in the following areas:
 - .1 Where indicated on Silencer Schedules

- 2.5.6. No-media silencers shall contain no absorptive media of any kind. Attenuation shall be achieved with controlled impedance membranes and broadly tuned resonators.
- 2.5.7. Silencer materials, including acoustic media and Tedlar film, shall have the following combustion ratings when tested in accordance with ASTM E84 "Standard Test Method for Surface Burning Characteristics of Building Materials": maximum Flame spread Classification 25, maximum Smoke Development Rating 50.
- 2.5.8. Rectangular type silencers for duct systems operating less than 4 in. WG and designated as Class 1 on the Silencer Schedule shall be constructed with a minimum 22 gauge (0.78 mm) lock formed galvanized steel outer casing and 26 gauge (0.47 mm) galvanized perforated steel liner.
- 2.5.9. Rectangular type silencers for duct systems operating greater than 4 in. WG and less than 8 in. WG and/or designated as Class 2 on the Silencer Schedule shall be constructed with a minimum 18 gauge (1.18 mm) Pittsburgh lock formed galvanized steel outer casing and 22 gauge (0.78 mm) galvanized perforated steel liner.
- 2.5.10. Rectangular type silencers for duct systems operating under more than 8 in. WG and/or designated as Class 3 on the Silencer Schedule shall be constructed with a minimum 16 gauge (1.46 mm) continuously welded galvanized or hot rolled steel painted with one anti-rust prime coat of paint casing and 22 gauge (0.78 mm) galvanized perforated steel liner.
- 2.5.11. Rectangular type elbow silencers shall have minimum Class 2 construction, 18 gauge (1.18 mm) Pittsburgh lock formed galvanized steel outer casing and 22 gauge (0.78 mm) galvanized perforated steel liner, unless indicated as Class 3 on the Silencer Schedule. All acoustical splitters shall be internally radiused and aerodynamically designed for efficient turning of the air. Half and full splitters are required as necessary to achieve the scheduled insertion loss. All elbow silencers with a turning cross-section dimension greater than 1200 mm (48 in.) shall have at least two half splitters and one full splitter.
- 2.5.12. Circular media filled silencers, unless noted on the Silencer Schedule as Class 3, 16 gauge (1.46 mm) construction shall have gauges and construction as follows: under 750 mm (30 in.) casing diameter, 20 gauge (0.91mm) lockformed galvanized steel outer casing, under 1350 mm (54 in.) casing diameter, 18 gauge (1.18 mm) lockformed galvanized steel outer casing, otherwise 16 gauge (1.46 mm) stitch welded galvanized steel outer casing. Galvanized steel perforated inner liner shall be 22 gauge (0.78 mm) for all diameters.
- 2.5.13. Circular no-media silencers, unless noted on the Silencer Schedule as Class 3, 16 gauge (1.46 mm) construction shall have gauges and construction as follows: under 450 mm (18 in.) duct diameter, 22 gauge (0.78 mm) lockformed galvanized steel outer casing, under 750 mm (30 in.) duct diameter, 20 gauge (0.91 mm) lockformed galvanized steel outer casing, under 1350 mm (54 in.) duct diameter, 18 gauge (1.18 mm) lockformed galvanized steel casing, otherwise 16 gauge (1.46 mm) stitch welded galvanized steel outer casing. Galvanized steel perforated inner liner shall be 26 gauge (0.47 mm) for all diameters.
- 2.5.14. Silencers shall be complete with high transmission loss (HTL) casing where indicated on the silencer schedule. HTL walls shall consist of media, airspace, mass and outer protective metal skin as required to obtain specified room noise criteria. Standard acoustic panels will not be accepted as HTL walls. Where requested by the Engineer's Representative, provide breakout noise calculations for each air handling and fan system with silencer submittal to ensure compliance with the room noise criteria. Breakout noise calculations shall be based on the sound power levels of the specified equipment and calculation methods in accordance with ASHRAE HVAC Applications handbook.

3. Execution

3.1. INSTALLATION

- 3.1.1. Obtain one copy of all Shop Drawings of equipment to be isolated showing weights, shaft centres and all dimensions.
- 3.1.2. On system start-up, inspect the complete installation and provide a report in writing.
- 3.1.3. Furnish concrete bases, including concrete fill, on springs or other vibration isolation materials for mechanical isolation.
- 3.1.4. All floor mounted equipment shall be erected on concrete housekeeping pads, with thickness as identified, over the complete floor area of the equipment, unless shown or specified otherwise. Wherever vibration eliminating devices and/or concrete inertia pads are specified, these items shall be mounted on concrete housekeeping pads.
- 3.1.5. Furnish and install neoprene mounting sleeves for hold-down bolts to prevent any metal to metal contact.
- 3.1.6. All equipment shall be provided with lateral restraining isolators as required to limit horizontal motion to 6 mm maximum, under all operating conditions. Lateral restraining isolators shall have the same static deflection as equipment being isolated.
- 1.1.5. Seismic snubbers shall be installed on all equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 3.2 mm (1/8 in.). Install seismic restraint devices using methods approved by required submittals for component.
- 3.1.7. Unless otherwise indicated, all equipment mounted on vibration isolators shall have a minimum operating clearance of 50 mm (2 in.) between the bottom of the equipment or inertia base (and height-saving bracket) and the concrete housekeeping pad (or bolt heads) beneath the equipment. The clearance shall be checked by the Contractor to ensure that no material has been left to short-circuit the vibration isolators. There shall be a minimum 100 mm (4 in.) clearance between isolated equipment and the walls, ceiling, floors, columns and any other equipment not installed on vibration isolators.
- 3.1.8. Piping, ductwork, conduit or mechanical equipment shall be supported from building structure, not hung from or supported on other equipment, pipes, or ductwork.
- 3.1.9. Equipment connected to water or other fluid piping shall be erected on isolators or isolated foundations at correct operating heights prior to connection of piping, and blocked-up with temporary shims to final operating height. When the system is assembled and fluid is added, the isolators shall be adjusted to allow removal of the shims.
- 3.1.10. All mechanical equipment not specifically identified in this Section that contains rotating or vibrating elements, and any associated electrical apparatus installed by this Division that contains transformers or inductors shall be installed on Type DDNM, MEP, or EP isolators as appropriate.
- 3.1.11. All wiring connections to mechanical equipment on isolators shall be made with a flexible conduit installed in a slack "U" shape.
- 3.1.12. Elastomeric isolators that will be exposed to temperatures below 0 deg. C. (32 deg. F.) shall be fabricated from natural rubber instead of neoprene.
- 3.1.13. Springs shall be designed and installed so that ends of springs remain parallel and all springs installed with adjustment bolts.
- 3.1.14. Springs shall be sized to be non-resonant with equipment forcing frequencies or support structure natural frequencies.

- 3.1.15. Fans and air handling units shall be levelled with fans operating before the flexible connectors are attached.
- 3.1.16. All fan bases and isolators shall be sized so that thrust restraints (which would act against turning moment caused by static pressure) are not required.
- 3.2. EQUIPMENT ISOLATION
- 3.2.1. Floor Mounted Centrifugal Fans and axial flow fans less than 0.87 kPa (3-1/2 in. WG) static pressure and/or under 29.8 kW (40 hp), shall be mounted on a Type SB base with Type SPNM isolators and shall have static deflection not less than 50 mm under actual load conditions unless shown otherwise in the Vibration Isolation Schedule.
- 3.2.2. Floor Mounted Centrifugal Fans and axial fans 0.87 kPa (3-1/2 in. WG) static pressure and over and/or 29.8 kW (40 hp) and larger, shall be mounted on Type CB with Type SPNM isolators and shall have static deflection not less than 50 mm (2 in.) under actual load conditions unless stated otherwise on the Vibration Isolation Schedule.
- 3.2.3. Ceiling Suspended Centrifugal Fans, and axial flow fans shall be mounted on Type SPNH spring isolators. Static deflection of the isolators shall be 50 mm (2 in.) unless shown otherwise on the Vibration and Isolation Schedule. Fans shall be suspended from above only if expressly noted as such on the Drawings and Schedules. Thrust restraint shall be by pre-compressed springs.
- .1 If the fan to be suspended is not furnished with integral structural frame and external mounting lugs of suitable strength and rigidity, install approved structural base with lugs in the field.
- 3.2.4. Fans in packaged or custom air handling units shall be mounted on a Type SB base with Type SPNM isolators. The static deflection shall not be less than 50 mm (2 in.) under actual load conditions.
- .1 Structural steel floor supports shall be located beneath the spring isolators and shall be equivalent to the structural perimeter frame of the air handling unit.
- .1 Custom or packaged air handling units with spring isolation shall be mounted on 25 mm (1 in.) Type MEP isolators between the unit base rail and the housekeeping pad or curb.
- 3.2.5. Roof mounted air conditioning units without internal fan isolation shall be mounted on RTIC isolator. Static deflection shall be as shown in the Schedules.
- .1 For roof mounted units that have openings through the structure directly below the unit provide a flexible neoprene coated canvas connection to provide an air tight/weather tight finish between the unit and the curb.
- 3.2.6. Floor mounted air handling units
- .1 Install Type MEP isolation under floor mounted air handling units located above occupied areas. Where hold down fasteners are used, include neoprene vibration isolation washers and sleeves.
- 3.2.7. Base mounted pumps 3.73 kW (5 hp) and larger except where located on slab-on-grade. Mount each pump with motor on a Type CB inertia base. Minimum base thickness shall be:
- .1 Pumps 3.73 kW (5 hp) to 5.52 kW (7.5 hp) 150 mm (6 in.)
- .2 Pumps 5.6 kW (7-1/2 hp) to 18.7 kW (25 hp) 200 mm (8 in.)
- .3 Pumps 22.4 kW (30 hp) to 74.6 kW (100 hp) 250 mm (10 in.)
- .4 Pumps 93.3 kW (125 hp) and larger 300 mm (12 in.)
- .1 Base for horizontally split pumps shall include supports for base elbows for the discharge and suction connections. Vertically split pumps shall include support

- for base elbow for suction connection. Bolt and grout base elbows to the pump base.
 - .5 Mount the base on Type SPNM isolators. Where the base is 'T' shaped or other than rectangular, locate the isolators under the projections as well as the main body of the base.
 - .6 Pour bases on roofing felt and elevate a minimum of 50 mm (2 in.) with mounting adjustment bolts after the pumps are grouted to the base.
 - .7 No damping or snubbing materials shall be used. Spring deflection shall be as specified in the Vibration Isolation Schedule, but in no case less than 25 mm (1 in.) and all mountings shall have 6 mm (1/4 in.) thick neoprene vibration isolation pads at the bottom.
- 3.2.8. Base mounted pumps less than 3.73 kW (5 hp), except where located on slab-on-grade, bolt and grout each pump to a Type CB inertia base.
- .1 Mount the base on Type EP isolators.
 - .2 Minimum base thickness shall be 150 mm (6 in.).
- 3.2.9. Base mounted pumps On Slab On Grade: Bolt and grout each pump to a Type CB base. The minimum base thickness shall be:
- .1 Pumps up to 3.73 kW (5 hp) 150 mm (6 in.)
 - .2 Pumps 5.6 kW (7-1/2 hp) to 18.7 kW (25 hp) 200 mm (8 in.)
 - .3 Pumps 22.4 kW (30 hp) to 74.6 kW (100 hp) 250 mm (10 in.)
 - .4 Pumps 93.3 kW (125 hp) and larger 300 mm (12 in.)
 - .5 Mount the base on Type MEP isolators. Where the base is 'T' shaped or other than rectangular, locate the isolators under the projections as well as the main body of the base. The isolators shall be in accordance with the manufacturer's written instructions for the size and weight distribution of the pump supported.
- 3.2.10. Vertical in-line pumps floor mounted 7.5 kW (10 hp) and larger except where located on slab-on-grade bolt and grout each elbow support to a Type CB inertia base. The minimum base thickness shall be:
- .1 Pumps 5.6 kW (7-1/2 hp) to 18.7 kW (25 hp) 200 mm (8 in.)
 - .2 Pumps 22.4 kW (30 hp) to 74.6 kW (100 hp) 250 mm (10 in.)
 - .3 Pumps 93.3 kW (125 hp) and larger 300 mm (12 in.)
 - .4 Mount the base on Type SPNM isolators.
 - .5 Pour bases on roofing felt and elevate a minimum of 50 mm (2 in.) with mounting adjustment bolts after the pump elbows are grouted to the base.
 - .6 No damping or snubbing materials shall be used. Spring deflection shall be as specified in the Vibration Isolation Schedule, but in no case less than 25 mm (1 in.) and all mountings shall have 6 mm (1/4 in.) thick neoprene vibration isolation pads at the bottom.
- 3.2.11. Vertical in-line pumps floor mounted 5.6 kW (7-1/2 hp) and smaller and 7.5 kW (10 hp) and larger where located on slab-on-grade, shall be supported on Type MEP isolation. Refer to Mechanical Standard Details.
- 3.2.12. Vertical in-line pumps ceiling hung shall be supported by Type SPNH spring isolators. Refer to Mechanical Standard Details.
- 3.2.13. Floor mounted air compressors shall be bolted and grouted to Type CB inertia base supported by Type SPNM isolators. Spring deflection shall be 50 mm (2 in.) minimum. Resilient pipe hangers shall be as specified for piping in Mechanical Rooms.

- 3.2.14. Fan coil units or heat pumps suspended from overhead structure shall be hung on Type SPNH spring isolators. Unless otherwise specified in the Vibration and Isolation Schedule, the static deflection of the isolators shall be 50 mm (2 in.).
- 3.2.15. Refrigeration machines and boilers shall be mounted on a Type SB base with CSNM isolators. Spring deflection shall be 50 mm (2 in.) minimum. If the equipment is suitable and an additional steel base is not required, the equipment can be mounted directly on the isolators.
- 3.2.16. Diesel generator exhaust pipe shall have Type SPNH hangers for the entire length. Hangers shall have a minimum of 38 mm (1-1/2 in.) deflection.
- 3.2.17. Mount cooling tower and air source heat pumps on a Type SB base supported by CSNM isolators. Spring deflection shall be 50 mm (2 in.) minimum. If the equipment is suitable and an additional steel base is not required, the equipment can be mounted directly on the isolators.
- 3.2.18. Suspend all piping in Mechanical Rooms on Type SPH or SPNH isolators as required. Where piping is supported from the floor, weld brackets to the piping and support on Type SPNM isolators. Isolators do not replace constant support hangers or mounts.
- 3.2.19. The first isolator both upstream and downstream of equipment on springs shall have a static deflection of 1.5 times the deflection of the vibration isolated equipment to a maximum of 50 mm (2 in.). All other piping supports shall have a static deflection of 25 mm (1 in.) minimum.
- 3.2.20. Where a pipe connects to multiple pieces of equipment in the Mechanical Room the pipe isolators for the entire run shall be chosen to suit the connected equipment of the greatest static deflection.
- 3.2.21. Piping that is connected only to equipment installed on neoprene isolators shall be either supported from the floor by Type DDNM isolators or suspended from the structure on Type DDNH isolators within the Mechanical Equipment Rooms.
- 3.2.22. Install double sphere EPDM type flexible piping connectors with: control rods with grommets to limit vibration transfer; stabilizing ring; and floating flanges, to connect piping of diameter 50 mm (2 in.) or greater to reciprocating or rotating equipment.
- 3.2.23. Piping attached to either coil sections separated from the fan sections of air handling units by flexible connections, or to air handling units with internal isolators meeting the requirements of these Specifications is exempt from these requirements and is not considered connected to vibrating equipment.
- 3.2.24. No rigid connections between equipment and the building structure shall be made that degrades the specified noise and vibration control system.
- 3.2.25. Any conflicts with other trades which result in rigid contact with the equipment or piping due to inadequate space or other unforeseen conditions shall be brought to the Engineer's Representative's attention prior to installation. If not brought to the attention of the Engineer's Representative prior to installation corrective Work necessitated by conflicts shall be at the Contractor's expense.
- 3.2.26. Locate isolation hangers with the housing a minimum of 50 mm (2 in.) below but as close as possible to the structure. Where isolator hangers would be concealed by a non-accessible acoustical sub-ceiling, install the hangers immediately below the sub-ceiling for access.
- 3.2.27. Ducts shall be connected to fans, fan casings and fan plenums by means of flexible connectors. Flexible connectors shall be installed to prevent metal-to-metal contact across flexible connection.
 - .1 Flexible connections are not permitted on NFPA 96 "Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations" kitchen exhaust systems.
 - .2 Flexible connectors shall be in accordance with Section 23 31 13.00 - DUCTWORK AND SPECIALTIES.

3.3. SILENCERS

- 3.3.1. Where silencers are to be installed in stainless steel or aluminum ductwork, the silencer shall be all stainless steel or aluminum construction to match the ductwork.
- 3.3.2. Silencers for all variable air volume boxes, and fan powered variable volume boxes shall be as scheduled in the Silencer Schedule. Refer to Drawings for specific number required. The Silencer Schedule only indicates type. Receive from VAV box manufacturer dimension and sound data. Adjust silencers as required to match box discharge size. Adjust silencer as required to ensure insertion loss necessary to meet the room noise criteria.
- 3.3.3. Silencers shall have outside dimensions that match the connecting duct size unless indicated otherwise.
- 3.3.4. Submittals shall include certified test data on dynamic insertion loss, self-noise power levels, and pressure drop for reverse or forward flow. Silencer performance must have been substantiated by laboratory testing according to ASTM E477 "Standard Test Method for Laboratory Measurements of Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers" and so certified when submitted for approval. The laboratory must be NVLAP accredited for the ASTM E477 test standard. Provide a copy of the accreditation certificate with the submittals upon request by the Engineer's Representative. Data from non-NVLAP accredited test facilities will not be accepted.
- 3.3.5. The certification of the pressure drop, insertion loss and generated noise data shall be based upon tests of the same silencer for all measurements.
- 3.3.6. For specific silencers indicated on the Silencer Schedule, the manufacturer shall provide acoustic analysis for approval showing that this silencer will reduce mechanical fan noise to acceptable levels in the occupied space. Use sound power levels of actual equipment to be installed on Project. Analysis shall include breakout noise calculations.

3.4. ACOUSTICAL LINING OF DUCTS

- 3.4.1. Acoustically line ductwork where shown on the Drawings and as Specified.
- 3.4.2. Provide a minimum of 25 mm (1 in.) thick acoustical duct lining in all internally lined sheet metal ducts, unless otherwise specified or shown on the Drawings.
- 3.4.3. In addition, internally line all low or medium pressure supply air ductwork in mechanical rooms, fan rooms, or equipment rooms.
- 3.4.4. Install acoustic lining using both pins and a minimum of 50 % coverage of a fire-resistant adhesive. Install pins on maximum 450 mm (18 in.) centres on all sides and tack weld to the duct or plenum. Mechanical fasteners that pierce the duct are unacceptable. Seal all edges of acoustic lining to prevent air erosion with sheet metal nosing that overlaps the insulation by 19 mm (3/4 in.) minimum. Coat all ends of the liner with a fire resistant cementing material to prevent delamination, leakage or erosion. Firmly butt all joints and coat ends with an adhesive to ensure that the lining is smooth across all joints.
- 3.4.5. For acoustic lining downstream of VAV boxes refer to Section 23 36 16.00 - VARIABLE VOLUME BOXES.
- 3.4.6. Where acoustical duct lining is installed, increase the dimensions of the sheet metal to include the thickness of the lining material. Dimensions shown on the Mechanical Drawings are the clear internal dimensions after the liner has been installed.
- 3.4.7. Internally insulate the following ductwork:
 - .1 All return air transfer ductwork.
 - .2 All ductwork specifically identified in Specifications and/or on the Drawings.

- .3 All supply and return air ductwork in the amenity spaces, lobbies, and common areas that serve that space.

3.5. ACOUSTICAL DUCT AND PIPE LAGGING

- 3.5.1. Install Acoustical Duct and Pipe Lagging where indicated on Drawings.

END OF SECTION

20 05 53.00 Pipe and Ductwork Identification

1. General
 - 1.1. WORK INCLUDED
 - 1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
 - 1.2. RELATED WORK SPECIFIED ELSEWHERE
 - 1.2.1. Field painting of non-colour coded piping and ductwork - under Division 9, Section 09 90 00.00 - PAINTING AND COATING.
 - 1.3. SUBMITTALS
 - 1.3.1. Submit designations and abbreviations for review in accordance with Section 20 05 03.00 – SHOP DRAWINGS. Submit digital samples of identification for review.
 - 1.4. WARRANTY
 - 1.4.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
2. Products
 - 2.1. MATERIALS
 - 2.1.1. Paint shall be compatible with the surface material to be painted.
 - 2.1.2. Colour code shall conform to CAN/CGSB 24.3-92 “Identification of Piping Systems” and ANSI/ASME A13.1 “Scheme For The Identification Of Piping Systems.”
 - 2.1.3. Pipe covering shall be SMS, Brady, Primark Manufacturing Inc. and Seton equal to SMS Coil-Mark system pipe markers.
 - 2.1.4. All identification shall incorporate direction of flow arrows, and the specified system designations and abbreviations. Designations and abbreviations shall be submitted for review prior to installation.
 - 2.1.5. All reclaimed rainwater distribution systems shall be purple in colour and conform to requirements of NSF-RW and NSF/ANSI Standard 14 “Plastics Piping System Components and Related Materials.” All other non-potable water piping shall conform to the requirements of CAN/CSA B128.1 “Design and Installation of Non-potable Water Systems,” CAN/CSA B128.2 “Maintenance and Field Testing of Non-potable Water Systems,” and CAN/CSA B128.3 “Performance of Non-Potable Water Treatment Systems.”
 - 2.1.6. Colour code shall conform to the requirements under the by-laws of the Authority Having Jurisdiction.

3. Execution

3.1. INSTALLATION

- 3.1.1. After completion of insulation and/or painting, all piping and ductwork shall be marked to show the service and direction of flow.
- 3.1.2. Marking shall be placed at each side of any wall, partition or floor, at 9.1 m (30 ft.) intervals (maximum) on all exposed piping and ductwork and at each access panel or door. Marking shall be located so as to be in full view and visible from the floor.
- 3.1.3. All pipe identification shall be installed in accordance with the manufacturer's recommendations.
- 3.1.4. For insulated or non-insulated pipe sizes less than 150 mm (6 in.) outer diameter, provide pre-coiled pipe identification markers, cover the pipe in its entirety, and join using adhesive along the longitudinal joint. In addition to the adhesive, provide banded marking system with clear plastic tie-wraps on each end.
- 3.1.5. For insulated or non-insulated pipe sizes equal to and greater than 150 mm (6 in.) outer diameter, strap markers on with recommended tie-wraps.
- 3.1.6. Adhesive labels are not acceptable.
- 3.1.7. Gas piping shall be painted yellow for the entire length and identified with pipe identification markers. Banding is not permitted.
- 3.1.8. All electric traced piping shall have additional identification to show it is traced.
- 3.1.9. Identify ductwork with 50 mm (2 in.) stencils using black or white ink to contrast the surface being identified.
- 3.1.10. Identification location for ductwork shall conform to the guidelines for pipe and shall indicate flow medium, function, and direction.
- 3.1.11. Contractor shall ensure stenciling is performed in a neat, quality manner.

END OF SECTION

20 05 54.00 Nameplates

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.1.2. Nameplates for systems include the designated equipment name, model number and main design parameters.

1.1.3. Every piece of equipment shall have a nameplate.

1.2. SUBMITTALS

1.2.1. Submit samples of nameplates before installation in accordance with Section 20 05 03.00 – SHOP DRAWINGS.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. The nameplates must be a minimum 2 mm (3/32 in.) thick micro surface impact acrylic suitable for a service temperature up to -29 Deg. C. through 80 Deg. C. (-20 Deg. F. through 175 Deg. F.). Minimum size shall be 100 mm (4 in.) long x 50 mm (2 in.) wide with maximum size to suit nomenclature required. Nameplate shall be with black face and white centre and with 5 mm (7/32 in.) high lettering engraved through to the white lamination.

2.1.2. The nameplates shall have the equipment type and name as indicated in the Equipment Schedules.

2.1.3. The nameplates shall have the service and area of the building served (e.g. Chilled Water - South Zone).

3. Execution

3.1. INSTALLATION

3.1.1. Nameplates shall be securely fastened with screws or brass chains in a conspicuous place on the equipment.

END OF SECTION

20 05 55.00 Valve Tags and Charts

1. General
 - 1.1. WORK INCLUDED
 - 1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
 - 1.2. SUBMITTALS
 - 1.2.1. Submit samples of charts and numbering system before installation in accordance with Section 20 05 03.00 – SHOP DRAWINGS.
 - 1.3. WARRANTY
 - 1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
2. Products
 - 2.1. MATERIALS
 - 2.1.1. Tags must be a minimum 2 mm (3/32 in.) thick Micro Surface Impact Acrylic suitable for a service temperature up of -29°C through 80°C (-20°F through 175°F), with engraved numbers and/or letters as required. Tags shall be a minimum of 25 mm (1 in.) square and maximum to suit numbering system. Numbers shall be nominally 9 mm (3/8 in.) high. Letters shall be nominally 6 mm (1/4 in.) high.
 - 2.1.2. Number and nameplates for standpipe and sprinkler system supervisory and main operating valves shall be minimum 2 mm (3/32 in.) thick laminated phenolic plastic and a minimum 125 mm (5 in.) long x 100 mm (4 in.) wide with red face and white centre. Lettering shall be a minimum 9 mm (3/8 in.) high with maximum to suit local authorities and shall be engraved through to the white lamination. Each nameplate shall contain the system name, service and valve number.
 - 2.1.3. For all other valves on standpipe and sprinkler system not required to have laminated number and nameplates, provide plastic tags as specified above.
 - 2.1.4. Abbreviations and colour code shall be as shown on Standard Details.
3. Execution
 - 3.1. INSTALLATION
 - 3.1.1. Tags and nameplates shall be attached to the valve body or handle with brass hooks or chains.
 - 3.1.2. All valves shall be provided with tags, other than valves on convectors, induction units or other space heating, cooling units and valves on plumbing fixtures. Provide a chart or charts, indicating location, service and zone of each valve. This Work shall be co-ordinated between the various Mechanical Sections to prevent overlapping of numbering systems.
 - 3.1.3. Provide separate charts for all fire system nameplates and tags.

- 3.1.4. For extension and/or alterations to existing systems, provide new charts conforming in appearance to the existing charts.
- 3.1.5. Co-ordinate valve identification with pipe and ductwork identification.
- 3.1.6. Roof drains used for restricting or controlling the flow of water from the roof or acting as an overflow shall be affixed with an identification label "Control Flow Roof Drain - Do Not Remove Restriction Device".
- 3.1.7. Electronically submit charts as PDF files along with as-built drawings. Provide charts set in metal picture frames with a clear acrylic front and fastened securely where directed by Engineer's Representative.
- 3.1.8. All valve tag numbers for all systems shall be shown on the as-built drawings.

END OF SECTION

20 05 63.00 Access Doors and Accessibility

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings showing size, type and location of all access doors, for review, before installation in accordance with Section 20 05 03.00 – SHOP DRAWINGS.

1.2.2. Have Balancing Contractor review proposed access door sizes and locations to ensure that sufficient access is available. Confirm in writing that this review has occurred.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Provide access doors that comply with Section 08 31 00 - ACCESS DOORS AND PANELS from the Architectural Specification. Where the Architectural Specification section is silent on a required access door type, comply with the Part 2 clauses in this section.

2.1.2. Provide access doors by Acudor, Bauco or Mifab Manufacturing Inc. Steel thickness (US Gauge) indicated as minimum acceptable.

2.1.3. For doors in solid walls, provide a 16 US gauge, prime painted steel door panel, rust resistant concealed hinges, flanged frame, and screwdriver operated lock. Acudor Model UF-5000 or Mifab Model UA.

2.1.4. For doors in drywall partitions or ceilings, provide a minimum 22 US gauge, prime painted steel recessed door panel for the acceptance of a drywall insert, concealed hinges, drywall bead frame, and screwdriver operated lock. Bauco Plus II, Acudor model DW-5015 or Mifab Model CAD-DW.

2.1.5. For doors in drywall partitions or ceilings, provide prime painted steel flush door panel, concealed hinges, drywall bead frame, and screwdriver operated lock. Acudor model DW-5040 or Mifab Model MDW.

2.1.6. For access doors in fire rated walls or ceilings, provide ULC labeled with insulated door panel, concealed hinge, self-closing, self-latching, flanged frame, and prime painted. Provide master key operated catch in areas accessible to the public. Acudor Model FW-5050 or Mifab MPFR.

2.1.7. For doors in tiled walls or ceilings, provide 16 US gauge, stainless steel, type 304 with #4 satin finish, concealed hinges, wall frame and screw driver operated lock. Acudor Model UF-5000 or Mifab Model UA-SS.

2.1.8. For doors in tiled walls or ceilings, provide 16 US gauge, prime painted steel recessed door panel for the acceptance of tile finish, concealed hinges, flush frame and screw driver operated lock. Acudor Model AT-5020 or Mifab Model CAD.

- 2.1.9. For doors for medium and high security applications in solid walls, provide 10 US gauge door with minimum 4 mm (3/16 in.) welded angle frame with heavy duty butt hinges welded to the door and frame with master keyed cylinder lock provided by the Owner. Acudor Model SD-6000 or Mifab Model MI-SADH.

3. Execution

3.1. INSTALLATION

- 3.1.1. Provide access doors of minimum 600 mm x 600 mm (24 in. x 24 in.) size. Custom size access doors may be required to allow combining access doors in close proximity and to ensure maintenance and accessibility of all parts requiring periodic maintenance.
- 3.1.2. Ensure all parts of the installation requiring periodic maintenance are accessible. Wherever valves, dampers and other appurtenances are concealed by building construction, provide access doors and install under the respective Trade Sections (i.e. masonry, plaster, drywall, tile, etc.). Be responsible for the proper location of the access doors.
- 3.1.3. For all mechanical equipment located above drywall and other inaccessible ceilings, provide access doors that will allow for full removal and replacement.
- 3.1.4. For wall mounted plumbing fixtures with back water connection, provide an adjacent access door.
- 3.1.5. Where access doors are required in ductwork requiring a fire rating, install them in accordance with the fire rating system manufacturer's written installation instructions, to ensure that the Product listing is not compromised.
- 3.1.6. Wherever possible, locate items requiring access in easily accessible areas (i.e. exposed or T-bar ceilings).
- 3.1.7. Group items in order to minimize the number of access doors required.
- 3.1.8. Install each access door to provide complete access to equipment for maintenance and servicing.
- 3.1.9. Make any changes to locations of access doors as directed by the Engineer's Representative.
- 3.1.10. Show the final installed locations of all access doors on the as-built drawings.

END OF SECTION

20 05 73.00 Excavation and Backfill for Mechanical Work

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.1.2. This Section governs requirements for all Work required for the installation of underground storm drains, sanitary sewers, gas lines, pressurized water lines, and appurtenances associated with such services.

- .1 Excavation and backfill Work includes all Work within the building footprint (plan), and extends to a point 1500 mm (5 ft. 0 in.) beyond face of building foundation line. Services underground within interior courtyards are included in this Section.

1.1.3. Assume that material to be excavated is earth. When rock is encountered during construction, payment will be made on unit price basis to the extent of net difference in cost between dry earth excavation and solid rock excavation, all as indicated in Contract Documents.

1.2. RELATED WORK SPECIFIED ELSEWHERE

1.2.1. Removing subgrade materials for service trenches inside and outside building perimeter, for general grade adjustments, and backfilling of trenches from top of bedding up to bottom of slab-on-grade - under separate Contract.

1.2.2. Dewatering of Site - under Division 31.

1.2.3. Rock excavating and spreading - under Division 31.

1.2.4. Finish grading and spreading of topsoil - under Division 31.

1.2.5. Weeping tile drainage lines and filter media - under Division 31.

1.3. SUBMITTALS

1.3.1. Provide Shop Drawings indicating proposed method of bedding and backfilling in accordance with Section 20 05 03.00 – SHOP DRAWINGS.

1.4. WARRANTY

1.4.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. SOILS

2.1.1. Provide Granulars "A", "B" (Type 1), "M" and "Select Subgrade Material";

- .1 CAN/CSA A23.1 "Concrete materials and methods of concrete construction" and CAN/CSA A23.2 "Test methods and standard practices for concrete."
- .2 Ontario Provincial Standard Specifications (OPSS), Form No. 1010

- 2.1.2. Requirements for Pea Gravel: Granular, well-graded clean rounded pea gravel or stone with not more the 2% material that will pass 75 um (No. 200) sieve, maximum 6 mm (¼ in.), containing not other deleterious material, and subject to testing that specified density can be achieved without compaction.
- 2.1.3. Requirements for Sand Fill: Uniform quality and unwashed river sand or any clean sand containing less than 5% organic materials, clay or silt (passing 125 um sieve) is acceptable. It can contain a limited amount of small stones or rocks as it comes from the pit. Sharp, clean, coarse sand, water washed, free from clay, salts and organic matter, and in accordance with CAN/CSA A179 "Mortar and Grout for Unit Masonry" for masonry sand is also acceptable.

3. Execution

3.1. INSTALLATION

- 3.1.1. All excavation and backfilling for all services shall be in accordance with Division 31.
- 3.1.2. Refer to Division 31 for rough excavation, removal of excavated material and backfill.
- 3.1.3. Protection:
 - .1 Provide protection to existing structures and services. Be responsible for rectifying any damage to existing structures and services resulting from this operation.
- 3.1.4. Excavation in Soil:
 - .1 Where rough excavation is carried out by Division 31, perform all layout Work for trenches required under this Division, including verification of trench depths and slopes. Work in close cooperation with excavating trades that remove subgrade to within 6 in. (150 mm) of the correct and final trench depth.
 - .2 Perform the final excavation to the correct trench invert to permit proper bedding as detailed in the Standard Drawings. Excavation carried below the correct inverts shall be backfilled with 2000 psi (13.5 MPa) concrete to the underside of the pipe lines, unless otherwise directed in writing.
- 3.1.5. Excavation in Rock:
 - .1 All excavation in rock is included under a separate Section, and is taken to a minimum of 150 mm (6 in.) below the correct pipe invert. This Division shall use a bedding material as detailed in the Standard Details to the correct trench invert.
- 3.1.6. Backfilling
 - Backfill with sand from the bottom of the trench or excavation up to a point 300 mm (12 in.) above the top of service line or appurtenance. Backfill pipe trenches with sand to a depth 300 mm (12 in.) above the pipe. The sand shall be thoroughly tamped around and over the pipes in 150 mm (6 in.) layers.
 - .2 Backfill up to top of subgrade.
 - .3 Backfill the remainder of trench or excavation up to top of subgrade or bottom of floor slabs on grade.

END OF SECTION

20 05 83.00 Sleeves and Escutcheons

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. RELATED WORK SPECIFIED ELSEWHERE

1.2.1. Firestopping and smoke seals within mechanical assemblies (i.e. inside ducts, dampers, etc.) with the exception of sleeves shown for future use installed in fire or smoke rated partitions shall be the responsibility of Mechanical Division. All other firestopping and smoke seals of mechanical services are part of Mechanical Division.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Sleeves passing through stud partitions shall be 0.75 mm (0.0299 in. - 22 GSG) steel.

2.1.2. Sleeves passing through concrete or masonry partitions and floors shall be Schedule 40 steel pipe.

2.1.3. Sleeves passing through floors in finished areas and concealed spaces may be sheet metal where additional protection is provided to prevent water from passing freely (i.e. housekeeping pad).

2.1.4. Sleeves for pipes passing through exterior foundation walls shall be pre-manufactured molded non-metallic HDPE equal to GPT Industries/Garlock Century-Line. Each sleeve assembly shall have end caps manufactured of the same material as the sleeve and installed at each end to prevent deformation during the concrete pour.

.1 The annular space between the service pipe and the sleeve shall be a modular EPDM seal element, reinforced nylon polymer pressure plates, joined with ASTM B633 "Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel" carbon steel bolts with zinc dichromate and corrosion inhibiting coating equal to GPT Industries/Garlock Link-Seal Model C wall seal.

.2 A reinforced concrete bridge shall be installed between the wall and the adjacent undisturbed soil.

2.1.5. Firestopping and smoke seal systems shall be in accordance with CAN/ULC-S115 "Standard Method of Fire Tests of Firestop Systems," CAN/ULC-S101 "Standard Methods of Fire Endurance Tests of Building Construction and Materials," ASTM E119 "Standard Test Methods for Fire Tests of Building and Construction Materials" and ASTM E814 "Standard Test Method for Fire Tests of Penetration Firestop Systems."

.1 Unless noted otherwise, "F" and "T" ratings are required. Provide "F" rating and "FT" rating that both equal or exceed the fire-resistance rating of the fire separation.

- .2 Systems shall be asbestos free and maintain an effective barrier against flame, smoke, and gases in accordance with CAN/ULC-S115 and shall not exceed opening sizes for which they are intended.
 - .3 Firestopping and smoke seals at openings around mechanical services shall be an elastomeric seal for sound and vibration control.
 - .4 Fire resistance rating of firestopping assembly shall not be less than the fire resistance rating of surrounding floor or wall assembly.
 - .5 Service penetration assemblies shall be ULC certified in accordance with CAN/ULC-S115 and listed in ULC Guide No. 40 U19.
 - .6 Service penetration firestop components shall be ULC certified in accordance with CAN/ULC-S115 and listed in ULC Guide No. 40 U19.13 and ULC Guide No. 40 U19.15.
 - .7 Firestopping and smoke seals shall be by Hilti, Tremco/Royal Quickstop, STI Firestop or 3M.
 - .8 Firestop Products shall be mold and mildew resistant.
- 2.1.6. Escutcheons shall be satin finish stainless steel or satin finish chrome or nickel plated brass, with non-ferrous set screws. Do not use stamped steel split plates. Split cast plates with screw locks may be used. For escutcheons for plumbing fixtures refer to Section 22 42 00.00 - FIXTURES AND TRIM.
- 2.1.7. Provide adequate bracing for support of sleeves during concrete and masonry Work. For floors and walls with a fire resistance rating, build fire damper assemblies into structure to attain fire rated construction, in a manner acceptable to the governing authorities.
- 2.1.8. Cover exposed duct sleeves in finished areas with 1.42 mm (0.0561 in. - 18 GSG) galvanized sheet steel in the form of duct collars. Fix in position with non-ferrous metal screws.
- 2.1.9. Counter flashing for roof penetrations shall be commercial quality galvanized sheet steel to ASTM A653/A653M "Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process," 0.70 mm (0.0276 in. - 24 GSG) minimum thickness, Z275 275 zinc coated by hot dip process.
3. Execution
- 3.1. INSTALLATION
- 3.1.1. Arrange for all chases and formed openings in walls and floors as required by the Mechanical Division for the mechanical services. These chases and openings shall not be larger than necessary to accommodate the equipment and services. Advise on these requirements well in advance, before the concrete is poured and the walls are built. All necessary sleeves and inserts shall be supplied by this Division.
- 3.1.2. Chases and openings not located in accordance with the above provisions shall be made at the expense of this Division. Cutting of structural members shall not be permitted without specified written acceptance of the Engineer's Representative.
- 3.1.3. Provide sleeves for all service penetrations through walls, partitions, floor slabs, plenums and similar barriers.
- 3.1.4. Sleeves shall be sized to maintain insulation and vapour barrier around all pipes and ducts for all service penetrations. Coordinate thickness requirements with Section 20 07 00.00 - INSULATION.
- 3.1.5. For sleeves through barriers without a fire resistance rating, for non-insulated pipe, fill the annular space between the service and the sleeve with insulation as specified in Section 20 07 00.00 - INSULATION and caulk around the edges with sealant.

- 3.1.6. Firestopping and smoke seal material and components shall be installed in accordance with the ULC Listing and manufacturer's written instructions. Examine the sizes and conditions of the cavities to be filled to determine the correct thicknesses and installation of materials. All substrates and surfaces in contact with firestopping materials shall be dry and prepared in accordance with the Manufacturer's written instructions at appropriate ambient conditions.
- 3.1.7. Where holes are core drilled in existing structures, sleeves shall be provided as specified complete with a combination puddle/anchor flange bolted to the floor. Seal watertight between the flange and the floor.
- 3.1.8. Provide escutcheons at all penetrations of piping into finished areas, and at insulated pipes, make the escutcheons large enough to fit around the insulation.
- 3.1.9. Counter flash vertical duct penetrations through roof at intersection of roof curb and duct.
- 3.1.10. Extend sleeves a minimum of 50 mm (2 in) above floor and seal water tight to prevent seeping to the floor below. Sleeves passing through housekeeping pads are permitted to be flush with the top of the housekeeping pad.

END OF SECTION

20 05 88.00 Cutting and Patching

1. General

1.1. WORK INCLUDED

- 1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
- 1.1.2. Openings required for mechanical services for new construction shall be in accordance with Section 20 05 83.00 - SLEEVES AND ESCUTCHEONS. This Section shall apply for openings required in existing construction or where sleeves for mechanical services have been omitted in new construction in error.
- 1.1.3. Include for all cutting and patching for all mechanical services for holes and openings with dimensions up to 200 mm (8 in.) in size and related patching. Perform cutting and patching Work in accordance with requirements of Section 01 60 00.00 - PROJECT FORMS.
- 1.1.4. Cutting and Patching shall be in accordance with Section 01 60 00.00 - PROJECT FORMS.

1.2. WARRANTY

- 1.2.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

- 2.1.1. All services and materials used for the cutting and patching shall meet all requirements specified in Section 01 60 00.00 - PROJECT FORMS, and shall be carried out by professional workers experienced in the cutting and patching Work to be done.

3. Execution

3.1. INSTALLATION

- 3.1.1. Locate all openings in non-structural elements requiring cutting and patching in cooperation with the applicable Trades in a timely manner to avoid unnecessary cutting. All openings shall be shown on drawings and submitted to the Engineer's Representative for review. No holes through structure shall be permitted prior to review by the Structural Engineer's Representative.
- 3.1.2. Core drilling for individual services shall be by this Division. Cut all openings no larger than is required for the services.
- 3.1.3. Locate all openings in structural elements requiring cutting and patching (concrete walls or floors) and x-ray the structure to obtain Structural Engineer's Representative's approval prior to cutting or core drilling of structure. Make adjustments to location of openings as required to minimize cutting of rebar and completely avoid electrical conduit.
 - .1 Cut holes through slabs or walls only.
 - .2 Do not cut holes through beams.
 - .3 Holes to be cut are 200 mm (8 in.) diameter or smaller only.

- .4 Maintain at least 100 mm (4 in.) clear from all beam faces. Space at least 3 hole diameters on Centre.
 - .5 For holes that are required closer than 25% of slab span from the supporting beam face, use cover meter above the slab to clear slab top bars.
 - .6 For holes that are required within 50% of slab span, use cover meter underside of slab to clear slab bottom bars.
 - .7 X-rays shall be performed by a qualified technician, in a safe manner and in accordance with all applicable regulations governing this activity.
- 3.1.4. Obtain written approval from the Structural Engineer's Representative before cutting or core drilling openings or holes.
- 3.1.5. Patch all openings after services have been installed to match the surrounding finishes.

END OF SECTION

20 07 00.00 Insulation

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Provide Shop Drawings with technical data on all types of insulation to be installed, in accordance with Section 20 05 03.00 – SHOP DRAWINGS.

1.2.2. Provide two samples of each type of insulation indicating where each is to be used, and a sample of a typical vapour barrier dam, where vapour barrier dams are called for: in Part 3 or on the Drawings. Samples shall be mounted on boards. One shall be kept at the Contractor's site office and the other shall be turned over to the Engineer's Representative.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. GENERAL

2.1.1. Provide insulation and jacket systems that are fire retardant, with a flame-spread rating not to exceed 25 and a smoke developed classification not to exceed 50, when tested in accordance with CAN/ULC S102 "Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies."

2.1.2. For indoor applications, provide insulation systems (insulation, jackets, adhesives, coatings, etc.) that are Certified under the UL GREENGUARD Certification Program for low chemical and particle (volatile organic compounds (VOC)) emissions.

2.2. PIPE INSULATION

2.2.1. Type P1 - Inorganic mineral fibre: glass wool, rock wool, or slag wool.

.1 To ASTM C547 "Standard Specification for Mineral Fiber Pipe Insulation."

.2 Rigid, pre-formed, with pressure sensitive longitudinal adhesion strip.

.3 Reinforced all service jacket (ASJ) vapour retarder.

.4 Suitable for temperature range of pipe application in question.

.5 Acceptable manufacturers:

.1 Johns Manville

.2 Knauf

.3 Manson

.4 Owens-Corning

2.2.2. Type P2 - Inorganic mineral fibre: rock wool, or slag wool.

- .1 To ASTM C547 "Standard Specification for Mineral Fiber Pipe Insulation."
 - .2 Rigid, pre-formed, with pressure sensitive longitudinal adhesion strip. Chopped fibre moulded is not acceptable.
 - .3 Reinforced all service jacket (ASJ) vapour retarder.
 - .4 Suitable for temperature range of pipe application in question.
 - .5 Acceptable manufacturers:
 - .1 Knauf
 - .2 Rockwool
- 2.2.3. Type P3 - Closed cell flexible elastomeric:
- .1 To ASTM C534 "Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form."
 - .2 Preformed, with self closing adhesion strips.
 - .3 Suitable for temperature range of pipe application in question.
 - .4 UV resistant with protective jacket/cladding where used outdoors.
 - .5 Adhesive for both surfaces to be joined.
 - .6 Acceptable manufacturers:
 - .1 Armacell
- 2.2.4. Type P4 - Inorganic rock wool mineral fibre pipe wrap:
- .1 To ASTM C553 "Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications."
 - .2 Flexible blanket, with foil scrim kraft (FSK) facing or reinforced all service jacket (ASJ) vapour barrier.
 - .3 Suitable for temperature range of pipe application in question.
 - .4 Acceptable manufacturers:
 - .1 Johns Manville
 - .2 Rockwool
- 2.2.5. Type P5 - Closed cell cellular glass:
- .1 To ASTM C552 "Standard Specification for Cellular Glass Thermal Insulation" and ASTM C1639 "Standard Specification for Fabrication Of Cellular Glass Pipe And Tubing Insulation."
 - .2 Acceptable manufacturer:
 - .1 Owens-Corning - Foamglas
- 2.2.6. Type P6 - Fire resistant pipe insulation:
- .1 Except where other methods of fire rating are shown on the Drawings and provided that the local authority having jurisdiction is in agreement, provide CL4Fire fire wrap system for natural gas piping, fuel oil piping, standpipes, or other pipes requiring a fire rating and employ a fire wrap system listed for the specific piping application and fire rating in question. Provide fire wrap complete with CCMC Canadian code compliance evaluation approval.
- 2.2.7. Type P7 - Hydrous calcium silicate high temperature insulation:
- .1 To ASTM C533 "Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation."
 - .2 Rigid, split formed, moulded insulation.

- .3 Asbestos free, non-combustible.
- .4 Abuse-resistant, 230 kg/cu.m. (14 lbs/cu.ft.) density.
- .5 Suitable for temperature range up to 538 Deg. C (1000 Deg. F).
- .6 Acceptable manufacturer:
 - .1 Johns Manville – Thermo-12 Gold

2.3. DUCT INSULATION

2.3.1. Type D1 - Inorganic mineral fibre blanket - glass wool, rock wool, or slag wool:

- .1 To ASTM C553 "Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications."
- .2 Flexible blanket, with foil scrim kraft (FSK) facing jacket vapour barrier.
- .3 Density: 24 kg/cu.m. (1.5 lbs/cu.ft.).
- .4 Suitable for temperature range of duct application in question.
- .5 Acceptable manufacturers:
 - .1 Johns Manville
 - .2 Knauf
 - .3 Rockwool

2.3.2. Type D2 - Inorganic mineral fibre board - glass wool, rock wool, or slag wool:

- .1 To ASTM C612 "Standard Specification for Mineral Fiber Block and Board Thermal Insulation."
- .2 Semi-rigid board, with factory applied foil scrim kraft (FSK) facing jacket vapour barrier.
- .3 Suitable for temperature range of duct application in question.
- .4 Density: 48 kg/cu.m. (3 lbs/cu.ft.).
- .5 Acceptable manufacturers:
 - .1 Johns Manville
 - .2 Knauf
 - .3 Owens-Corning
 - .4 Rockwool

2.3.3. Type D3 - Closed cell flexible elastomeric:

- .1 To ASTM C534 "Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form."
- .2 Preformed.
- .3 Suitable for temperature range of duct application in question.
- .4 UV resistant with protective jacket/cladding where used outdoors.
- .5 Adhesive for both surfaces to be joined.
- .6 Acceptable manufacturers:
 - .1 Armacell

2.3.4. Type D4 - Extruded polystyrene (XPS):

- .1 To ASTM C578 "Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation" and CAN/ULC S701.1 "Thermal Insulation, Polystyrene Boards."
- .2 Rigid, formed into board insulation.

- .3 Suitable for temperature range of duct application in question.
 - .4 Acceptable manufacturers:
 - .1 Dupont
 - .2 Owens-Corning
- 2.3.5. Type D5 - Fire resistant duct insulation:
- .1 To meet the requirements of NFPA 96 "Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations."
 - .2 To meet the fire resistance rating indicated on the Drawings or 2 hours.
 - .3 Complete with all manufacturer's standard fastenings, including (where applicable) aluminum foil tape, filament tape, banding materials, pins, cup-head weld pins, and speed clips for a ULC listed installation.
 - .4 Acceptable manufacturers:
 - .1 3M - Fire Barrier Duct Wrap
 - .2 CL4Fire
 - .3 Unifrax Corporation – FyreWrap
- 2.4. EQUIPMENT INSULATION
- 2.4.1. Type E1 - Inorganic mineral fibre blanket - glass wool, rock wool, or slag wool:
- .1 To ASTM C553 "Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications."
 - .2 Blanket, foil faced.
 - .3 Suitable for temperature range of equipment application in question.
 - .4 Density: Minimum 12 kg/cu.m. (0.75 lbs/cu.ft.).
 - .5 Acceptable manufacturers:
 - .1 Johns Manville
 - .2 Knauf
 - .3 Manson
 - .4 Owens-Corning
- 2.4.2. Type E2 - Inorganic mineral fibre blanket - glass wool, rock wool, or slag wool:
- .1 To ASTM C553 "Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications."
 - .2 Blanket, with foil scrim kraft (FSK) facing jacket or all service jacket (ASJ), vapour barrier.
 - .3 Suitable for temperature range of equipment application in question.
 - .4 Density: Minimum 24 kg/cu.m. (1.5 lbs/cu.ft.).
 - .5 Acceptable manufacturers:
 - .1 Johns Manville
 - .2 Knauf
 - .3 Manson
 - .4 Owens-Corning
- 2.4.3. Type E3 - Inorganic mineral fibre blanket - glass wool, rock wool, or slag wool:

- .1 To ASTM C553 "Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications."
 - .2 Flexible blanket, with foil scrim kraft (FSK) facing jacket or all service jacket (ASJ), vapour barrier.
 - .3 Density: minimum 48 kg/cu.m. (3 lbs/cu.ft.).
 - .4 Suitable for temperature range of equipment application in question.
 - .5 Acceptable manufacturers:
 - .1 Johns Manville
 - .2 Knauf
 - .3 Owens-Corning
 - .4 Rockwool
- 2.4.4. Type E4 - Inorganic mineral fibre board - glass wool, rock wool, or slag wool:
- .1 To ASTM C612 "Standard Specification for Mineral Fiber Block and Board Thermal Insulation."
 - .2 Semi-rigid board, with factory applied foil scrim kraft (FSK) facing jacket vapour barrier.
 - .3 Suitable for temperature range of equipment application in question.
 - .4 Density: minimum 48 kg/cu.m. (3 lbs/cu.ft.).
 - .5 Acceptable manufacturers:
 - .1 Johns Manville
 - .2 Knauf
 - .3 Owens-Corning
 - .4 Rockwool
- 2.4.5. Type E5 - Inorganic mineral fibre board - glass wool, rock wool, or slag wool:
- .1 To ASTM C612 "Standard Specification for Mineral Fiber Block and Board Thermal Insulation."
 - .2 Semi-rigid board, with factory applied foil scrim kraft (FSK) facing jacket vapour barrier.
 - .3 Suitable for temperature range of equipment application in question.
 - .4 Density: minimum 128 kg/cu.m. (8 lbs/cu.ft.).
 - .5 Acceptable manufacturers:
 - .1 Johns Manville
 - .2 Owens-Corning
 - .3 Rockwool
- 2.4.6. Type E6 - Closed cell flexible elastomeric:
- .1 To ASTM C534 "Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form."
 - .2 Self adhering roll sheets.
 - .3 Suitable for temperature range of equipment application in question.
 - .4 UV resistant with protective jacket/cladding where used outdoors.
 - .5 Acceptable manufacturers:
 - .1 Armacell
- 2.4.7. Type E7 - Stone wool high temperature insulation:

- .1 To ASTM C547 "Standard Specification for Mineral Fiber Pipe Insulation."
- .2 Moulded stone wool, non-combustible.
- .3 Suitable for operating temperatures up to 760 Deg. C.(1400 Deg. F).
- .4 Acceptable manufacturer:
 - .1 Rockwool – ProRox PS 980
- 2.4.8. Type E8 - Spun ceramic fibre blanket high temperature insulation:
 - .1 To ASTM C892 "Standard Specification for High-Temperature Fiber Blanket Thermal Insulation."
 - .2 Suitable for applications with temperatures from 538 Deg. C (1000 Deg. F) to 1345 Deg. C (2450 Deg. F).
 - .3 Nominal density:128 kg/cu.m. (8 lbs/cu.ft.).
 - .4 Acceptable manufacturers:
 - .1 Nutech - MaxWool spun ceramic fibre blanket.
- 2.4.9. Type E9 - Spun low bio-persistent (LBP) fibre blanket high temperature insulation:
 - .1 To ASTM C892 "Standard Specification for High-Temperature Fiber Blanket Thermal Insulation."
 - .2 Suitable for applications with temperatures up to 1100 Deg. C (2000 Deg. F).
 - .3 Nominal density: 128 kg/cu.m. (8 lbs/cu.ft.).
 - .4 Acceptable manufacturer:
 - .1 Nutech – Supermag HI low-biopersistence spun blanket.
- 2.4.10. Type E10 - Hydrous calcium silicate high temperature insulation:
 - .1 To ASTM C533 "Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation."
 - .2 Rigid, split formed, moulded insulation.
 - .3 Asbestos free, non-combustible.
 - .4 Abuse-resistant, 230 kg/cu.m. (14 lbs/cu.ft.) density.
 - .5 Suitable for temperature range up to 538 Deg. C (1000 Deg. F).
 - .6 Acceptable manufacturer:
 - .1 Johns Manville – Thermo-12 Gold
- 2.5. JACKETS
- 2.5.1. All service jacket (ASJ)
 - .1 As indicated in insulation types above.
- 2.5.2. Foil skim kraft (FSK)
 - .1 As indicated in insulation types above.
- 2.5.3. Insulation Jacketing System:
 - .1 Multi-layered, reinforced laminate jacketing tape with acrylic pressure sensitive adhesive.
 - .2 Zero permeability; self-adhesive; UV and weather resistant.
 - .3 Colour: Natural aluminum or white, as chosen at Shop Drawing stage.
 - .4 Finish: flat or embossed, as chosen at Shop Drawing stage.

- .5 Acceptable manufacturers:
 - .1 3M – VentureClad Insulation Jacketing System 1577 Series
 - .2 3M – VentureClad Heavy Duty Jacketing System 1579 Series
- 2.5.4. Canvas jacket:
 - .1 ULC listed plain weave cotton fabric insulation jacket.
 - .2 Weight of canvas: 220 g/sq.m (6 oz/sq.yd.).
 - .3 Complete with two coats of fire retardant lagging finish.
- 2.5.5. Polyvinyl Chloride (PVC) jacket:
 - .1 Pre-moulded PVC covers.
 - .2 Pre-moulded PVC elbows and fittings.
 - .3 Minimum thickness: 20 mil.
 - .4 Colour: white or coloured as chosen at Shop Drawing stage.
 - .5 Tape: vinyl, pressure sensitive, colour matched.
 - .6 Sealed with adhesive.
- 2.5.6. Aluminum jacket:
 - .1 Finish: smooth.
 - .2 Minimum thickness: 0.41 mm (0.016 in.).
 - .3 Factory applied polysurlyn moisture barrier laminated to inside surface of jacket.
 - .4 Longitudinal and circumferential slip joints.
- 2.5.7. Stainless Steel (SS) jacket:
 - .1 Grade: 304.
 - .2 Finish: smooth.
 - .3 Minimum thickness: 0.25 mm (0.01 in.).
 - .4 Factory applied polysurlyn moisture barrier laminated to inside surface of jacket.
 - .5 Longitudinal and circumferential slip joints.
- 2.6. SECUREMENT
- 2.6.1. Banding
 - .1 Aluminum or Stainless steel.
- 2.6.2. Tie Wire
 - .1 Stainless steel.
 - .2 Minimum 1.3 mm (16 gauge).
 - .3 Twisted ends.
- 2.6.3. Corner beads and channels at floor line:
 - .1 Minimum 0.4 mm (28 gauge) galvanized sheet metal.
- 2.6.4. As per insulation / jacket manufacturer's written installation instructions.
- 2.7. CEMENTS AND ADHESIVES
- 2.7.1. Where cements or adhesives are required, provide those that are compatible with insulation and jacket, per insulation and jacket manufacturer's written recommendations / instructions.

- 2.7.2. Fire retardant lagging coating:
 - .1 Chil Seal CP-50A by Childers Products Company or Henry equivalent.
- 2.7.3. Vapour barrier dam:
 - .1 CHIL-PERM CP-30 with fibreglass cloth reinforcing.
- 3. Execution
 - 3.1. INSTALLATION
 - 3.1.1. Install insulation in accordance with the manufacturer's written installation instructions unless noted otherwise.
 - 3.1.2. Insulation thicknesses and conductivities shall meet or exceed the minimum standards set out in ASHRAE 90.1 "Energy Standard for Buildings except Low-rise Residential Buildings" and in National Energy Code of Canada for Buildings (NECB), (refer to Table 2 below), and as specified herein for the services covered.
 - 3.1.3. Apply insulation to clean, dry surfaces only while ambient temperature is at least 10 Deg. C. (50 Deg. F.).
 - 3.1.4. Commence application of insulation following required testing of piping, ductwork, and apparatus where such items are to be covered. Do not commence insulation installation until testing report is submitted to Engineer's Representative and is reviewed by Engineer's Representative without requesting a resubmit.
 - 3.1.5. Where pipes and ducts are specified to be insulated, insulate complete piping system and duct system with no gaps in insulation.
 - 3.1.6. Protect insulation and pipe from moisture ingress where insulation is installed exterior to the building.
 - 3.1.7. Utilize oversized hangers and pipe supports where pipes are installed exterior to the building and are to be insulated. Hangers and supports to support assembly on the outside of the insulation, so as to protect insulation and pipe from water damage due to ambient conditions.
 - 3.1.8. Where vapour barrier dams are called for, terminate the insulation and seal the vapour barrier to the pipe or ductwork using a mesh embedded in a vapour barrier mastic. Provide dams at valves, fittings used for servicing, groups of other types of fittings, irregular shaped objects at floor and wall penetrations, and at 15 m (50 ft.) intervals of straight pipe or straight ductwork for the following services: water piping that is less than 26.7 deg. C. (80 deg. F.), including but not limited to the following:
 - .1 Domestic cold water piping
 - .2 Chilled drinking water piping
 - .3 Chilled water piping
 - .4 Glycol piping
 - .5 Spray coil piping
 - .6 Dual temperature piping
 - .7 Condenser water pipe piping and
 - .8 Exterior ductwork
 - 3.1.9. Terminate insulation on pipes passing through fire rated walls or floors, and fit tight to the fire stop material.

- 3.1.10. Irregular shaped objects such as strainers, pipe system filters, cyclone separators, blowdown valves and other accessories requiring servicing, on insulated piping, shall be insulated with removable caps or sections. All edges shall be sealed between pipe and vapour barrier and held in place with stainless steel straps. Finish all insulation smooth, making the outline of pipe insulation a true circular and concentric shape. Shape the outline of fitted insulation to blend with adjacent covering.
- 3.1.11. On piping systems specified to be insulated, include insulation on valves, flanges, couplings and unions.
- 3.1.12. Do not use staples to secure joints of insulation jackets.
- 3.1.13. Where tie wires are used, install on maximum 305 mm (12 in.) centres.
- 3.1.14. Install insulation jackets with minimum 50 mm (2 in.) laps.
- 3.1.15. Provide insulation and jacket systems in accordance with Table 1 below:

TABLE 1: INSULATION AND JACKET SYSTEMS

Pipe Application	Insulation	Thickness	Jacket
Piping services that will be painted	See table contents below	See table contents below	Do not use PVC.
Pipe insulation exposed to view / not concealed, where being painted	See table contents below	See table contents below	Canvas pasted on
Pipe insulation exposed to view / not concealed, where NOT being painted	See table contents below	See table contents below	Canvas pasted on or PVC
Pipes that are electrically heat traced	Do not use Type P3	See table contents below	See table contents below
Where pipes are installed outdoors, provide pipe coatings in accordance with Section 23 21 13.23 – Piping, Valves & Fittings (Except Plumbing).	See table contents below	See table contents below	See table contents below
Hot fluid such as heating water services, heating glycol, low pressure steam and condensate piping, etc.	Type P1	Per Table 2	Per insulation type; for high temperature heating water do not use PVC; see Section 23 21 13.23 for more info on temperatures.
Domestic hot water piping	Type P1	Per Table 2	Per insulation type
Refrigerant liquid and suction piping	Type P3	25 mm (1 in.), unless a greater thickness is required by the manufacturer's written instructions.	Per insulation type

Domestic cold water and chilled drinking water piping. In residential suite applications, downstream of the suite shut off valve, PEX piping used for domestic cold water does not require insulation.	Type P1 or P3	Per Table 2 domestic cold water requirements	Per insulation type
First 4500 mm (15 ft.) of standpipe and/or sprinkler main	Type P1 or P3	12 mm (1/2 in.)	Per insulation type
Chilled water	Type P1 or P3	Per Table 2	Per insulation type
Dual temperature water or glycol	Type P1 or P3	Per Table 2	Per insulation type
Ground source condenser water system piping – consider as dual temperature service.	See table contents below	See table contents below	See table contents below
Dual temperature condenser water piping	Type P1 or P3	Per Table 2	Per insulation type
Chemical feed piping for evaporative fluid cooler basin, where piping is outdoors	Type P3	Per Table 2	Per insulation type
Piping in air handling or air conditioning units	Type P3	25 mm (1 in.)	Per insulation type
Piping serving pumps for cold fluid systems such as chilled water, domestic water, etc. and located inside air handling or air conditioning units	Type P3	25 mm (1 in.)	Per insulation type
Drainage piping 75 mm (3 in.) and smaller as indicated below: Storm drainage: roof drain sump; all horizontal or sloping storm piping; all elbows connecting the horizontal storm drainage piping to the vertical leaders; and where the roof drain is less than 3000 mm (10 ft.) horizontally from the vertical leader, insulate the first 3000 mm (10 ft.) of pipe length (horizontal and vertical) closest to the roof drain.	Type P1 or P3	12 mm (1/2 in.)	Per insulation type

Sanitary drainage: sanitary drainage pipes from urinals, direct and indirect drains from drinking fountains, floor drains from air conditioning apparatus, all horizontal drainage carrying chilled condensate, all piping passing through areas with relative humidity of 70% or higher, and sanitary drainage pipe from barrier free lavatories.			
Drainage piping larger than 75 mm (3 in.) as indicated below: Storm drainage: roof drain sump; all horizontal or sloping storm piping; all elbows connecting the horizontal storm drainage piping to the vertical leaders; and where the roof drain is less than 3000 mm (10 ft.) from the vertical leader insulate the first 3000 mm (10 ft.) of pipe closest to the roof drain and the exposed portion of the roof drain. Sanitary drainage: sanitary drainage pipes from urinals; direct and indirect drains from drinking fountains; floor drains from air conditioning apparatus; all horizontal drainage carrying chilled condensate; all piping passing through areas with relative humidity of 70% or higher; and sanitary drainage pipe from barrier free lavatories.	Type P1 or P3	25 mm (1 in.)	Per insulation type
Electrical heat traced piping – insulated for the entire length of piping	As specified for the service being traced; for services not specifically designated, insulate as specified for heating water	For pipes 250 mm (10 in.) and smaller: minimum 38 mm (1-1/2 in.) or thicker as required for the service in question.	As specified for the service being traced

		For pipes 300 mm (12 in.) and larger: minimum 50 mm (2 in.) or thicker as required for the service in question. Thickness of insulation over fittings, valves, and other appurtenances to match the pipe insulation. Provide thicker insulation as required by heat tracing manufacturer's installation requirements.	
Duct Application	Insulation	Thickness	Jacket
Flexible duct connections do not require insulation except where a factory applied insulation has been specified with the flexible duct connection.	See ductwork spec	See ductwork spec	See ductwork spec
Exposed insulation in mechanical rooms	See table contents below	Increase thickness as necessary to give 12 mm (1/2 in.) thickness over flanges and angles.	See table contents below
Ductwork internal to the building within conditioned spaces	Type D2	25 mm (1 in.)	Per insulation type
Ductwork in conditioned concealed spaces and on round duct smaller than 600 mm (24 in.)	Type D1	38 mm (1-1/2 in.)	Per insulation type
Ductwork external to the building	Type D3 or D4	2 layers of 50 mm (2 in.)	Per insulation type for Type D3 or Insulation jacketing system for Type D4

		Provide sloped extruded polystyrene insulation support on top of ductwork to maintain slope at a minimum of 5%. Cover all flanges by a minimum of 12 mm (1/2 in.).	
Apparatus casings	As per connected ductwork, see table above	As per connected ductwork, see table above	As per connected ductwork, see table above
Outside air plenums and mixed air plenums.	See indoor ductwork above	Thickness to suit minimum RSI-2.12 (R-12) for plenums exposed to outside air.	See indoor ductwork above
Outdoor air ductwork and mixed air ductwork, including ducts to and from independent heat recovery units (ERW, HRV, etc.).	See indoor ductwork above	Thickness to suit minimum RSI-2.12 (R-12).	See indoor ductwork above
Heating and cooling coil sections of ductwork and plenums.	Per indoor ductwork	Per indoor ductwork	Per indoor ductwork
Casings of supply fans in equipment rooms.	Per indoor ductwork	Per indoor ductwork	Per indoor ductwork
Supply ductwork in equipment rooms.	Per indoor ductwork	Per indoor ductwork	Per indoor ductwork
Exhaust and relief air: ductwork, plenums, and/or casings, from 1500 mm (60 in.) upstream of shut-off dampers and from dampers to connection to exterior wall or roof.	Per indoor ductwork	Thickness to suit minimum RSI-2.12 (R-12).	Per indoor ductwork
Exhaust air ductwork from independent heat recovery units (ERW, HRV, etc.) up to connection to exterior wall or roof.	Per indoor ductwork	Thickness to suit minimum RSI-2.12 (R-12).	Per indoor ductwork

Exhaust, relief, supply, and return air: ductwork, plenums and/or casings, through non-air conditioned or unheated internal space.	Per indoor ductwork	Use 50 mm (2 in.) thickness.	Per indoor ductwork
All supply ductwork from fans to air outlets (e.g. diffusers, grills, etc.)	Per indoor ductwork	Per indoor ductwork	Per indoor ductwork
Silencers and fan capacity monitors.	Insulate to suit service and location.	To suit service and location.	To suit service and location.
All supply ductwork from VAV box for variable volume systems up to and including terminal grill or diffuser.	Per indoor ductwork	Per indoor ductwork	Per indoor ductwork
Equipment Application	Insulation	Thickness	Jacket
Domestic hot water tanks	Type E2, wired on	50 mm (2 in.)	Canvas
Heating water tanks / thermal buffer tanks	Type E2, wired on	50 mm (2 in.)	Canvas
Shell and tube heat exchangers	Type E2, wired on	50 mm (2 in.)	Canvas
Radiant heating panels	Type E1	25 mm (1 in.)	Per insulation type
Cold water service: valves, water meters, drain valves, vent connections, thermometer wells, pressure gauges, and other irregular shaped objects	Type E6	To suit service, per Table 2	Per insulation type
Hot water service ≤ 66 deg. C. (150 deg. F.): valves, water meters, drain valves, vent connections, thermometer wells, pressure gauges, and other irregular shaped objects	Type E6 or E2	To suit service, Per Table 2	Per insulation type
Hot water service > 66 deg. C. (150 deg. F.): valves, water meters, drain valves, vent connections, thermometer wells, pressure gauges, and other irregular shaped objects	Type E2	To suit service, Per Table 2	Per insulation type
Chilled water storage tanks / thermal storage tanks / dual temperature tanks; including legs/supports	Type E6	50 mm (2 in.)	Per insulation type

Pumps for chilled water, spray coils, and domestic water	Type E6	25 mm (1 in.)	Per insulation type
Equipment internal to the building within conditioned spaces	Type E4	25 mm (1 in.)	Per insulation type
Chillers	Type E6 Insulate in accordance with the manufacturer's printed insulation instructions, and insulate all components shown or noted in the instructions. Insulate evaporator, water heads, suction connections and auxiliary water piping of centrifugal water chillers. Insulate auxiliary water piping as per chilled water piping. Provide removable sections of insulation at all components that require servicing, and secure with stainless steel straps.	25 mm (1 in.)	Per insulation type
Plate type heat exchangers with hot surfaces	Type E4	25 mm (1 in.)	Enclose hot surfaces in a removable galvanized steel box. Construct box using flanged, bolted and gasketed joints, with sections removable for servicing the heat exchanger. Bolt box to floor base around the heat exchanger. Provide construction similar to built-up air plenums.

Plate type heat exchangers with cold surface	Type E6, installed in sections with all joints sealed. Also insulate in accordance with the manufacturer's printed insulation instructions. Insulate plate heat exchangers when both services are insulated.	25 mm (1 in.)	Per insulation type
Shell and tube heat exchangers <= 66 deg. C. (150 deg. F.), when service in the shell is insulated.	Type E6	25 mm (1 in.)	Per insulation type
Shell and tube heat exchangers > 66 deg. C. (150 deg. F.), when service in the shell is insulated.	Type E2	25 mm (1 in.)	Per insulation type
Unlisted generator exhaust systems, under 538 Deg. C. (1000 Deg. F.); confirm temperature rating of generator flue prior to insulation.	Type E10	Two layers of 50 mm (2 in.) with staggered joints, wired on.	Cover entire length of insulation with an aluminum jacket. Form expansion joints with slip joints extending 300 mm (12 in.) past the flange at each end of the joint.
Unlisted generator exhaust systems, under 538 Deg. C. (1000 Deg. F.); confirm temperature rating of generator flue prior to insulation.	Type E7	Two layers of 50 mm (2 in.) with staggered joints, wired on.	Cover entire length of insulation with an aluminum jacket. Form expansion joints with slip joints extending 300 mm (12 in.) past the flange at each end of the joint.
Unlisted generator exhaust systems, 538 Deg. C. (1000 Deg. F.) and greater; confirm temperature rating of generator flue prior to insulation.	Type E8 or E9, AND Type E7	Two layers of 25 mm (1 in.), Type E8 or E9, with staggered joints, AND one layer of 50 mm (2 in.) thick Type E7, wired on.	Cover entire length of insulation with an aluminum jacket. Form expansion joints with slip joints extending 300 mm (12 in.) past the flange at each end of the joint.
Site fabricated breaching, up to and including connection to chimney stack. Insulate all breaching, except for double walled insulated gas vents, from all boilers and other equipment up to the chimney stack.	Type E7, secured with pins and covered with expanded metal lath. Apply insulation to permit expansion and contraction of breaching without damage to the insulation.	100 mm (4 in.) thick	Final finish consisting of two layers of cement, reinforced with canvas and trowelled smooth, to effect a uniform finish.

3.1.16. Hot Services

- .1 On hot services, insulate valves, fittings, couplings, unions, flanges and all other appurtenances through which the fluid passes, using mitred sections of preformed insulation of a thickness equal to the adjoining pipe insulation, and securely wire in place.
- .2 For domestic hot water piping, apply insulation with all joints butted firmly together, and bond securely, sealing flaps by pasting down to give a smooth finish.
- .3 Provide removable sections at access doors/manholes and all components requiring servicing.

3.1.17. Cold Services

- .1 Protect insulation by means of sheet steel shields at each hanger or support on the following:
 - .1 All sizes of chilled water
 - .2 All sizes of chilled glycol
 - .3 All sizes of spray coil
 - .4 All sizes of dual temperature
 - .5 All sizes of condenser water pipes
 - .6 Domestic cold water piping larger than 25 mm (1 in.)
- .2 Provide Type P5 closed cellular glass insulation inserts the full length of shields at all hangers and supports.
- .3 For domestic cold water piping 25 mm (1 in.) and less where hangers on cold water lines penetrate vapour barrier, ensure that the penetration is properly sealed with insulation and vapour barrier continued up hanger a further 75 mm (3 in.).
- .4 Where sheet metal shields are used, refer to Section 20 05 29.00 - HANGERS AND SUPPORTS.
- .5 On cold water service valves, water meters, drain valves, vent connections, thermometer wells, pressure gauges and other irregular shaped objects, cut and mitre insulation as necessary. Bond and seal edges of insulation to the adjacent surfaces.
- .6 Chilled water storage tanks: provide removable sections at access doors/manholes and all components requiring servicing.
- .7 Refer to the Table 2 for required insulation thicknesses.

3.1.18. Ductwork and Equipment

- .1 Butt join insulation and attach with pins and speed washers, one per 0.186 sq.m. (2 sq.ft.), but not more than 450 mm (18 in.) apart in any direction. Apply fire resistive adhesive in 100 mm (4 in.) wide strips on 300 mm (12 in.) centres. Seal all joints with adhesive and apply vapour barrier tape. Install pins of suitable length for the thickness of insulation and clip flush after final installation of washers. Tack weld pins to sheet metal.
- .2 On exposed insulation in mechanical rooms, provide corner beads to protect corners to a height of 2135 mm (84 in.) above floor and provide channels at floor line to finish off insulation on apparatus.
- .3 Coordinate with Sheet Metal Contractor to ensure duct insulation is applied prior to ductwork being installed to underside of slabs, beams or other services or behind other duct risers and shafts.

- 3.1.19. Apply fire resistant duct insulation directly onto the ductwork and plenums in strict accordance with the manufacturer's written instructions and Listing. Tested to CAN/ULC-S144 "Standard Method of Fire Resistance Test – Grease Duct Assemblies," ISO Standard 6944-1 "Fire containment - Elements of building construction - Part 1: Ventilation ducts," and ISO Standard 6944-2 "Fire containment - Elements of building construction - Part 2: Kitchen extract ducts" as a gypsum shaft alternative per NFPA 96 "Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations" guidelines.
- 3.1.20. Except where other methods of fire rating are shown on the Drawings, where fire wrap systems for pipes are acceptable to the local authority having jurisdiction, install fire wrap system, in accordance with the CCMC listing and the manufacturer's written instructions.

3.1.21. TABLE 2: MINIMUM PIPE INSULATION THICKNESS/PERFORMANCE (BASED ON ASHRAE 90.1 AND NATIONAL ENERGY CODE FOR BUILDINGS)

- .1 Comply with the more stringent (i.e. larger) minimum pipe insulation thickness when comparing ASHRAE 90.1 and National Energy Code for Buildings.
- .2 Minimum pipe insulation thickness - mm (in.)
 - .1 ASHRAE 90.1: Heating and Hot Water Systems (Steam, Steam Condensate, Hot-Water Heating, Domestic Water Systems, Heating Glycol, Other Heating)

Fluid Design Operating Temp. range deg. C. (deg. F.)	Insulation Conductivity		Nominal Pipe Diameter - mm (in.)					
	Conductivity W/(m-K) ((Btu-in.)/h-sq.ft. – deg. F.)	Mean Rating Temp deg. C. (deg. F.)	Runouts* <38.1 (<1.5)	<25.4 (<1)	25.4 to <38.1 (1 to <1-1/2)	38.1 to <101.6 (1-1/2 to <4)	101.6 to <203.2 (4 to <8)	≥203.2 (≥8)
Above 177	0.046 to 0.049	121	101.6	114.3	127.0	127.0	127.0	127.0
Above (350)	(0.32 to 0.34)	(250)	(4.0)	(4.5)	(5.0)	(5.0)	(5.0)	(5.0)
122-177	0.042 to 0.046	93	76.2	76.2	101.6	114.3	114.3	114.3
(251 to 350)	(0.29 to 0.32)	(200)	(3.0)	(3.0)	(4.0)	(4.5)	(4.5)	(4.5)
94-121	0.039 to 0.043	66	38.1	63.5	63.5	63.5	76.2	76.2
(201 to 250)	(0.27 to 0.30)	(150)	(1.5)	(2.5)	(2.5)	(2.5)	(3.0)	(3.0)
61-93	0.036 to 0.042	52	25.4	38.1	38.1	50.8	50.8	50.8
(141 to 200)	(0.25 to 0.29)	(125)	(1.0)	(1.5)	(1.5)	(2.0)	(2.0)	(2.0)
41-60	0.032 to 0.040	38	25.4	25.4	25.4	38.1	38.1	38.1
(105 to 140)	(0.22 to 0.28)	(100)	(1.0)	(1.0)	(1.0)	(1.5)	(1.5)	(1.5)

*For piping located in partitions within conditioned spaces, reduction per footnote to ASHRAE 90.1 table.

.2 National Energy Code for Buildings: Heating Systems (Steam, Steam Condensate, Hot Water Heating, Domestic Water Systems, Heating Glycol, Other Heating)

Fluid Design Operating Temp. range deg. C. (deg. F.)	Insulation Conductivity		Nominal Pipe Diameter - mm (in.)					
	Conductivity W/(m-deg. C) ((Btu-in.)/h-sq.ft. – deg. F.)	Mean Rating Temp deg. C. (deg. F.)	Runouts ^y ≤51 (2)	≤25.4 (<1)	32 to 51 (1-1/4 to 2)	64 to 102 (2-1/2 to 4)	≥127 (≥5)	Not used
Above 177	0.046 to 0.049	121	38.1	114	127	127	127	
Above (350)	(0.32 to 0.34)	(250)	(1.5)	(4.5)	(5.0)	(5.0)	(5.0)	
122-177	0.042 to 0.045	93	38.1	76.2	101.6	114	114	
(251 to 350)	(0.29 to 0.31)	(200)	(1.5)	(3.0)	(4.0)	(4.5)	(4.5)	
94-121	0.039 to 0.043	65	38.1	63.5	63.5	76.2	76.2	
(201 to 250)	(0.27 to 0.30)	(149)	(1.5)	(2.5)	(2.5)	(3.0)	(3.0)	
61-93	0.036 to 0.042	52	25.4	38.1	50.8	50.8	50.8	
(141 to 200)	(0.25 to 0.29)	(125)	(1.0)	(1.5)	(2.0)	(2.0)	(2.0)	
41-60	0.035 to 0.040	38	25.4	25.4	38.1	38.1	38.1	
(105 to 140)	(0.24 to 0.28)	(100)	(1.0)	(1.0)	(1.5)	(1.5)	(1.5)	

^yRefers to runouts to individual terminal units not exceeding 3.7 m in length.

.3 ASHRAE 90.1: Cooling Systems (Chilled Water, Brine, Refrigerant, Chilled Glycol, Dual Temperature Condenser Water (condenser water systems that may operate below 16 deg. C)) and Domestic Cold Water.

Fluid Design Operating Temp. range deg. C. (deg. F.)	Insulation Conductivity		Nominal Pipe Diameter - mm (in.)					
	Conductivity [W/(m-K)] [(Btu-in.)/h-sq.ft. – deg. F.]	Mean Rating Temp deg. C. (deg. F.)	Not used	<25.4 (<1)	25.4 to <38.1 (1 to <1-1/2)	38.1 to <101.6 (1-1/2 to <4)	101.6 to <203.2 (4 to <8)	≥203.2 (≥8)
4.4-16	0.030 to 0.039	24		12.7	12.7	25.4	25.4	25.4
(40-60)	(0.21 to 0.27)	(75)		(0.5)	(0.5)	(1.0)	(1.0)	(1.0)
<4.4	0.029 to 0.038	10		12.7	25.4	25.4	25.4	38.1
<(40)	(0.20 to 0.26)	(50)		(0.5)	(1.0)	(1.0)	(1.0)	(1.5)

.4 National Energy Code for Buildings: Cooling Systems (Chilled Water, Brine, Refrigerant, Chilled Glycol, Dual Temperature Condenser Water (condenser water systems that may operate below 16 deg. C)) and Domestic Cold Water.

Fluid Design Operating Temp. range deg. C. (deg. F.)	Insulation Conductivity		Nominal Pipe Diameter - mm (in.)					
	Conductivity [W/(m-deg. C)] [(Btu-in.)/h-sq.ft. – deg. F.]	Mean Rating Temp deg. C. (deg. F.)	Runouts ^y ≤51 (2)	≤25.4 (<1)	32 to 51 (1-1/4 to 2)	64 to 102 (2-1/2 to 4)	≥127 (≥5)	Not used
4-16	0.030 to 0.039	24	25.4	25.4	25.4	25.4	25.4	
(39-61)	(0.21 to 0.27)	(75)	(1.0)	(1.0)	(1.0)	(1.0)	(1.0)	
<4	0.030 to 0.039	24	25.4	25.4	38.1	38.1	38.1	
<(39)	(0.21 to 0.27)	(75)	(1.0)	(1.0)	(1.5)	(1.5)	(1.5)	

^yRefers to runouts to individual terminal units not exceeding 3.7 m in length.

END OF SECTION

20 08 00.01 Commissioning (with Commissioning Agent)

1. General

1.1. WORK INCLUDED

- 1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
- 1.1.2. Conform to Section 20 05 02.00 - AS-BUILT DRAWINGS.
- 1.1.3. Conform to Section 20 05 03.00 - SHOP DRAWINGS.
- 1.1.4. Conform to Section 20 08 03.00 - OPERATING AND MAINTENANCE INSTRUCTIONS.
- 1.1.5. Conform to Section 23 05 93.13 - TESTING AND BALANCING PIPING SYSTEMS.
- 1.1.6. Conform to Section 23 05 93.23 - TESTING AND BALANCING AIR SYSTEMS.
- 1.1.7. Conform to Section 23 09 00.00 - BUILDING AUTOMATION SYSTEM (BAS).
- 1.1.8. The commissioning process for the Mechanical Systems shall include:
 - .1 Verification that the installation meets the requirements of the Contract Documents.
 - .2 Verification that the system's performance meets the design intent.
 - .3 Provision of building operator training.
 - .4 Provision of as-built documentation, operating and maintenance manuals, and systems operating manuals.
- 1.1.9. The Contractor and the Commissioning Agent shall provide the services to complete the process. The execution portion of this Section defines the areas of responsibility.
- 1.1.10. Provide labour, equipment and material to conduct the Contractor commissioning process as outlined in this Section.
- 1.1.11. The Owner will hire a Commissioning Agent who will provide services identified in the Commissioning Agent articles within this Section.
- 1.1.12. On an on-going basis, advise the Engineer's Representative of the latest schedule for testing and commissioning. The Engineer's Representative may selectively attend at their discretion.
- 1.2. SUBMITTALS
- 1.2.1. Submittals requested in this Section shall be submitted in accordance with Section 20 05 03.00 – SHOP DRAWINGS.
- 1.3. WARRANTY
- 1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

- 2.1.1. The Contractor and manufacturers shall provide all instrumentation and equipment necessary to conduct the tests as specified in the Mechanical Sections. The Contractor shall advise the Commissioning Agent of instrumentation to be used and the dates the instruments were calibrated.

3. Execution

3.1. INSTALLATION

- 3.1.1. This Section describes the commissioning process to be performed by the Contractor. The process shall provide a high level of quality control during the construction.

- 3.1.2. The commissioning process shall consist of:

- .1 Shop Drawings/as-built drawings
- .2 Installation review and equipment verification
- .3 Plumbing and drainage system testing
- .4 Testing of piping systems
- .5 Balancing of piping systems
- .6 Testing of air systems
- .7 Balancing of air systems
- .8 Testing of equipment and systems
- .9 Building Automation System Commissioning
- .10 Commissioning Agent performance testing
- .11 Commissioning meetings
- .12 Operating and maintenance manuals
- .13 Training
- .14 Systems acceptance

3.2. INSTALLATION REVIEW AND EQUIPMENT VERIFICATION

- 3.2.1. Complete the equipment verification forms for each piece of equipment. Forward to the Commissioning Agent and Engineer's Representative for review and include in the operating and maintenance manuals.

3.3. TEST FORMS AND VERIFICATION FORMS

- 3.3.1. The Commissioning Agent will prepare a test form manual, which will contain a form for every test identified in the Specification. A copy of this manual will be given to the Contractor, the General Contractor and the Engineer's Representative.
- 3.3.2. Arrange for the forms to be signed by either the Authorities Having Jurisdiction or the Commissioning Agent where applicable.

3.4. PLUMBING AND DRAINAGE SYSTEM TESTING

3.4.1. Test the plumbing and drainage system in accordance with Section 23 05 93.13 - TESTING AND BALANCING PIPING SYSTEMS.

3.4.2. Notify the Building Inspector when systems are available for testing. Document all tests performed and arrange for the Building Inspector to sign the forms when tests completed.

3.5. TESTING OF PIPING SYSTEMS

3.5.1. Test all piping systems in accordance with Section 23 05 93.13 - TESTING AND BALANCING PIPING SYSTEMS.

3.5.2. Perform all tests in the presence of the Commissioning Agent.

3.6. TESTING OF AIR SYSTEMS

3.6.1. Conform to Section 23 05 93.23 - TESTING AND BALANCING AIR SYSTEMS.

3.6.2. Perform all tests in the presence of the Commissioning Agent.

3.7. TESTING OF EQUIPMENT AND SYSTEMS

3.7.1. Conform to Section 20 08 03.00 - OPERATING AND MAINTENANCE INSTRUCTIONS.

3.7.2. Engage the services of the manufacturer's technicians to test the equipment and associated systems. Have the technician record the results of the tests on the testing forms. Arrange for the tests to be witnessed by the Commissioning Agent. When the tests have been completed satisfactorily the technician and witnessing authority shall sign the forms.

3.7.3. Should equipment or systems fail a test, repeat the test after repairs or adjustments have been made. Arrange for these additional tests to be witnessed by the Commissioning Agent.

3.7.4. Tests which have not been witnessed will not be accepted and must be repeated.

3.8. COMMISSIONING MEETINGS AND SCHEDULING

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

3.8.2. The commissioning meetings shall occur during the regular construction meetings. The testing schedules and results of all tests shall be reviewed.

3.9. OPERATING AND MAINTENANCE MANUALS

3.9.1. Conform to Section 20 08 03.00 - OPERATING AND MAINTENANCE INSTRUCTIONS.

3.9.2. Submit Operating and Maintenance Manuals to Commissioning Agent for review.

3.10. OPERATOR TRAINING

3.10.1. Conform to Section 20 08 03.00 - OPERATING AND MAINTENANCE INSTRUCTIONS.

3.10.2. Conduct the training in a classroom and at the equipment or system.

3.10.3. Training will begin when the operating and maintenance manuals have been reviewed by the Engineer's Representative without requesting a resubmission and have been delivered to the Owner.

3.10.4. Submit a course outline to the Engineer's Representative and Commissioning Agent before training commences. Provide course documentation for up to eight people.

3.10.5. Structure each training session to cover:

- .1 The operating and maintenance manual
 - .2 Operating procedures
 - .3 Maintenance procedures
 - .4 Trouble-shooting procedures
 - .5 Spare parts required
- 3.10.6. The training sessions will be scheduled and co-ordinated by the Commissioning Agent. The Commissioning Agent will digitally video record the sessions.
- 3.10.7. Provide training for the following systems:
- | System | Minimum Training Times |
|---------------------------------------|------------------------|
| Chillers | 4 hours |
| Cooling towers | 2 hours |
| Boilers | 2 hours |
| Air handling units | 2 hours |
| Life safety & fire protection systems | 2 hours |
| Water treatment systems | 2 hours |
| The mechanical system | 8 hours |
| Fuel oil system | 2 hours |
| Generator Ventilation System | 1 hour |
| BAS Controls System | Conform to 23 09 00.00 |
- 3.10.8. Refer to Section 23 09 00.00 - BUILDING AUTOMATION SYSTEMS (BAS).
- 3.10.9. As part of the training requirement for the mechanical systems, conduct a walk-through of the building. During the walk-through the Contractor shall:
- .1 Identify equipment
 - .2 Identify starters associated with equipment
 - .3 Identify valves and balancing dampers
 - .4 Identify access doors
 - .5 Review general maintenance of equipment
 - .6 Review drain locations in pipework systems
 - .7 Identify maintenance items
- 3.10.10. When each training session has been completed with the Owner's representatives, have the Commissioning Agent sign the associated form to verify completion.
- 3.11. COMMISSIONING AGENT
- 3.11.1. A Commissioning Agent will be hired by the Owner.
- 3.11.2. The Commissioning Agent responsibilities shall include:
- .1 Preparing the commissioning plan
 - .2 Co-ordinating with the Contractor to schedule tests
 - .3 Preparing a test form manual
 - .4 Witnessing selected tests
 - .5 Receiving all test forms

- .6 Conducting performance test
- .7 Co-ordinating the Contractor's training
- .8 Attending commissioning meetings
- .9 Preparing the systems operating manuals (as required)
- 3.11.3. Co-ordinate and co-operate with the Commissioning Agent.
- 3.12. PERFORMANCE TESTING
- 3.12.1. The Commissioning Agent will conduct performance tests on each mechanical system to verify that the design intent performance has been met. The performance tests will cover all seasonal modes. The Commissioning Agent will visit the building in six months to retest the systems.
- 3.12.2. The Contractor shall conduct performance tests on all mechanical systems and document the results on the performance forms.
- 3.12.3. The Contractor shall provide assistance to the Commissioning Agent and have personnel available during the performance testing procedures during construction and the warranty period.
- 3.12.4. Performance testing will begin when all mechanical systems have been completed, tested by the Contractor, reviewed by the Engineer's Representative and Substantial Performance has been achieved.
- 3.13. COMMISSIONING PROCESS ALLOCATION
- 3.13.1. The commissioning process shall be allocated a value equal to 8% of the Contract. This value shall be itemized in the Statement of Prices which forms the basis for progress payments for the various portions of Work. The Contractors may draw from this allocation as the commissioning process is completed.
 - .1 The Contractors shall submit all test and verification forms. The Engineer's Representative will use these forms to calculate a percentage complete.
 - .2 The Contractor may claim up to 5% of the Contract, as per Schedule of Breakdown, on a monthly basis, from this allocation leading up to performance testing. The remaining 3% shall not be paid out until the performance testing, O&M manuals and training have been completed satisfactorily.
- 3.13.2. Break down the commissioning process allocation as follows:

Shop Drawings	0.50%
Installation review and equipment verification	0.50%
Plumbing and drainage system testing	0.50%
Testing of piping systems	0.50%
Contractor balancing of piping systems	0.25%
Testing of air systems	0.50%
Contractor balancing of air systems	0.25%
Testing of equipment and systems (system start-up)	0.50%
BAS commissioning	1.00%
Commissioning Agent Performance Testing	2.00%
Operating and Maintenance Manuals	0.50%

Training	0.50%
As-built drawings	0.50%

END OF SECTION

20 08 02.00 Cleaning and Protection

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. WARRANTY

1.2.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. NOT USED

3. Execution

3.1. INSTALLATION

3.1.1. Clean thoroughly all fixtures and equipment from grease, dirt, plaster or any other foreign material. Chrome-plated fittings, piping and trim shall be polished upon completion.

3.1.2. Fixtures and equipment shall be properly protected from damage during the construction period and shall be cleaned and polished in accordance with manufacturer's written directions. Motors and equipment bearings shall be protected with plastic sheets, tied or taped in place. Aluminum fin heating or cooling elements shall be protected with cardboard covers.

3.1.3. Any dirt, rubbish, or grease on walls, floors or fixtures accumulated from the Work of the Mechanical Division shall be removed promptly from the premises by this Division.

3.1.4. Any unpainted steel surfaces, installed for longer than one year prior to the completion date, shall be prime coated under this Division.

3.1.5. During construction protect all services and equipment from dirt and debris, by using temporary caps over the open ends of pipes ductwork and equipment connections.

3.1.6. All equipment installed or stored on site shall be maintained in accordance with manufacturer's recommended instructions (i.e. rotate shafts on fans, pumps, etc.).

3.1.7. Refinish and restore to the original condition and appearance all mechanical equipment which has sustained damage to the manufacturer's prime and finish coats of enamel or paint. Materials and work quality shall be equal to the manufacturer's original.

END OF SECTION

20 08 03.00 Operating and Maintenance Instructions

1. General

1.1. WORK INCLUDED

- 1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
- 1.1.2. Comply with all requirements of Section 20 05 02.00 - AS-BUILT DRAWINGS.
- 1.1.3. Comply with all requirements of Section 20 05 03.00 - SHOP DRAWINGS.
- 1.1.4. Comply with all requirements of Section 20 08 00.00 - COMMISSIONING.
- 1.1.5. Comply with all requirements of Section 01 78 00 - CLOSEOUT SUBMITTALS.

2. Products

2.1. REQUIREMENTS FOR MANUALS

- 2.1.1. Three copies of complete and approved operating and maintenance instructions for all mechanical equipment and systems shall be supplied before Substantial Completion. Manuals shall be also submitted in electronic format. Electronic manuals shall be prepared in Adobe PDF format with all sections bookmarked for quick reference and submitted on a portable data storage device.
- 2.1.2. Binders shall be three-ring, hard-cover, loose-leaf type and identified on the binding edges as "Maintenance Instructions and Data Book", for "(Project Name)".
- 2.1.3. Terminology used in all the Sections shall be consistent.
- 2.1.4. Include the data and requirements noted in this specification section in both hardcopy and electronic versions of all manuals. Divide pages in the hardcopy manuals by tabs and sub-tabs as per the clauses and sub-clauses below. Provide only searchable PDF files as part of electronic version of the manuals and divide PDF document(s) using section cover pages and PDF bookmarks as per the clauses and sub-clauses below.
- 2.1.5. Volume One shall contain the master index of all systems, the name of the Contractor, Mechanical Subcontractors and the date of Substantial Performance of the Work.
- 2.1.6. Volume One shall contain a section with all necessary warranty information.
- 2.1.7. Each binder shall have a complete index for all volumes.
- 2.1.8. Each binder shall be no more than half filled.
- 2.1.9. There shall be a separate section for all materials used on the Project which fall under the WHMIS legislation. There shall be a hazard data sheet for each of the materials.
- 2.1.10. There shall be a separate section for all Insurance Certificates, Test Certificates, Verification Forms and Test Forms.
- 2.1.11. All relevant information relating to a system or Product shall be contained within one binder.
- 2.1.12. The manual sections shall follow the Specification sections.
- 2.1.13. Any diagrams, installation drawings, flow charts, etc. shall be mechanically reduced while maintaining full legibility to standard page size. If this cannot be achieved they shall be carefully folded and contained within a clear plastic wallet within the manual.

2.2. DATA FOR MANUALS

2.2.1. Equipment data shall contain:

- .1 Operating instructions
- .2 Operating conditions such as temperature and pressure
- .3 Location of equipment
- .4 Maintenance instructions and schedules for one year routine
- .5 Recommended list of spare parts
- .6 Lubrication schedule
- .7 A trouble shooting table showing where to look for problems under various conditions of malfunction
- .8 All wiring diagrams
- .9 Equipment operating curves
- .10 Equipment nameplate data and serial numbers

2.2.2. System data shall contain:

- .1 A listing of all systems
- .2 A valve schedule and locations
- .3 Equipment name tags
- .4 Filter schedule
- .5 An electric pipe tracing schedule including location and electrical service location
- .6 Cleaning, maintaining and preserving instructions for all material, Products and surfaces. Include warnings of harmful cleaning, maintaining and preserving practices.

2.2.3. Subcontractor manuals are required for:

- .1 BAS
- .2 Water treatment
- .3 Sprinkler system
- .4 Piping and air balancing

2.2.4. As-built documentation shall contain:

- .1 Reviewed As-built Shop Drawings
- .2 As-built construction drawings
- .3 Originals of test forms
- .4 Originals of test certificates
- .5 Cyber Security Report Letter and backup schedule as required by Section 20 05 00.00
– GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2.3. OPERATING INSTRUCTIONS

2.3.1. Instruct the Owner's representative in all aspects of the operation and maintenance of systems and equipment.

2.3.2. Comply with all requirements of Section 20 08 00.00 - COMMISSIONING, for duration of tests.

2.3.3. Instruct the Owner for a minimum of five (5) Working Days.

2.3.4. Arrange for and pay for the services of engineers and other manufacturer's representatives required for instruction on the systems and the equipment as requested by the Engineer's Representative and/or the Owner.

- 2.3.5. At the time of final review, provide a sheet for each system and piece of equipment showing the date instructions were given. Each sheet shall show the duration of instruction, name of persons receiving instruction, other persons present (manufacturer's representative, Engineer's Representative, etc.), system or equipment involved and signature of the Owner's staff stating that they understood the system installation, operating and maintenance requirements. This information shall be inserted in the manuals after all instructions have been completed.
- 2.3.6. Review information with the Owner's representative to ensure that all information required has been provided.
- 2.3.7. Mechanical equipment and systems included in the instruction requirements are:
- .1 Chillers and associated equipment
 - .2 Heating water generators and associated equipment
 - .3 Automatic controls and instrumentation
 - .4 Water treatment and cleaning
 - .5 Life safety and fire protection
 - .6 Noise and vibration
 - .7 Condenser water distribution system
 - .8 Chilled water distribution systems
 - .9 Heating water distribution systems
 - .10 Air handling distribution and components
 - .11 Miscellaneous ventilation systems
 - .12 Humidification systems
 - .13 Storm, sanitary and domestic water pumping and distribution system
- 2.4. TRIAL USAGE
- 2.4.1. The Owner shall be permitted trial usage of systems or parts of systems for the purpose of testing and learning operational procedures. Trial usage shall not affect the warranties nor be construed as acceptance, and no claim for damage shall be made against the Owner for any injury or breakage to any part or parts due to the tests, where such injuries or breakage are caused by a weakness or inadequacy of parts, or by defective materials or work quality of any kind.
3. Execution
- 3.1. NOT USED
- END OF SECTION

22 05 33.00 Electric Tracing for Domestic Hot Water

1. General
 - 1.1. WORK INCLUDED
 - 1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
 - 1.1.2. Conform to Section 26 05 01.00 - GENERAL INSTRUCTIONS FOR ELECTRICAL SECTIONS.
 - 1.2. SUBMITTALS
 - 1.2.1. Submit Shop Drawings of all items supplied in accordance with requirements of Section 20 05 03.00 - SHOP DRAWINGS.
 - 1.3. WARRANTY
 - 1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
2. Products
 - 2.1. MATERIALS
 - 2.1.1. Electric tracing for Domestic Hot Water nVent Raychem HWAT self-regulating (ranges 40.5 deg. C. (105 deg. F.), 46 deg. C. (115 deg. F.), 52 deg. C. (125 deg. F.), 60 deg. C. (140 deg. F.)) with minimum 40 year life rating for 208 volt, 1 phase supply.
 - 2.1.2. Tracing cable shall be self regulating type.
 - 2.1.3. Contactors if required shall be Allen Bradley 702L Series with 120 volt coil and pilot light in cover. Provide control transformer as required.
3. Execution
 - 3.1. INSTALLATION
 - 3.1.1. Cable shall cover the pipe for the full length shown with no gaps. Particular care shall be taken to ensure that valve body and bonnet are completely protected.
 - 3.1.2. Heating cable shall be installed after pipe installation and testing is complete. Attach cable as recommended by the manufacturer with pipe straps.
 - 3.1.3. The entire installation shall be inspected and approved by the manufacturer before the pipe is concealed and/or insulated. Check for breaks with a 2500 volt meter. Provide report as a submittal for Engineer's review and include final reviewed copy in the operating manuals. The cost of inspection shall be included in the Contract Price.
 - 3.1.4. The installation by this section shall be complete requiring power supply only by the electrical division. Provide all wiring between the electric tracing and the electrical junction box and make final connections.

END OF SECTION

22 05 76.00 Cleanouts

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings and/or catalogue cuts of all items supplied in accordance with requirements of Section 20 05 03.00 - SHOP DRAWINGS.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.2. FINISHED AREAS

2.2.1. Cleanouts in finished areas with membrane floors shall be coated cast iron body with adjustable nickel bronze frame and round scoriated gas tight access cover with secondary gas tight plug. Jay R. Smith 4020-F-C, Zurn ZN 1400-KC, Mifab C1100C-R-1-34, Watts CO-100-C-R-1-34G.

2.2.2. Cleanouts with recess for terrazzo shall be similar to cleanouts in finished areas with membrane floors but shall have terrazzo recess. Jay R. Smith 4180-F-C, Zurn ZN 1400-Z-KC, Mifab C1100C-UR-1-34, Watts CO-100-C-R-1-34G.

2.2.3. Cleanouts with recess for tile shall be similar to cleanouts in finished areas with membrane floors but shall have 3 mm (1/8 in.) tile recess. Jay R. Smith 4140-F-C, Zurn ZN 1400-X-KC, Mifab C1100C-T-1-34, Watts CO-100-C-R-1-34G.

2.2.4. Cleanouts for carpeted areas shall be similar to cleanouts in finished areas but shall have stamped stainless steel carpet marker. Jay R. Smith 4020-Y, Zurn ZN 1400-CM, Mifab C1100-RC-1-34, Watts CO-100-C-R-1-34G.

2.3. NON-FINISHED AREAS

2.3.1. Cleanouts in non-finished areas shall be all coated cast iron body with heavy duty cast iron or ductile iron top. Jay R. Smith 4220-F-C, Zurn Z-1400-KC, Mifab C1100-XR-4-34, Watts CO-100-C-R-1-34G.

2.3.2. Cleanouts at the base of each vertical stack and rain water leader shall be either Daisy or Barrett type.

3. Execution

3.1. INSTALLATION

- 3.1.1. Cleanouts in furred ceiling spaces shall extend up through floor slab above, except where the Engineer's Representative gives specific approval to its location in the ceiling space.
- 3.1.2. Cleanouts shall be installed in horizontal drains at each change of direction and as required.

END OF SECTION

22 05 79.00 Service Connections

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.1.2. Arrange and pay for all service connections.

1.1.3. Include the cost of all service connections required for the gas, plumbing and drainage systems, including water meter, in the mechanical bid price.

1.2. WARRANTY

1.2.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. NOT USED

3. Execution

3.1. NOT USED

END OF SECTION

22 11 13.00 Pipes, Valves and Fittings (Plumbing System)

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings and/or catalogue cuts of all items supplied in accordance with requirements of Section 20 05 03.00 - SHOP DRAWINGS.

1.3. WARRANTY

1.3.1. Unless where indicated otherwise, provide a warranty in accordance with the requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Pipes and fittings shall be in accordance with the following unless specified otherwise by local authorities.

2.1.2. All valves on potable water systems shall be equal in performance to the models specified, shall be lead free or low lead meeting the requirements of CSA B125.3 "Plumbing fittings," CSA B125.14 "Manually operated valves for use in plumbing systems," NSF/ANSI 372 "Drinking Water System Components - Lead Content," NSF/ANSI 61 "Drinking Water System Components - Health Effects," NSF/ANSI 14 "Plastics Piping System Components and Related Materials," and/or ANSI/AWWA C550 "Protective Interior Coatings for Valves and Hydrants" as applicable.

2.1.3. All city and domestic water, above ground, 75 mm (3 in.) and smaller, less than 1380 kPa (200 psi) working pressure:

- .1 Pipe: Copper Tubing, Type "L", Hard Drawn, ASTM B88 "Standard Specification for Seamless Copper Water Tube." Fittings: wrought copper solder joint pressure fittings, ANSI/ASME B16.22 "Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings" or cast copper alloy solder joint pressure fittings, ANSI/ASME B16.18 "Cast Copper Alloy Solder Joint Pressure Fittings."
- .2 Joints made with 95-5 tin antimony, 96-6 tin silver, or 96-4 tin silver solder, ASTM B32 "Standard Specification for Solder Metal."
- .3 Grooved end copper fittings designed to accept grooved end couplings of the same manufacturer. Fittings shall be wrought copper or bronze casting, conforming to ASTM B75/B75M "Standard Specification for Seamless Copper Tube." Victaulic Copper Connection Fittings.
- .6 Couplings to be designed with angle bolt pads to provide a rigid joint.
 - .1 Installation ready for direct stab installation without field disassembly, complete with grade P fluoroelastomer gasket, rated for -18 deg. C. to 82 deg. C. (0 deg. F. to 180 deg. F.). Victaulic 607.

- .7 Stainless steel pipe may be used as an alternative material if acceptable to Local Authorities. Follow applicable codes for stainless steel pipe joints. Stainless steel pipe to conform to ASTM A312 "Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes." Stainless steel fittings to conform to ASTM A403 "Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings."
 - .1 Schedule 10 Type 304/304L to ASTM A312.
 - .8 Butterfly valves, bubble-tight service up to 2065 kPa (300 psi) with cast brass bronze body, aluminum-bronze disc, pressure-responsive grade P fluoroelastomer seat, and stainless steel stem. Victaulic 608N.
 - .9 Gate valves, 860 kPa (125 psi) WSP or 1380 kPa (200 psi) non-shock WOG with lead free bronze body, rising stem screwed. Kitz 827/828, Toyo 206A-LF/207A-LF, Apollo 101T-LF.
 - .10 Globe valves, 860 kPa (125 psi) WSP or 1380 kPa (200 psi) non-shock WOG with lead free bronze body, solder ends or with screwed to solder adapter and composition disc for water service. Kitz 811/812, Toyo 211A-LF/212A-LF, Apollo 120S-LF.
 - .11 Check valves 860 kPa (125 psi) WSP or 1380 kPa (200 psi) non-shock WOG with lead free bronze body, swing check, solder ends. Kitz 822/823, Toyo 236A-LF/237A-LF, Apollo 161S-LF.
 - .12 Non-slam check valves downstream from pumps, ANSI Class 150, 1032 kPa (150 psi) WSP pressure rating, dual flapper design with 316 stainless steel body and stainless steel check, renewable disc and resilient seat for flanged installation. Non-slam check valves shall be Velan-ProQuip Model DDD11-1D, Duo CHEK II H15CMF3-14, Mueller 72-HHH-3-H, or NCI/SSI 150WTTTV-T.
 - .13 Strainers shall be lead free bronze Y body equal to Mueller LF351.
 - .14 Drain valves and blow-off valves shall be 4137 kPa (600 psi) WG 19 mm (3/4 in.) ball valves with lead free, bronze body or forged brass body, solid ball, male threaded garden hose end, brass cap and chain equal to Watts B6000, Toyo 5046-LF, Kitz 868C or Apollo 78-100. Hose bibbs shall be for 860 kPa (125 psi) non-shock, bronze body with composition disc and 19 mm (3/4 in.) garden hose thread, complete with a ULC vacuum breaker.
 - .15 Pipe sizes 12 mm (1/2 in.) to 50 mm (2 in.) Schedule 10 Type 304/304L to ASTM A312/A312M "Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes."
 - .1 Vic-Press 304 ASTM A312 stainless steel housings with ASTM A276 "Standard Specification for Stainless Steel Bars and Shapes" and A312 outlets and austenitic stainless steel plain or grooved ends, type 304, complete with synthetic rubber Grade "H" (HNBR) seals rated for applicable services to 82 deg. C (180 deg. F).
- 2.1.4. All city and domestic water above ground 100 mm (4 in.) and larger, less than 1380 kPa (200 psi) working pressure.
- .1 Pipe: Copper Tubing, Type "L", Hard Drawn, ASTM B88 "Standard Specification for Seamless Copper Water Tube." Fittings: wrought copper solder joint pressure fittings, ANSI/ASME B16.22 "Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings" or cast copper alloy solder joint pressure fittings, ANSI/ASME B16.18 "Cast Copper Alloy Solder Joint Pressure Fittings."
 - .2 Domestic Cold Pipe: Copper Tubing, Type "L", Hard Drawn, ASTM B88 "Standard Specification for Seamless Copper Water Tube." Fittings: wrought copper solder joint pressure fittings, ANSI/ASME B16.22 "Wrought Copper and Copper Alloy Solder-Joint

- Pressure Fittings” or cast copper alloy solder joint pressure fittings, ANSI/ASME B16.18 “Cast Copper Alloy Solder Joint Pressure Fittings.”
- .3 Domestic Hot and Recirculation Pipe: Copper Tubing, Type “K”, Hard Drawn, ASTM B88 “Standard Specification for Seamless Copper Water Tube.” Fittings: wrought copper solder joint pressure fittings, ANSI/ASME B16.22 “Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings” or cast copper alloy solder joint pressure fittings, ANSI/ASME B16.18 “Cast Copper Alloy Solder Joint Pressure Fittings.”
 - .4 Joints made with 96-6 tin silver, or 96-4 tin silver solder, ASTM B32 “Standard Specification for Solder Metal.”
 - .5 Grooved end copper fittings designed to accept grooved end couplings of the same manufacturer. Fittings shall be wrought copper or bronze casting, conforming to ASTM B75/B75M “Standard Specification for Seamless Copper Tube.” Victaulic Copper Connection Fittings.
 - .8 Couplings to be designed with angle bolt pads to provide a rigid joint.
 - .1 Installation ready for direct stab installation without field disassembly, complete with grade P fluoroelastomer gasket, rated for -18 deg. C. to 82 deg. C. (0 deg. F. to 180 deg. F). Victaulic 607.
 - .9 Butterfly valves, bubble-tight service up to 2065 kPa (300 psi), with cast brass bronze body, aluminum-bronze disc, pressure-responsive grade P fluoroelastomer seat, and stainless steel stem.. Victaulic 608N.
 - .10 Stainless steel pipe may be used as an alternative material if acceptable to Local Authorities. Follow applicable codes for stainless steel pipe joints. Stainless steel pipe to conform to ASTM A312 “Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.” Stainless steel fittings to conform to ASTM A403 “Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.” Schedule 10 Type 304/304L to ASTM A312.
 - .1 Rigid type: Couplings to be designed with angle bolt pads to provide a rigid joint. Installation ready for direct stab installation without field disassembly, complete with grade P fluoroelastomer gasket, rated for -18 deg. C. to 82 deg. C. (0 deg. F. to 180 deg. F). Victaulic 807N.
 - .2 Flexible Type: For use in locations where vibration attenuation and stress relief are required or in a Victaulic riser design. Three flexible couplings may be used in lieu of a flexible connector. Flexible grooved couplings may be used where system flexibility is desired. Installation ready for direct stab installation without field disassembly, complete with grade P fluoroelastomer gasket, rated for -18 deg. C. to 82 deg. C. (0 deg. F. to 180 deg. F). Victaulic Style 877N.
 - .3 Butterfly valves, bubble-tight service up to 2065 kPa (300 psi), with stainless steel body, grade P fluoroelastomer seat. Victaulic 861.
 - .4 Check valves, Stainless steel body, grade P fluoroelastomer seat, stainless steel disc with spring loaded design for non slam operation. Victaulic Series 816.
 - .11 Gate valves, 860 kPa (125 psi) WSP or 1380 kPa (200 psi) non-shock WOG with ANSI/AWWA C550 “Protective Interior Coatings for Valves and Hydrants” coated iron body, lead free bronze mounted, outside screw and yoke, and flanged ends.
 - .12 Globe valves, 860 kPa (125 psi) WSP or 1380 kPa (200 psi) non-shock ANSI/AWWA C550 “Protective Interior Coatings for Valves and Hydrants” coated iron body, lead free bronze mounted, outside screw and yoke, flanged ends and composition disc for water service.
 - .13 Check valves 860 kPa (125 psi) WSP or 1380 kPa (200 psi) non-shock WOG with ANSI/AWWA C550 “Protective Interior Coatings for Valves and Hydrants” coated iron body, lead free bronze mounted, swing check, flanged ends.

- .14 Non-slam check valves downstream from pumps, 1032 kPa (150 psi) pressure rating, dual flapper design with 316 stainless steel body and stainless steel check, renewable disc and resilient seat for flanged installation. Non-slam check valves shall be Velan-ProQuip Model DDD11-1D1, Duo CHEK II H15CMF3-14, Mueller Sure Check #72-HHH-3-H, or NCI/SSI 150WTTTV-T.
 - .15 Strainers shall be lead free grooved or flanged ANSI/AWWA C550 "Protective Interior Coatings for Valves and Hydrants" coated cast iron Y body equal to Victaulic 968-F or Mueller #758.
 - .16 Drain valves and blow-off valves shall be 4137 kPa (600 psi) WG 19 mm (3/4 in.) ball valves with lead free, bronze or forged brass body, solid ball, virgin Teflon seat and packing, male threaded hose end, brass cap and chain equal to Watts B6000, Toyo 5046, Kitz 58CC or Apollo 78-100.
- 2.1.5. All domestic water above ground 75 mm (3 in.) and smaller, over 1380 kPa (200 psi) working pressure and under 2070 kPa (300 psi) working pressure:
- .1 Pipe: Copper Tubing, Type "L", Hard Drawn, ASTM B88 "Standard Specification for Seamless Copper Water Tube."
 - .2 Joints, brazed.
 - .3 Grooved end copper fittings designed to accept grooved end couplings of the same manufacturer. Fittings shall be wrought copper or bronze casting, conforming to ASTM B75/B75M "Standard Specification for Seamless Copper Tube." Victaulic Copper Connection Fittings.
 - .4 Couplings to be designed with angle bolt pads to provide a rigid joint.
 - .1 Installation ready for direct stab installation without field disassembly, complete with grade P fluoroelastomer gasket, rated for -18 deg. C. to 82 deg. C. (0 deg. F. to 180 deg. F). Victaulic 607.
 - .5 Stainless steel pipe is an acceptable alternative where accepted by authorities having jurisdiction. Follow applicable codes for stainless steel pipe joints. Stainless steel pipe to conform to ASTM A312 "Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes." Stainless steel fittings to conform to ASTM A403 "Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings."
 - .6 Butterfly valves, bubble-tight service up to 2065 kPa (300 psi) with cast brass bronze body, aluminum-bronze disc, pressure-responsive grade P fluoroelastomer seat, and stainless steel stem. Victaulic 608N.
 - .7 Gate valves, 1035 kPa (150 psi) WSP or 2070 kPa (300 psi) non-shock WOG, lead free bronze body solder ends or screwed to solder adapter. Kitz 827/828, Toyo 206A-LF/207A-LF.
 - .8 Globe valves, 1035 kPa (150 psi) WSP or 2070 kPa (300 psi) non-shock WOG, lead free bronze body solder ends or screwed to solder adapter, composition disc. Kitz 811/812, Toyo 211A-LF/212A-LF, Apollo 120S-LF.
 - .9 Check valves, 1380 kPa (200 psi) WSP or 2760 kPa (400 psi) non-shock WOG, lead free bronze body swing check, solder or screwed ends to solder adapters. Kitz 822/823, Toyo 236A-LF/237A-LF, Apollo 161S-LF.
 - .10 Non-slam check valves downstream from pumps, dual flapper design with stainless steel body, check, renewable disc and resilient seat for flanged installation equal to Velan Proquip 2070 kPa (300 psi) pressure rating model 4DD111, Duo CHEK II S-3 G30CPF 559, Mueller Sure Check #74-HHH-6-H, or NCI/SSI 150WTTTV-T.
 - .11 Strainers shall be lead free bronze Y body equal to Mueller LF352.

- .12 Drain valves and blow-off valves shall be 4137 kPa (600 psi) WG 19 mm (3/4 in.) ball valves with bronze or forged lead free brass body, solid ball, virgin Teflon seat and packing, male threaded hose end, cap and chain. Equivalent to Watts B6000, Toyo 5046-LF, Kitz 868C or Apollo 78-100.
- .13 Pipe sizes 12 mm (1/2 in.) to 50 mm (2 in.) Schedule 10 Type 304/304L to ASTM A312/A312M "Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes."
 - .1 Vic-Press 304 ASTM A312 stainless steel housings with ASTM A276 "Standard Specification for Stainless Steel Bars and Shapes" and A312 outlets and austenitic stainless steel plain or grooved ends, type 304, complete with synthetic rubber Grade "H" (HNBR) seals rated for applicable services to 82 deg. C (180 deg. F).
- 2.1.6. All domestic water 100 mm (4 in.) and larger, over 1380 kPa (200 psi) working pressure and under 3440 kPa (500 psi) working pressure:
 - .1 Pipe: Copper Tubing, Type "L", Hard Drawn, ASTM B88 "Standard Specification for Seamless Copper Water Tube." Fittings: wrought copper solder joint pressure fittings, ANSI/ASME B16.22 "Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings" or cast copper alloy solder joint pressure fittings, ANSI/ASME B16.18 "Cast Copper Alloy Solder Joint Pressure Fittings."
 - .2 Joints, brazed.
 - .3 Stainless steel pipe is an acceptable alternative on sizes 100 mm (4 in.) and over where accepted by authorities having jurisdiction. Follow applicable codes for stainless steel pipe joints. Stainless steel pipe to conform to ASTM A312 "Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes." Stainless steel fittings to conform to ASTM A403 "Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings."
 - .4 Gate valves, 1730 kPa (250 psi) WSP or 3440 kPa (500 psi) WOG non-shock, NSF/AWWA coated cast steel, half stelite, outside screw and yoke, flanged ends.
 - .5 Globe valves, 1730 kPa (250 psi) WSP or 3440 kPa (500 psi) WOG non-shock, NSF/AWWA coated iron body, lead free bronze mounted, outside screw and yoke, flanged ends, stainless steel seat and disc.
 - .6 Check valves, 1720 kPa (250 psi) WSP or 3440 kPa (500 psi) WOG, NSF/AWWA coated iron body lead free bronze mounted, swing check, flanged ends.
 - .7 Non-slam check valves downstream of pumps dual flapper design with stainless steel body, check, renewable disc and resilient seat for flanged installation equal to Velan Proquip 2069 kPa (300 psi) pressure rating Model 4DD111, DUO CHEK II, Mueller Sure Check 74-HHH-3-H, or NCI/SSI 150WTTTV-T.
 - .8 Strainers shall be extra heavy flanged cast iron Y body equal to Mueller #752.
 - .9 Drain valves and blow-off valves shall be 4137 kPa (600 psi) WOG, 19 mm (3/4 in.) ball valves with bronze or forged brass body, solid ball, virgin Teflon seat and packing, male threaded hose end, cap and chain. Equivalent to Watts B6000, Toyo 5046, Kitz 58CC or Apollo 78-100.
- 2.1.7. All city and domestic water, buried, 50 mm (2 in.) and smaller:
 - .1 Soft copper Type K conforming to ASTM B88 "Standard Specification for Seamless Copper Water Tube."
 - .2 Minimum number of joints brazed using BCuP-3 alloy with 5% silver, 89% copper, and 6% phosphorus.
 - .3 Gate valves, bronze body, non-rising stem, extension sleeve and box to grade, to local authorities' approval.

- 2.1.8. All city and domestic water, buried, 65 mm (2-1/2 in.) and larger:
- .1 Copper pipes Type L with wrought or cast couplings and fittings conforming to ASTM B88 "Standard Specification for Seamless Copper Water Tube," etc.
 - .2 Joints brazed using BCuP-3 alloy with 5 % silver, 89 % copper, and 6 % phosphorus.
 - .3 Alternate for underground pipe; cast or ductile iron coated to AWWA.
 - .4 Gate valves, AWWA iron body, non-rising stem, extension sleeve and box to grade, to local authorities' approval.
- 2.1.9. For storm and sanitary drains and vents above ground, provide cast iron or copper pipe installed as in regulations; except where copper pipe is used, make joints with 95-5 solder. ABS and asbestos cement (Transite) pipes are not acceptable.
- .1 For cast iron pipe fittings on sanitary and storm, provide fittings equal to Bibby-Ste-Croix Husky SD 4000 heavy duty fittings in the following areas:
 - .1 Between P1 and XXXX Floor.
 - .2 All vertical to horizontal pipe connections.
 - .3 All joints in the Lobby and other amenity areas.
 - .4 Horizontal to horizontal connections within 3 m of the vertical to horizontal connection.
 - .2 For cast iron pipe fittings on vents, provide fittings equal to Bibby-Ste-Croix Husky SD 4000 heavy duty fittings in the following areas:
 - .1 Horizontal offsets between the roof penetration and the normally vertical vent stack where vents penetrate sloped roofs.
 - .2 The first two (2) couplings or fittings below the roof penetration where vents penetrate sloped roofs.
 - .3 Do not provide unshielded couplings.
- 2.1.10. Storm and sanitary drains and vents, not buried, inside the building, to CSA B1800 "Thermoplastic nonpressure piping compendium":
- .1 Provide PVC DWV pipe and fittings manufactured by IPEX or engineer reviewed equivalent. Provide Products from one manufacturer throughout the Project.
 - .2 For retail spaces: IPEX System XFR PVC DWV Schedule 40 pipe and fittings, meeting flame-spread rating not more than 25, and smoke developed classification not more than 50, both per CAN/ULC-S102.2, with pipe manufacturer's approved solvent weld joints or pipe manufacturer's approved mechanical joint couplings. Do not provide unshielded mechanical joint couplings.
 - .3 For Buildings that are not classified as High Buildings, except for retail spaces: IPEX System 15 PVC DWV Schedule 40 pipe and fittings, meeting flame-spread rating not more than 25, per CAN/ULC-S102.2 "Standard Method of Testing for Surface Burning Characteristics of Flooring, Floor Coverings, and Miscellaneous Materials and Assemblies," with pipe manufacturer's approved solvent weld joints or pipe manufacturer's approved mechanical joint couplings. Do not provide unshielded mechanical joint couplings.
 - .4 For High Buildings or for inside air plenums: IPEX System XFR PVC DWV Schedule 40 pipe and fittings, meeting flame-spread rating not more than 25, and smoke developed classification not more than 50, both per CAN/ULC-S102.2, with pipe manufacturer's approved solvent weld joints or pipe manufacturer's approved mechanical joint couplings. Do not provide unshielded mechanical joint couplings.
- 2.1.11. Where localized spill containment is required for liquid filled transformers, provide welded Schedule 40 steel piping from the floor drain to the oil sump.

- .1 Provide Fernco Flexible Chemical Coupling between drain and piping system, rated for a maximum temperature as follows:
 - .1 100 deg. C (212 deg. F) consistent
 - .2 130 deg. C (266 deg. F) intermittent
- 2.1.12. Vent stack covers:
 - .1 1100-0T alloy aluminum with vandal proof removable cap
 - .2 EPDM base seal
 - .3 PVC coated deck flange or bituminous deck flange as required to suit roof membrane
 - .4 Insulated for inverted steel roof construction with insulation on top of deck
 - .5 Uninsulated for concrete roof construction
 - .6 Uninsulated: Thaler Metal Industries SJ-34/SJ-35/SJ-36
 - .7 Insulated: Thaler Metal Industries SJ-37/SJ-38/SJ-39
- 2.1.13. Buried storm and sanitary inside the building shall be Class 4000 grey cast iron soil pipe, black bituminous coating, fittings and means of joining to meet the requirements of CSA B70 "Cast iron soil pipe, fittings, and means of joining." Mechanical couplings for drain, waste, vent pipe and sewer pipe to meet the requirements of CSA B602 "Mechanical couplings for drain, waste, and vent pipe and sewer pipe." Bituminous fibre, vitrified clay, ABS and PVC pipe are not acceptable.
- 2.1.14. Buried storm and sanitary inside the building shall be SDR 28 rigid for 100 mm (4 in.) to 150 mm (6 in.), SDR 35 for 200 mm (8 in.) and larger, green PVC gasketed hub and spigot pattern sewer pipe and injection molded and fabricated gasketed fittings to meet the requirements of CSA B182.2 "PSM type polyvinylchloride (PVC) sewer pipe and fittings" assembled with PVC pipe lubricant.
- 2.1.15. Buried storm and sanitary, inside the building: PVC DWV Schedule 40 to CSA B1800 "Thermoplastic nonpressure piping compendium."
- 2.1.16. All embedded pipe and materials in parking structures and ramps shall meet the requirements of CSA S413 "Parking Structures" for corrosion resistant materials or shall have a corrosion resistant coating.
- 2.1.17. Sump and sewage pump discharge, non potable, buried:
 - .1 Type "L" copper, brazed; or
 - .2 Schedule 80 PVC pressure piping conforming to CSA B137.3 "Rigid polyvinylchloride (PVC) pipe and fittings for pressure applications."
- 2.1.18. Butterfly valves may be used in lieu of gate valves in size 65 mm (2-1/2 in.) and over in systems 1380 kPa (200 psi) and less. Where specifically shown on Drawings, butterfly valves must be used. Install between 860 kPa (125 psi) flanges.
 - .1 Valves shall have NSF/AWWA coated iron body, one piece or split alloy steel shaft, top and bottom bearings, lead free bronze disc or coated iron disc with stainless steel trim and resilient elastomer replaceable seat with integral reinforcing ring or keyed to body.
 - .2 Body shall have threaded lugs.
 - .3 Valve shall have bubble tight shut-off to 1035 kPa (150 psi) pressure in either direction when the piping and connecting flange is removed from one side of the valve.
 - .4 Valves 100 mm (4 in.) and smaller shall have lever operator with lock.
 - .5 Valves larger than 100 mm (4 in.) shall have worm gear manual operator with indication of valve opening.

- .6 Butterfly valves for grooved end systems shall be Victaulic 608N for copper and Victaulic 861 for stainless steel.
- 2.1.19. Backflow Preventers – Reduced Pressure Back Flow Preventer:
 - .1 Reduced pressure zone assemblies to prevent the reverse flow of polluted water from entering into the potable water supply due to back-siphonage and or backpressure.
 - .2 Lead Free bronze body construction (1/4 to 2 in.).
 - .3 Lead Free epoxy coated ductile or cast iron (2 1/2 to 10 in.).
 - .4 Two, in-line independent check valves, replaceable check seats with an intermediate relief valve, and ball valve test cocks.
 - .5 Maximum Working Pressure: 1207 kPa (175 psi).
 - .6 BEECO FRP, Zurn-Wilkins 975XL2/375A or Watts LF009/LF909 Series.
- 2.1.20. Ball valves 50 mm (2 in.) and smaller shall be lead free, bronze body or forged brass 4137 kPa (600 psi) WOG, virgin Teflon seat, TFE stem packing and thrust washer, 1/4 turn open-closed operation with solid ball. Ball valves shall be Watts No. LFB-6000, Toyo 5044A-LF/5049A-LF, Kitz 858/859, Apollo 70LF-100/200, or NCI 600FP-T/S. Stem extensions shall be provided on all ball valves. Ball valves may be substituted for gate valves only.
- 2.1.21. Except where special features are required or unless otherwise approved or noted, all valves shall be of one manufacturer with the manufacturer's name and the pressure rating clearly marked on the outside of the valve body.
- 2.1.22. Pressure Reducing Valves:
 - .1 For all sizes of grooved piping, provide pressure reducing valves equal to Victaulic Series 386-SB single branch pressure reducing valve stations with integral low flow bypass. For single stage pressure reducing valves, provide valves equal to Victaulic 386A-SB. For two stage pressure reducing valve stations, provide valves equal to Victaulic 386B-SB. Provide valves at capacity shown in PRV Schedule and with a pressure drop not exceeding 69 kPa (10 psi) under full flow. Provide valves that maintain downstream pressure within a range of plus or minus 35 kPa (5 psi). Provide required outlet pressure, inlet pressure, and flow rate as shown. Alternate manufacturers will not be accepted.
 - .1 Provide pressure reducing station that is complete with inlet and outlet isolation valve, strainer, and pressure reducing valve with integral low flow by-pass.
 - .2 For 65 mm (2-1/2 in.) and larger, non grooved, provide Cla-Val 90-01 or equal with capacity shown and a pressure drop not exceeding 69 kPa (10 psi) under full flow. Provide valve that maintains downstream pressure within a range of plus or minus 35 kPa (5 psi). Provide required outlet pressure, inlet pressure and flow rate as shown. Alternate manufacturers will not be accepted.
 - .1 Provide valve that maintains a constant downstream pressure regardless of fluctuations in demand and that also prevents a pressure rise when demand is zero.
 - .2 Provide valve that is single-seated, hydraulically operated, pilot controlled diaphragm type globe valve. Provide valve stem that is top and bottom guided and actuated by a resilient diaphragm. Provide cast iron, flanged valve body and cover. Provide bronze trim. Provide replaceable valve seat. Do not provide external packing glands. Provide valve that is NSF/ANSI 61 "Drinking Water System Components - Health Effects" and NSF/ANSI 372 "Drinking Water System Components - Lead Content" compliant.
 - .3 Provide pilot control that is a direct acting, adjustable, spring-loaded valve with bronze body and stainless steel trim.

- .4 Factory assemble main valve, pilot control valve, and all trim into one unit.
- .5 Provide valve that is Class 125 for low pressure systems less than 1380 kPa (200 psi) working pressure and Class 250 for high pressure systems greater than 1380 kPa (200 psi) working pressure.
- .6 See Drawing for capacities and operating pressures.
- .7 For isolation valves, provide full port ball valves for 64 mm (2-1/2 in.) and smaller and butterfly valves for 76 mm (3 in.) and larger.
- .8 For combination pressure reducing and check valve, provide Cla-Val 90-01-D and as specified for the pressure reducing valve, but with a check valve and isolation valve.
- .3 50 mm (2 in.) and smaller: Threaded lead free water pressure reducing valve and integral strainer, suitable for 2068 kPa (300 psi) incoming pressure with downstream pressure adjustable range from 172 to 517 kPa (25 psi to 75 psi). Provide thermal expansion by-pass check valve that allows water to flow back to main when the downstream pressure exceeds setpoint.
 - .1 Materials:
 - .1 Lead free copper silicon alloy body
 - .2 Sealed spring cage with stainless steel fasteners
 - .3 High temperature reinforced diaphragm
 - .4 Replaceable seat
 - .5 Stainless steel strainer
 - .2 Acceptable Manufacturers:
 - .1 Watts LFU5B-Z3 Cash Acme E3 See Drawings for capacities and operating pressures.
- 2.1.23. Backwater valves for services larger than 100 mm (4 in.) shall be by Jay R. Smith. Valves shall be complete with cast iron body and bolted cover, plain end inlet and outlet, bronze flap and bronze valve seat. Valve shall be normally open.
 - .1 Unit up to 300 mm (12 in.) underground, shall be complete with access cover at grade and extension sleeve between cover and valve casing.
 - .2 Unit more than 300 mm (12 in.) underground, shall be complete with minimum 600 mm (24 in.) dia. galvanized steel, concrete or vitrified clay tile access pit with 600 mm (12 in.) dia. heavy duty scoriated manhole cover and frame.
- 2.1.24. Provide extendable backwater valve complete PVC extendable valve body and normally open cassette for services 100 mm (4 in.) and smaller. Extend to grade with PVC DWV pipe and provide 19 mm (3/4 in.) cassette pipe extension to grade for cassette retrieval. Provide cleanout access suitable for floor finish in accordance with Section 22 05 76.00 - CLEANOUTS. Backwater Valve shall be Mainline Adapt-A-Valve Model ML-#XP to suit size of drain.
- 2.1.25. Water hammer arresters shall be stainless steel bellows type and shall bear the Plumbing and Drainage Institute seal of approval. JR Smith 5000 Series, Zurn Z1700, Mifab WHB, Watts SS Series. Piston type are not permitted.

- 2.1.26. Exterior site sewers shall be PVC non-pressure, SDR 28, cement, or concrete of class and type to suit depth of trench and bedding. PVC non-pressure sewer piping shall be IPEX for sizes 100 mm (4 in.) to 150 mm (6 in.) conforming to CSA B182.1 "Plastic drain and sewer pipe and pipe fittings" and ASTM D3034 "Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings." For sizes 200 mm (8 in.) to 375 mm (15 in.) shall be IPEX conforming to CSA B182.2 "PSM type polyvinylchloride (PVC) sewer pipe and fittings" and ASTM D3034. For size 450 mm (18 in.) to 1200 mm (48 in.) shall be IPEX conforming to CSA B182.4 "Profile polyvinylchloride (PVC) sewer pipe and fittings" and ASTM F794 "Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter." Sewers shall be laid in accordance with manufacturer's written instructions and in accordance with regulatory requirements.
- 2.1.27. Exterior site PVC pressure piping shall be IPEX Blue Brute conforming to AWWA C900 "Polyvinyl chloride (PVC) pressure pipe and fabricated fittings, 4 in. through 60 in. (100 mm through 1,500 mm)" and CSA B137.3 "Rigid polyvinylchloride (PVC) pipe and fittings for pressure applications" standards laid in accordance with the manufacturer's written instructions and in accordance with regulatory requirements.
- 2.1.28. Exterior site PVC pressure piping expansion joints for differential settlement and seismic movement:
- .1 Manufactured of ductile iron conforming to the material requirements of ASTM A536 "Standard Specification for Ductile Iron Castings" and ANSI/AWWA C153/A21.53 "Ductile-iron Compact Fittings for Water Service."
 - .2 Pressure test each flexible expansion joint prior to shipment against its own restraint to a minimum of 2413 kPa (350 PSI) for 76 mm (3 in.) through 406 mm (16 in.) and 1724 kPa (250 PSI) for 457 mm (18 in.) and larger. Provide a minimum 2:1 safety factor, determined from the published pressure rating.
 - .3 Provide flexible expansion joints that consist of an expansion joint designed and cast as an integral part of a ball and socket type flexible joint, having a minimum per ball deflection of: 20° for sizes 102 mm (4 in.) through 305 mm (12 in.); 15° for sizes 356 (14 in.) through 914 mm (36 in.) and 12° for size 1219 mm (48 in.). Provide flexible expansion fitting that does not expand or exert an axial imparting thrust under internal water pressure. Provide flexible expansion fitting that does not increase or decrease the internal water volume as the unit expands or contracts. Provide minimum total linear travel of 203 mm (8 in.).
 - .4 Line all internal surfaces (wetted parts) with a minimum of 15 mils of fusion bonded epoxy conforming to the applicable requirements of ANSI/AWWA C213 "Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings." Provide EPDM sealing gaskets. Provide coatings that meet NSF/ANSI/CAN 61 "Drinking Water System Components."
 - .5 Coat exterior surfaces with a minimum of 6 mils of fusion bonded epoxy conforming to the applicable requirements of ANSI/AWWA C116/A21.16 "Protective Fusion-Bonded Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings."
 - .6 Include polyethylene sleeves, meeting ANSI/AWWA C105/A21.5 "Polyethylene Encasement for Ductile-Iron Pipe Systems" for direct buried applications.
 - .7 Provide manufacturer's certification of compliance to the above standards and requirements.
 - .8 Provide flexible expansion joints: Force Balanced FLEX-TEND or Victaulic 257 Dynamic Movement Joint.
- 2.1.29. Manual flow balancing valves up to 2 in. (50.8 mm): Victaulic TA Series 790 on domestic water recirculation system.
- 2.1.30. Thermostatic mixing valves

- .1 Thermostatic mixing valves shall be Lawler Series 801 (19 mm (3/4 in.) inlet and 25 mm (1 in.) outlet) High-Low Water Mixer combination thermostatic and pressure balanced water controller, liquid filled motor. The valve shall maintain output temperature for changes in inlet pressure and temperature. Valve construction shall be bronze body and stainless steel piston and liner. Mixing valve shall include a union end stop and check valve with removable strainer on each inlet. Complete with 0 - 200 deg. F. dial thermometer and shut off valve on tempered water outlet.

2.2. FLUSHING AND DISINFECTING:

2.2.1. Chlorine:

- .1 Sodium hypochlorite to ANSI/AWWA B300 "Hypochlorites."

3. Execution

3.1. INSTALLATION

- 3.1.1. Valves shall be provided as shown and as required for the satisfactory operation and control of all equipment and shall be installed to enable each piece of equipment to be isolated.
- 3.1.2. Isolation valves shall be installed at the base of each riser and at each branch take-off. Where the equipment is to be isolated within easy view of and not more than 6000 mm (20 ft.) from the main, at the branch take-off, then the branch take-off valve may serve as the equipment isolating valve.
- 3.1.3. Drain valves shall be installed at each low point in the piping systems and at each tank.
- 3.1.4. Blow-off valves shall be provided on each 65 mm (2-1/2 in.) strainer and larger.
- 3.1.5. Globe valves shall be installed as shown and in each bypass.
- 3.1.6. Install manual flow balancing valves where shown on the Drawings or where required.
- 3.1.7. Install automatic flow balancing valves where shown on the Drawings or where required.
- 3.1.8. Where combined domestic water and fire protection services are provided, provide master isolation supervised shut off valve. Refer to Section 21 13 00.00 – SPRINKLER SYSTEMS for valve specifications.
- 3.1.9. Install building premise isolation back flow prevention as required by CSA B64.
- 3.1.10. Install reduced pressure backflow preventers where required by CSA B64 and in the following locations:
 - .1 Chilled water systems make-up
 - .2 Heating water systems make-up
 - .3 Glycol systems make-up (where provided)
 - .4 Laboratory sink supply systems, both hot and cold water
 - .5 Fume hood plumbing systems
 - .6 RO and other systems not used as potable water
 - .7 Upstream of all trap seal primer assemblies unless the trap seal primer assembly includes a 1" air gap, or other device suitable for Severe Hazard sources
 - .8 Where shown on the Drawings
 - .9 As requested by the Authority Having Jurisdiction
- 3.1.11. Install check valves as shown, and as required by the Authority Having Jurisdiction.

- 3.1.12. Buried piping shall be of a class and type and laid in a bedding as noted and/or as recommended by the manufacturer and any Authority Having Jurisdiction. Class of pipe and bedding shall take into consideration location, size of pipe, type, width and depth of trench and type of soil.
- 3.1.13. The following publications shall be used to establish class of bedding and class of piping for installation other than the above. They shall also serve as guide for preparation of bedding, installation and testing.
- .1 Cast Iron Soil Pipe and Fittings Handbook of the Cast Iron Soil Pipe Institute.
 - .2 Sewer pipe manual of Canron.
 - .3 Sewer Design & Construction of the Water Pollution Control Federation.
 - .4 The Blue Brute and Ring Tite PVC gravity sewer pipe installation Guide by Manville.
- 3.1.14. Pipe passing under a driveway or parking lot with less than 1.5 m (5 ft.) of cover shall be encased in 150 mm (6 in.) of 13800 kPa (2000 psi) concrete on top, bottom and sides.
- 3.1.15. Provide thrust blocks of 20 MPa (3000 psi) concrete at each tee, elbow, valve and other fitting where thrust forces could occur. Thrust blocks shall be sized to suit the local authorities' requirements, but in no case be smaller than 150 mm (6 in.) greater on all sides than the pipe served.
- 3.1.16. PC4 jointing material shall not be used on buried piping. PC4 or similar jointing material shall be used for caulking waste pipes from sinks or dishwashers and other waste pipes carrying hot discharge liquids.
- 3.1.17. Connections between copper and steel pipe shall be made with brass or bronze fittings where other type of connection is not specified in regulations.
- 3.1.18. All piping shall run parallel with closest wall.
- 3.1.19. Piping in walk-in pipe spaces shall be installed as close to one wall as possible.
- 3.1.20. Each water hammer arrester shall be accessible for service and replacement. They shall be installed in compliance with the recommendations of the Plumbing and Drainage Institute as found in Standard PDI-WH 201 "Water Hammer Arresters." The water pressure at fixture level on the first floor is 550 kPa (80 psig).
- 3.1.21. Slope all drains and vents in accordance with the Plumbing Code but not less than the minimum slopes shown on the Drawings. Slope all water lines 25 mm in 12 m (1 in. in 40 ft.) unless shown otherwise.
- 3.1.22. Install vent piping in accordance with requirements of the authority having jurisdiction.
- 3.1.23. Vent stack covers shall be properly sized for each vent penetrating the roof. Division 23 shall supply vent stack covers for installation and flashing by the Roofing Contractor.
- 3.1.24. Provide bird screen on all vents terminating horizontally, with a gooseneck or other configurations where a vent stack cover is not provided.
- 3.1.25. Securely attach vent piping to the building structure immediately below the roof deck and above the first coupling where vents penetrate sloped roofs.
- 3.1.26. Refer to Section 22 63 53.00 - LABORATORY LIQUID SYSTEMS.
- 3.1.27. Provide an isolation valve downstream of all flow balancing valves on the domestic water distribution.
- 3.1.28. Provide all mechanical piping and fittings within the cistern. Rainwater cistern floating device shall intake water 150 mm below the water surface and shall ensure that the foot valve is always submerged.
- 3.1.29. Provide a thermostatic mixing valve on discharge of domestic hot water systems.

- 3.1.30. Grooved pipe ends shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove for proper gasket sealing. All grooved Products to be from a single manufacturer. All couplings shall meet the manufacturer's standards for visual inspection. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Install in accordance with manufacturer's latest recommendations. A manufacturer's factory trained representative shall periodically visit the site and review the installation for best practices. The Contractor shall correct any identified deficiencies. Grooved Product that has been examined and has not met the visual inspection criteria for proper installation must be corrected and re-examined by the manufacturer prior to the completion of the Work.
- 3.1.31. Install flexible expansion joints in the locations indicated on the Drawings and as required by piping manufacturer.
- 3.1.32. Where site servicing expansion joints are required, provide signed and sealed engineered drawings for review and record.
- 3.1.33. Main Incoming Domestic Cold Water Filtration:
- .1 Insulate per manufacturer's written recommendations.
 - .2 Pipe backwash flush connection to nearest drain using an indirect connection.
- 3.1.34. Do not install combustible (e.g. PVC, etc.) piping in a vertical service space.
- 3.2. FLUSHING AND DISINFECTING
- 3.2.1. Flush and disinfect all new or reworked domestic water piping, ensure water flows through all fixtures, hose outlets, service connections and/or any other potable water outlet. Remove sediment from aerators as required.
- 3.2.2. Provide circulating pumps, connections and valves as required for complete flushing and disinfection of the system.
- 3.2.3. When flushing is complete, disinfect the piping with a solution of chlorine in accordance with ANSI/AWWA C651 "Disinfecting Water Mains."
- 3.2.4. Test water samples from disinfected water system at a certified laboratory for purity and conformance with governing standards.
- .1 Submit a copy of the test results prior to building occupancy.

END OF SECTION

22 11 23.29 Circulators

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings and/or catalogue cuts of all items supplied in accordance with requirements of Section 20 05 03.00 - SHOP DRAWINGS.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Circulators, in the line type with flanged inlet and outlet, mechanical seal and suitable for 125 psig working pressure from:

- .1 Armstrong
- .2 Grundfos-Paco
- .3 Xylem Bell & Gossett
- .4 Patterson Pump Company
- .5 Taco Industries
- .6 Wilo

2.1.2. For domestic water systems (potable) pump body shall be lead free bronze or stainless steel with impeller meeting the low lead requirements of NSF/ANSI/CAN 372 "Drinking Water System Components - Lead Content" for all wetted parts.

2.1.3. All systems except domestic water pump shall be cast iron, steel impeller and stainless steel shaft.

2.1.4. Pump capacity shall be as shown in the Pump Schedule.

3. Execution

3.1. INSTALLATION

3.1.1. Support pump as shown on Standard Details.

END OF SECTION

22 13 19.13 Floor Drains

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings and/or catalogue cuts of all items supplied in accordance with requirements of Section 20 05 03.00 - SHOP DRAWINGS.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Floor drains shall be Jay R. Smith, Mifab, Watts, or Zurn.

2.2. FINISHED AREAS

2.2.1. Floor drains in finished areas shall be all coated cast iron body, flashing clamp with seepage openings and adjustable 127 mm (5") diameter nickel bronze 6.35 mm (1/4") thick strainer, secured with SS screws, 100 mm (4") throat on strainer. Drain shall be complete with trap primer connection. Jay R. Smith 2005A05NB-P050, Zurn ZN-415-B5, Mifab F1100C-5-1, Watts FD-100-C-A5-1.

2.2.2. Floor drains in finished areas and stainless steel top shall be all coated cast iron body, flashing clamp with seepage openings and adjustable 127 mm (5") diameter stainless-steel heavy duty strainer with No. 4 satin finish, secured with SS screws, 100 mm (4") throat on strainer. Drain shall be complete with trap primer connection. Jay R. Smith 2005-A05SS-P050, Zurn ZXSS-415-A5, Mifab F1000C-5-3, Watts FD-1100-C-5-3.

2.2.3. Floor drains in quarry or mosaic tiled areas shall be similar to floor drains in finished areas but with 127 mm x 127 mm (5" x 5") square nickel bronze strainer. Jay R. Smith 2005-B05NB-P050, Zurn ZN-415-Y5, Mifab F1100C-S5-1, Watts FD-100-C-L5-1.

2.2.4. Floor drains in quarry or mosaic tiled areas and stainless steel top shall be similar to floor drains in finished areas but with 127 mm x 127 mm (5" x 5") square stainless-steel strainer with No. 4 satin finish. Jay R. Smith 2005-B05SS-P050, Zurn ZS-415-Y5, Mifab F1000C-S5-3, Watts FD-1100-C-L5-3.

2.2.5. Funnel floor drains in finished areas shall be similar to floor drains in finished areas but with minimum nominal 127 mm (5") dia. strainer, full opening for funnel and nominal 75 mm x 225 mm (3 in. x 9 in.) oval funnel. Jay R. Smith 2005-A05-NB-3591-OT-P050, Zurn ZN-415-BF, Mifab F1100C-EG-1, Watts FD-100-C-EG-1.

2.2.6. Floor drains in Safety Sheet Vinyl Flooring Areas shall be similar to floor drains in finished areas but with 2-piece flashing clamp collar. Jay R. Smith 2051, Zurn ZN-415-R9, Mifab F1100C-FC9-1, Watts FD-100-C-FC9-1.

- 2.2.7. Hub drains shall be similar to floor drains in finished areas but with cast iron hub. Jay R. Smith 2005-2645, Zurn Z-415-S, Mifab F1100C-DD-50, Watts FD-100-DD-50.
- 2.3. NON-FINISHED AREAS
- 2.3.1. Floor drains in non-finished areas: coated cast iron body, drainage flange, adjustable nominal 200 mm (8 in.) dia. heavy-duty strainer and complete with trap primer connection. Jay R. Smith 2110, Zurn Z-536-8, Mifab F1320C-4, Watts FD320-4.
- 2.3.2. Funnel floor drains in non-finished areas: similar to floor drains in non-finished areas but with nominal 75 mm x 225 mm (3 in. x 9 in.) oval funnel. Jay R. Smith 2110-3591, Zurn Z-536-8-F0, Mifab 1320C-4-G-50, Watts FD320-4-G-50.
- 2.3.3. Plenum drains (Plenum Floor Drains) for use in suspended sheet metal plenums: 225 mm (9 in.) overall dia. strainer with screwed attachment for sheet metal pan. Jay R. Smith SQ-4-1753-SM, Zurn ZN-211-R9, Watts FD-200-FC9-1.
- 2.3.4. Floor drains in floating floor areas: cast iron body, drainage flange, nominal 200 mm (8 in.) dia. heavy-duty strainer, movement compensator and vibration isolator. Jay R. Smith 9340, Zurn Z-556-FS, Mifab F1600C-4, Watts FD-620-C.
- 2.3.5. Funnel floor drains in floating floors: similar to floor drains in floating floors but with nominal 75 mm x 225 mm (3 in. x 9 in.) oval funnel. Jay R. Smith 9340-3591, Zurn Z-556-FS-F0, Mifab F1600C-4-G-50, Watts FD-620-C-G-50.
- 2.3.6. Floor drains in transformer vaults: coated cast iron or steel body, with heavy duty 300 mm x 300 mm (12 in. x 12 in.) tractor grate, body grounding screw, side outlet connection, bronze backwater valve/flame arrestor assembly and gasketed internal cleanout cover. Jay R. Smith 2235 EVFAHQ, Zurn ZZ-HQ-605-1-HVV, Mifab F1560-4-8-GS, Watts FD-460-F-9-46-4.
- 2.3.7. Floor drains in parking structures and ramps: to the requirements of CSA-S413 "Parking Structures" for materials and corrosion resistance and with double drainage, anti-ponding top, sediment bucket and membrane clamp. Supply drain complete with membrane extension as required. Jay R. Smith SQ-2-2347, Zurn Z-535, Mifab F1510-CSA, Watts FD-490-F-80.
- 2.3.8. Garage floor drains at slab on grade: heavy duty, coated cast iron, with heavy duty 300 mm x 300 mm (12 in. x 12 in.) tractor type grate and sediment bucket. Non-adjustable drainage flange with clamp where moisture proof membrane is installed. Jay R. Smith SQ-2-1717-B, Zurn Z-610-H-Y, Mifab F1440C-4-5, Watts FD-460-A-C-4-5.
- 2.3.9. Garage floor drains at slab on grade: heavy duty, coated cast iron, with heavy duty 300 mm x 300 mm (12 in. x 12 in.) tractor type grate and sediment bucket. Adjustable drainage flange to suit topping depths with clamp where moisture proof membrane is installed. Jay R. Smith SQ-2-1717-ADJ-B, Zurn Z-610-H-ADJ-Y, Mifab F1440C-4-5, Watts FD-460-AF-C-4-5.
- 2.3.10. Catch basin floor drains: heavy duty coated top with coated steel sump, side outlet for sand storage and 600 mm x 600 mm (24 in. x 24 in.) tractor grate. Jay R. Smith 8930-M, Zurn ZF-799-75-AF, Mifab 1570, Watts FD-410.
- 2.3.11. Trench drain systems shall be precast polymer concrete, nominal 125 mm (5 in.) wide sloped modular system with interlocking components and extra heavy-duty class "E" ductile iron grates and integral channel rail frame, catch basin, foul air trap as required. Provide minimum 100 mm (4 in.) bedding of concrete around trench. Jay R. Smith 9895, ACO S100K.
- 2.3.12. Trench drain shall be all stainless-steel body, frame and grate. Grate shall be nominal 150 mm (6 in.) and designed for class "E" traffic loading. Jay R. Smith SQ-2-1744-SS-M, Zurn Z890-SBG.
- 2.3.13. Elevator pit drains: Vertical wall or angled scupper drain, coated cast iron body, secured cast iron grate, clamping collar. Zurn Z187 or Z629-C-LV, Jay R. Smith 1510 or 2090-C, Mifab R1310-50, Watts RD-270-50.

- 2.3.14. Electronic automatic trap seal primer system with 12 mm (1/2 in.) connection, complete with integral ball valve and CSA B64 backflow prevention to the requirements of the Authority Having Jurisdiction. Pre-pipe the unit with a copper manifold and distribution system suitable for the number of drains served. Provide electrical components with a single point power connection at 120 V. Include with unit a manual override switch and 24-hour timer with relay and adjustable delay. Factory assemble all components and install into a coated steel box with access door for surface mounted installation. Mifab MI 100-UA series; Zurn Z1020 series; Precision Plumbing Products PT Series; or Smith Fluid Controls 270/271/272 Series.
- 2.3.15. Where acceptable to the Authority Having Jurisdiction, provide trap seal protection device in lieu of hydronic. Trap seal protection is permitted in the following locations:
- .1 .
 - .2 Trap Guard Pro Vent System, preassembled inline floor drain trap sealer, commercial grade ABS housing and proprietary neoprene diaphragm with soft rubber sealing gasket, ASSE 1072 "Performance Requirements for Barrier Type Trap Seal Protection for Floor Drains" AF-GW rating or approved equal. Install in accordance with manufacturer's recommendations.
 - .3 The use of a trap seal protection device does not negate the requirement for the installation of a trap.
- 2.4. LOCATED OUTSIDE OF THE BUILDING ENVELOPE
- 2.4.1. Trench drains located outside of the building envelope: pre-sloped trench drain system with ductile iron frame, nominal 150 mm (6 in.) wide sloped modular system with interlocking components and extra heavy-duty class "F" ductile iron grates and integral channel rail frame and catch basin. Provide minimum 100 mm (4 in.) bedding of concrete around trench. Acceptable materials include precast polymer concrete, polypropylene, and HDPE. Watts Dead Level D, Zurn Z886, or approved equivalent.
- 2.4.2. Trench drains located outside of the building envelope: pre-sloped trench drain system with ductile iron frame, nominal 300 mm (12 in.) wide sloped modular system with interlocking components and extra heavy-duty class "F" ductile iron grates and integral channel rail frame and catch basin. Provide minimum 100 mm (4 in.) bedding of concrete around trench. Acceptable materials include precast polymer concrete, polypropylene, and HDPE. Watts Dead Level DX, Zurn Z882, or approved equivalent.
3. Execution
- 3.1. INSTALLATION
- 3.1.1. Provide floor drains in air plenums on the suction and discharge side of fans with deep seal traps.
- 3.1.2. Provide electronic trap seal primer assemblies for all floor drain traps. Trap primer shall be installed at the nearest cold water served fixture or faucet, except drinking fountains.
- .1 Provide access to primer assembly for repair or replacement.
 - .2 Provide a globe valve on the water supply for regulation and shut-off.
 - .3 Where integral backflow prevention is not sufficient to meet the requirements of CSA B64, provide a reduced pressure backflow prevention device on the water supply to the trap seal primer in a suitable location and discharge piped to drain.
- 3.1.3. Provide a running trap and cleanout for each pit drain. For elevator pits provide an external backwater valve in accordance with Section 22 11 13.00 - PIPES, VALVES AND FITTINGS (PLUMBING SYSTEM).

- 3.1.4. Provide a backwater valve in accordance with Section 22 11 13.00 - PIPES, VALVES AND FITTINGS (PLUMBING SYSTEM) on floor drains within walk-in coolers before connecting to sanitary drainage system.

END OF SECTION

22 13 29.13 Sump Pumps

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings and/or catalogue cuts of all items supplied in accordance with requirements of Section 20 05 03.00 - SHOP DRAWINGS.

1.2.2. Ensure Shop Drawings include unit Short Circuit Current Rating (SCCR).

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Obtain flow tests to determine actual flow rates before ordering pumps.

2.1.2. Pump capacity shall be as shown in the Pump Schedule.

2.1.3. Vertical Column Sump Pumps

- .1 Sump pumps, duplex pumping unit with vertical shaft driven single stage pumps from:
 - .1 Armstrong
 - .2 Pentair - Aurora
 - .3 Grundfos - LaBour Taber
 - .4 Wilo
- .2 For sanitary drainage systems the inlet shall be open to the impeller and it shall be capable of handling typical sewage without clogging.
- .3 Pumps on sanitary sewer systems conveying solid waste shall be grinder type.
- .4 For storm and weeping tile drainage systems the inlet shall be complete with a screen over the impellor.
- .5 Shaft shall be rust-resistant alloy steel. Pump design shall permit easy adjustment of the impeller in the volute. Bearings shall be grease lubricated with grease fittings anchored on cover plates.
- .6 Provide intermediate bearings complete with lubrication lines for all pumps in pits over 1.5 m (5 ft.) deep. Provide intermediate couplings to facilitate pump removal in limited headroom conditions.

2.1.4. Submersible Pumps

- .1 Non-clog submersible pumps from:
 - .1 Leader (Barnes)

- .2 Liberty Pumps
 - .3 Grundfos – Chicago
 - .4 Xylem – Flygt
 - .5 Pentair – Hydromatic.
 - .6 Wilo
 - .2 Pumps shall be cast iron casing with heavy duty base bronze wear ring, two vane impeller, heavy duty ball bearings, double mechanical seals, stainless steel shaft and double epoxy potted and compression fitted power cord and control cord fittings.
 - .3 Pumps on sanitary sewer systems conveying solid waste shall be grinder type.
 - .4 Pump shall be complete with coupling kit and guide rail assembly to allow for pump removal without entering the pit. Provide chain on pump and hoisting ring in structure above for hoisting pump.
- 2.1.5. Controls
- .1 There shall be two float operated switching mechanisms.
 - .2 The switching mechanism connected to one of the floats shall be a mechanical alternator. Action of the alternator shall be to alternate the lead pump in sequential starts. The switching mechanism connected to the other float shall start both pumps should the water level rise above the operating level of the alternator float.
 - .3 There shall be a high water alarm switch complete with transformer and bell, and auxiliary contacts for wiring to the building BAS system.
 - .4 All controls shall be mounted in a CSA Type 3R control panel and shall be complete with all starters, power wiring, control wiring, hand-off-auto switch and LED pilot light for each pump, transformer and wiring to the alarm panel and shall require only a single power supply by the Electrical Division. All conduit shall enter from the bottom only.
 - .5 System shall bear a minimum Short Circuit Current Rating (SCCR) listed by a Nationally Recognized Testing Lab, acceptable to the local Authority Having Jurisdiction, and shall be 10,000 A Lower SCCR listed units implying the use of current limiting fuses ahead of them in the field, in lieu of an actual appropriate SCCR rating, are not acceptable.
- 2.1.6. Cover and Sump Pit
- .1 Pumps shall be mounted on/covered by a galvanized steel cover plate that shall be sufficiently strong and rigid to support the pump or pumps as required, pump accessories and service technician without vibration or deflection. An inspection cover shall be provided in the cover plate.
 - .2 A galvanized steel frame shall be provided for receiving the cover plate in a concrete sump. Frame shall include a gasketed recess dimensioned for the cover plate, stainless steel threaded studs and nuts for fastening the cover and concrete anchors welded on at approximately 450 mm (18 in.) centres.
 - .3 The size of the cover plate and frame shall be determined from the pit size shown on the Drawings.
 - .4 Gasket all openings in cover plate and frame.
 - .5 Provide frames and cover plates for sand traps and inspection pits. Material shall be as specified for main cover plate.
 - .6 Provide galvanized steel ladder rungs at 300 mm (12 in.) on centres for full depth of all pits.
- 2.1.7. Prefabricated Sump Pit

- .1 Provide pre-fabricated fibreglass sump pits as indicated on the Drawings. Fibreglass basin shall be as follows:
 - .1 Fabricated from commercial grade polyester with commercial grade continuous strand or continuous mat glass fibre with coupling agent.
 - .2 Wall thickness as necessary to withstand wall collapse or buckling based on hydrostatic loading of 62.4 lbs per cu. ft., a saturated soil weight of 120 lbs per sq. ft. and a soil modulus of 700 lbs per sq. ft. Wall thickness to meet the pipe stiffness values as specified in ASTM D3753 "Standard Specification for Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Manholes and Wetwells". Wet well Fiberglass Reinforced Plastic (FRP) laminate constructed to withstand or exceed two times the assumed loading on any depth of the wet well.
 - .3 Wet well top flange outside diameter of at least 4.0 inches greater than the inside diameter of the wet well with a four or six-hole pattern to match the cover. Hole pattern complete with fully encapsulated stainless steel threaded inserts.
 - .4 Provide pump mounting studs, and fiberglass stud plates.
 - .5 Provide stainless steel float brackets.
 - .6 Complete with lifting lugs, threaded couplings, and pipe grommet inlet hubs.
 - .7 Acceptable manufacturers: TOPP Industries Inc., Crane, Green-Turtle, AK Industries, Liberty.

3. Execution

3.1. INSTALLATION

- 3.1.1. Provide gate valve, check valve and union or flange as applicable on pump discharge pipes and union or flange as applicable on vent pipe for sanitary pits.
- 3.1.2. Check valves downstream of pumps shall be swing type with external lever and adjustable weight.
- 3.1.3. The frame, intermediate platform, and ladder rungs shall be provided to Division 3 for setting in place.
- 3.1.4. If the main control panel is shipped without a splitter to serve the alarm panel, supply and install an additional junction box before the control panel to serve all related panels.
- 3.1.5. Intermediate platforms shall be equally spaced over the height of the pit and the maximum distance between shall not exceed 4.5 m (15 ft.). Platforms shall be installed clear of pump removal space.
- 3.1.6. Install fibreglass sump base flange in light weight concrete anchor slab prior to backfilling.

END OF SECTION

22 14 26.13 Roof Drains

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings and/or catalogue cuts of all items supplied in accordance with requirements of Section 20 05 03.00 - SHOP DRAWINGS.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Provide roof drains by Jay R. Smith, Zurn, Mifab, or Watts, unless indicated otherwise.

2.1.2. Provide roof drains in metal decks or poured concrete roofs as follows: coated cast iron body, large sump, wide non-crimping flange, vandal proof aluminum or ductile iron mushroom dome strainer, extension frame to suit thickness of insulation, sump receiver, under-deck clamps and flashing clamp with integral gravel stop. Jay R. Smith 1010-AD-E-R-C-U, Zurn ZA-100-E-C-R-VP, Mifab R1200-6-M-B-U-V, Watts RD-100-B-D-K80-L-V.

2.1.3. Provide planter drains as specified above but with the dome covered with stainless steel or bronze mesh.

2.1.4. Provide roof drains for flooded roofs as follows: as specified above but complete with flooding dam to provide approximately 50 mm (2 in.) depth of flooding.

2.1.5. Where flow quantities for roof drains are shown, provide drains as specified above but equipped with weirs to give flow quantities shown.

2.1.6. Provide roof drains in IRMA or upside-down roofs as follows: similar to drains specified above but with cast extensions to suit full depth of gravel and/or pavers and insulation and cast slotted surround for full depth of gravel and insulation for all openings larger than 12 mm (1/2 in.). Jay R. Smith 1012-AD-LR-C-U, Zurn ZA-100-SE-C-R-VP, Mifab R1200-HC-6-M-B-U-V, Watts RD-100-CH-B-D-K80-L-V.

2.1.7. Provide promenade drains in walking areas as follows: as specified above but with adjustable ductile iron or cast iron 300 mm x 300 mm (12 in. x 12 in.) square grate with cast nickel-bronze veneer.

2.1.8. Provide promenade drains shown as stainless steel as follows: as specified above but with adjustable ductile iron or cast iron 300 mm x 300 mm (12 in. x 12 in.) square grate with cast stainless steel veneer, all polished to No. 4 satin finish.

- 2.1.9. Provide roof drains in precast concrete roof as follows: coated cast iron body, with flange, small aluminum or ductile iron mushroom dome, sump receiver, under-deck clamp flashing clamp with integral gravel stop. Jay R. Smith 1330-CID-E-R-C-U, Zurn Z-125-C-E-R-VP, Mifab R1100-6-M-B-U-V, Watts RD-200-B-D-K80-L-E.
- 2.1.10. Provide screens as required to prevent gravel from entering the drain pipes.
- 2.1.11. Provide scupper drains as follows: coated cast iron body with flashing flange removable clamp and nickel bronze oblique angle grate. Provide outlet of 90 Degrees or 45 Degrees as required. Jay R. Smith 1510-SG-NB or Jay R. Smith 1530-SG-NB, Zurn ZN-187-TS or Zurn ZN-189-OB-TS, Mifab R1300-1 or Mifab R1310-1, Watts RD-270-1, or Watts RD-270-A-1.
- 2.1.12. Provide scupper drains as follows: coated cast iron body with flashing flange removable clamp and coated cast iron oblique angle grate. Provide outlet of 90 Degrees or 45 Degrees as required. Jay R. Smith 1510-SG or Jay R. Smith 1530-SG, Zurn Z-187-TS or Zurn Z-189-OB-TS, Mifab R1300 or Mifab R1310, Watts RD-270 or Watts RD-270-A.
- 2.1.13. Provide roof drains with integrated emergency overflow drains in metal decks or poured concrete roofs as follows: coated cast iron body, large sump, integral 150 mm (6 in.) diameter cast iron standpipe, dual outlet, wide non-crimping flange, vandal proof aluminum or ductile iron mushroom dome strainer, extension frame to suit thickness of insulation, sump receiver, under-deck clamps and flashing clamp with integral gravel stop. Jay R. Smith 1077-45, Zurn 100C Froet Drain, Mifab R1200-SO, or Watts RD-700.
- 2.1.14. Provide downspout and emergency overflow roof drain outlet nozzles as follows: cast nickel bronze body, anchor flange, countersunk mounting holes, perforated bird screen. Jay R. Smith 1770/1771, Zurn 199, Mifab R1940/1950, or Watts RD-940.
- 2.1.15. Provide downspout and emergency overflow roof drain outlet covers as follows: 304 stainless steel body, vandal proof hinged perforated bird screen, anchor flange, countersunk mounting holes. Jay R. Smith 1775, Zurn 199-DC, Mifab R1960, or Watts RD-950.
- 2.1.16. Provide expansion compensators as follows: Jay R. Smith 1710, Zurn Z-190, Mifab R1900, or Watts RD-900.

3. Execution

3.1. INSTALLATION

- 3.1.1. For roof drains connected to vertical rain water leaders with less than 1200 mm (4 ft.) of horizontal offset, provide complete with expansion compensators.
- 3.1.2. Turn drain bodies over to roofing and waterproofing trades on site for priming and setting into bearing pads of waterproofing materials.
- 3.1.3. Provide control flow roof drains with a lamacoid tag affixed to the dome indicating the following:
 - .1 DO NOT REMOVE, ADJUST, OR TAMPER WITH FLOW CONTROL WIER.

END OF SECTION

22 15 00.00 Machine Shop Air Compressors

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings and/or catalogue cuts of all items supplied in accordance with requirements of Section 20 05 03.00 - SHOP DRAWINGS.

1.2.2. Ensure Shop Drawings include unit Short Circuit Current Rating (SCCR).

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

.1 The compressor shall be a single stage, two cylinder, reciprocating air-cooled machine. The compressor shall be complete with kW (hp) electric motor, belt drive with guard and discharge line check valve.

.2 The compressor unit shall be mounted on an L (US gal.) horizontal air receiver. Receiver shall be complete with pressure switch, safety relief valve and pressure gauge.

.3 The compressor unit shall supply L/s (cfm) of free air at an operating pressure of 690 kPa (100 psig).

.4 The operating control of the compressor unit shall be automatic start and stop.

.5 The compressed air supply system shall be complete with air cleaners, fog lubrications, air filters, pressure regulators, automatic couplings, air cocks, moisture traps and all other fittings necessary to perform the required operation in the individual workshops.

2.1.2. System shall bear a minimum Short Circuit Current Rating (SCCR) listed by a Nationally Recognized Testing Lab, acceptable to the local Authority Having Jurisdiction, and shall be Lower SCCR listed units implying the use of current limiting fuses ahead of them in the field, in lieu of an actual appropriate SCCR rating, are not acceptable.

3. Execution

3.1. INSTALLATION

3.1.1. Resiliently mount the compressor and air receiver unit, as specified under Section 20 05 48.00 - VIBRATION AND NOISE CONTROL.

END OF SECTION

22 15 13.00 Compressed Air Piping Systems (Service Air)

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.1.2. Conform to the requirements of Authority Having Jurisdiction.

1.1.3. Provide an installation that is compliant with CSA B51 "Boiler, pressure vessel, and pressure piping code" and the ASME standards referenced therein.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings and/or catalogue cuts of all items supplied in accordance with requirements of Section 20 05 03.00 - SHOP DRAWINGS.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Compressed air up to 65 mm (2-1/2 in.) shall be copper tubing type K to ASTM B88 "Standard Specification for Seamless Copper Water Tube," fittings shall be wrought copper, silver soldered, ANSI B16.22 "Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings."

2.1.2. Systems, or parts of systems, in excess of 15 psig and/or larger than 19 mm (3/4 in.) shall meet the requirements of TSSA. Soldered joints are not permitted and shall be brazed.

2.1.3. Compressed air 65 mm (2-1/2 in.) and larger shall be steel pipe galvanized Schedule 40 to ASTM A53 "Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless," fittings malleable iron ASTM A197 "Standard Specification for Cupola Malleable Iron," 300 psi WSP threaded ANSI/ASME B16.3 "Malleable Iron Threaded Fittings Classes 150 and 300."

2.1.4. Gate valves 50 mm (2 in.) and smaller shall be 860 kPa (125 psi) WSP bronze body, rising stem, solder ends or screwed to solder adaptor.

2.1.5. Gate valves 65 mm (2-1/2 in.) and larger shall be 860 kPa (125 psi) WSP iron body bronze mounted, OS&Y flanged ends.

2.1.6. Drain valves shall be 1380 kPa (200 psi) non-shock WOG 19 mm (3/4 in.) size, bronze body, threaded garden hose end, chain and cap.

2.1.7. Check valves shall be 2068 kPa (300 psi) non-shock, bronze body, stainless steel disc, guided spring, silent type.

3. Execution

3.1. INSTALLATION

- 3.1.1. Provide drip leg at each low point. Drip leg shall be a minimum of 300 mm (12 in.) long and complete with drain valve.

END OF SECTION

22 33 00.00 Domestic Electric Hot Water Heaters

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings and/or catalogue cuts of all items supplied in accordance with requirements of Section 20 05 03.00 - SHOP DRAWINGS.

1.2.2. Ensure Shop Drawings include unit Short Circuit Current Rating (SCCR).

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.2. Tank based domestic electric hot water heaters:

- .1 Provide CSA approved domestic electric hot water heaters by John Wood, Bradford White, AO Smith or Rheem.
- .2 Provide glass lined steel tank, factory insulated and covered with an enamelled steel jacket. Provide tank rated for 860 kPa (125 psi) working pressure.
- .3 Provide heater elements of electric immersion type located at the top and bottom of the tank and complete with thermostats. Arrange elements to operate alternatively or simultaneously, as shown. Provide an additional high limit thermostat that prevents overheating. Provide access panels in jacket that provide access to thermostats and elements.
- .4 Provide tanks complete with temperature pressure relief valve. Pipe relief valve to nearest drain.
- .5 Provide tanks of size and heaters of capacity shown.
- .6 Provide tanks of size and heaters of capacity as shown on the Domestic Hot Water Heater Schedule.

2.1.3. Compact point of use tankless electric domestic hot water heaters:

- .1 Provide compact point of use tankless heaters that are:
 - .1 98% efficient.
 - .2 Mounted under sinks or recessed inside a wall enclosure with an access door in washroom areas.
 - .3 CSA approved and UL listed.
 - .4 Complete with copper heat exchanger and copper sheathed heating elements.
 - .5 Manufactured by Bosch, Bradford White, Rheem or Chronomite.

- .2 Refer to Domestic Hot Water Heater Schedule for sizing.
- 2.1.4. System shall bear a minimum Short Circuit Current Rating (SCCR) listed by a Nationally Recognized Testing Lab, acceptable to the local Authority Having Jurisdiction, and shall be Lower SCCR listed units implying the use of current limiting fuses ahead of them in the field, in lieu of an actual appropriate SCCR rating, are not acceptable.

3. Execution

3.1. NOT USED

END OF SECTION

22 34 36.00 Domestic Water Storage Tanks and Heaters

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings and/or catalogue cuts of all items supplied in accordance with requirements of Section 20 05 03.00 - SHOP DRAWINGS.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.2. Tank shall be Steelcraft Clemmer, Reco, PVI, or Niles Steel welded steel tank lined with Precrete or Alkrete. Flanged connections shall also be lined. Screwed connections shall be Everdur. Tanks shall be designed for 860 kPa (125 psig) working pressure and shall be complete with manhole, heater flanges and tapings for cold water, hot water recirculation, drain, relief valve, temperature controller and thermometer. Vertical tanks shall be complete with legs and floor flanges. Horizontal tanks shall be complete with saddles.

2.1.3. Heating element shall have seamless hard drawn copper tubes expanded into bronze tube sheets.

2.1.4. Connecting piping shall be installed to allow removal of heating element after disconnecting only two flanged pipe connections.

2.1.5. Controls for heating medium provided under Section 23 09 00.00 - BUILDING AUTOMATION SYSTEM (BAS).

2.1.6. Tank shall be complete with temperature pressure relief valve; valve shall be piped to drain.

2.1.7. Tank and heater shall be as shown on Drawings.

2.1.8. Tank and heater shall be as shown on Storage Tank and Heater Schedule.

3. Execution

3.1. NOT USED

END OF SECTION

22 42 00.00 Fixtures and Trim

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings and/or catalogue cuts of all items supplied in accordance with requirements of Section 20 05 03.00 – SHOP DRAWINGS.

1.2.2. For manual flush water closets located in barrier free applications, ensure that Shop Drawing clearly illustrates that flushing control is located on the transfer side (adjacent the clear floor space) of the water closet.

1.3. REFERENCES

1.3.1. Comply with CSA B45 Series of standards for fixtures.

1.4. MOCK UPS

1.4.1. Provide working mock up of ...

1.5. WARRANTY

1.5.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Plumbing fixtures shall be as indicated and specified with all required supports, accessories, drainage, vent and water connections to make the fixtures complete.

2.1.2. Fittings that supply water to a fixture shall not exceed the maximum flow rates in accordance with the following:

.1 Part 7 of the Building Code

2.1.3. Provide fixtures from American Standard, T&S Brass, Toto, Kohler, Franke, Zurn, Blanco, Mirolin or Novanni, equivalent to the fixtures specified. American Standard – Eljer and Placidus are not permitted. Provide white vitreous china fixtures unless indicated otherwise.

2.1.4. Provide fittings and trim from American Standard, T&S Brass, Kohler, Sloan, Chicago Faucets, Zurn, Moen, Symmons, or Delta/Cambridge except where specified otherwise. Provide polished chrome plated brass for all exposed valves, fittings, escutcheons, trim, etc., at each fixture, unless specified otherwise.

2.1.5. Provide Fixtures and Trim equal to Product Specification sheets.

2.1.6. Carriers shall be furnished for all wall hung water closets, urinals, and lavatories. Carriers shall be in conformance with Section 22 42 46.00 - FIXTURE CARRIERS.

2.2. WATER CLOSETS AND URINALS

- 2.2.1. All tanks of water closets shall be internally lined with anti-sweat insulation except pressure assist water closets.
- 2.2.2. For manual flush water closets located in barrier free applications, provide water closet with flushing control that is located on the transfer side (adjacent the clear floor space) of the water closet.
- 2.2.3. All flush valves shall have non-syphon by-pass and factory set rate of flow.
- 2.2.4. Water closets shown as type "WC-1 - Wall hung" shall be "High Efficiency", wall hung for flush valve, vitreous china, elongated syphon jet flush action bowl, 2-1/8" (54 mm) fully glazed internal trapway, 10" x 12" (254 mm x 305 mm) large water surface, 4.2 L (1.1 gal) per flush, 1-1/2" (38 mm) back spud, for use with concealed flush valve. American Standard AFWall Millennium FloWise Elongated 3351.101.020.020 HET, Zurn Z5615-BWL, Kohler Kingston High Efficiency Bowl K-84323-0.
- .1 Electronic "No Touch" flush valve unit for WC unit above shall be a safe 24 V system with fixed program-automatic 8 second blocking time, field adjustable flush delay setting, volume and sensing range, and manual over ride capability. Both a modular junction box and 120 to 24 VAC transformer are to be supplied with valve. The flush valve shall be high efficiency 4.2 L (1.1 US gal.) per flush, factory set flow, concealed quiet action, diaphragm flush and renewable seat with wheel handle angle pressure loss check stop. Unit to be supplied with metal recessed box and vandal resistant stainless steel face, measuring approximately 355 mm x 355 mm (14 in. x 14 in.) for both valve and sensor housing. Delta Commercial 1600T6103ARI and 1600T6103ATR with RP32508 transformer, Sloan "Royal Optima" 152-1.28--WB-ES-S with EL-154 transformer, Zurn ZEMS6152AV-HET-BX12 with P6000-HW6 power converter.
 - .2 Exposed flush valves for WC unit above shall be high efficiency 4.2 L (1.1 US gal.) per flush, quiet action, exposed diaphragm flush, renewable seat, polished chrome plated finish, volume control, vandal resistant cover screw, metal "non hold open" handle, 1 in. FIP/copper sweat inlet adaptor angle check stop with protecting cap, adjustable 120 mm (4¾ in.) plus or minus 11 mm (7/16 in.) inlet/valve outlet centers, vacuum breaker, 38 mm (1½ in.) dia. cover tube and wall flange, spud flange, and concealed spud nut. Sloan "Royal Flush" 111-1.28-YO, Zurn Z6000AV-HET-YO, Delta Commercial 81T201. Concealed power harvesting electronic "No Touch" flush valve unit for WC unit above shall be a safe 6 V system with fixed program-automatic 8 second blocking time, field adjustable flush delay setting, volume and sensing range, and manual over ride capability. Low battery alarm, 4 x AA battery backup. The flush valve shall be high efficiency 4.2 L (1.1 gal.) per flush, factory set flow, concealed quiet action, diaphragm flush and renewable seat with wheel handle angle pressure loss check stop. Unit to be supplied with metal recessed box and vandal resistant stainless steel face, measuring approximately 305 mm x 305 mm (12 in. x 12 in.) for both valve and sensor housing. Sloan Solis 8152-1.28 SWB, concealed Flushometer, or equal.
 - .4 Seats for WC unit above shall be elongated heavy-duty solid plastic open front toilet seat, less cover, with stainless steel check hinge and stainless steel posts, washers, and nuts. Bemis 1955-C, Centoco 500STSCC-001, Kohler Lustra K-4670-C, Olsonite 10CCSS, Zurn Z5955SS-EL.
- 2.2.5. Water closets shown as type "WC-2 - Wall hung" (Barrier Free Design) shall be "High Efficiency", wall hung for flush valve, vitreous china, elongated syphon jet flush action bowl, 2-1/8" (54 mm) fully glazed internal trapway, 10" x 12" (254 mm x 305 mm) large water surface, 4.2 L (1.1 gal) per flush, 1-1/2" (38 mm) back spud, for use with concealed flush valve. American Standard AFWall Elongated 3353.101.020.020 HET, Zurn Z5617-BWL, Kohler Kingston High Efficiency Bowl K-84323-0.

- .1 Electronic "No Touch" flush valve unit for WC unit above shall be a safe 24 V system with fixed program-automatic 8 second blocking time, field adjustable flush delay setting, volume and sensing range, and manual over ride capability. Both a modular junction box and 120 to 24VAC transformer are to be supplied with valve. The flush valve shall be high efficiency 4.2 L (1.1 US gal.) per flush, factory set flow, concealed quiet action, diaphragm flush and renewable seat with wheel handle angle pressure loss check stop. Unit to be supplied with metal recessed box and vandal resistant stainless steel face, measuring approximately 355 mm x 355 mm (14 in. x 14 in.) for both valve and sensor housing. Delta Commercial 1600T6103ARI and 1600T6103ATR with RP32508 transformer, Sloan "Royal Optima" 152-1.28 WB-ES-S with EL-154 transformer, Sloan Royal 152 ESS-1.28-ES-S, Zurn ZEMS6152AV-HET-BX12 with P6000-HW6 power converter.
 - .2 Exposed flush valves for WC unit above shall be high efficiency 4.2 L (1.1 US gal.) per flush, quiet action, exposed diaphragm flush, renewable seat, polished chrome plated finish, volume control, vandal resistant cover screw, metal "non hold open" handle, 1 in. FIP/copper sweat inlet adaptor angle check stop with protecting cap, adjustable 120 mm (4¾ in.) plus or minus 11 mm (7/16 in.) inlet/valve outlet centers, vacuum breaker, 38 mm (1½ in.) dia. cover tube and wall flange, spud flange, and concealed spud nut. Sloan "Royal Flush" 111-1.28-YG, Zurn Z6000AV-HET-YO, Delta Commercial 81T201-5.
 - .3 Concealed power harvesting electronic "No Touch" flush valve unit for WC unit above shall be a safe 6 V system with fixed program-automatic 8 second blocking time, field adjustable flush delay setting, volume and sensing range, and manual over ride capability. Low battery alarm, 4 x AA battery backup. The flush valve shall be high efficiency 4.2 L (1.1 US gal.) per flush, factory set flow, concealed quiet action, diaphragm flush and renewable seat with wheel handle angle pressure loss check stop. Unit to be supplied with metal recessed box and vandal resistant stainless steel face, measuring approximately 305 mm x 305 mm (12 in. x 12 in.) for both valve and sensor housing. Sloan Solis 8152-1.28 SWB, concealed Flushometer, or equal.
 - .4 Seat for WC unit above shall be elongated heavy-duty solid plastic toilet seat, open front with cover, with stainless steel stainless steel check hinge and stainless steel posts, washers, and nuts. Bemis 1950SS, Centoco 820STS-001, Kohler Lustra K-4650-EB, Olsonite 46SS, ZURN Z5957SS-EL.
- 2.2.6. Urinals shown as type "U-1 - Wall hung" shall be "Low Consumption", wall hung, vitreous china, wash out flush action 0.5 L (0.125 US gal.), flush, extended sides for privacy, integral flush spreader, 19 mm (¾ in.) top spud, wall hangers, open trap, removable stainless steel strainer, 50 mm (2 in.) outlet, and connecting flange with gasket and bolts. American Standard Washbrook FloWise 6590.001.020, Crane Cromwell 7398, Kohler Bardon K-4991-ER, Zurn Z5760-STR.
- .1 Automatic flush valve for urinal unit above shall be 0.5 L (0.125 US gal.), quiet action, low consumption, quiet action diaphragm flush, renewable seat, with proximity sensor, solenoid, circuitry, high pressure vacuum breaker, back-check angle stop, housed 330 mm x 430 mm (13 in. x 17 in.) in recessed metal box with 368 mm x 470 mm (14½ in. x 18½ in.) stainless steel face, located above urinal. Each unit shall be supplied with a 120/24 VAC 50 VA Transformer (5 VA power required for each unit). Delta Commercial 1600T6403ARI and 1600T6403ATR with RP32508 transformer, Sloan Optima 195-0.125 WB-ES-S with EL-154 transformer, Zurn ZEMS6195AV-OB-WS1-BX12 with P6000-HW6 Power converter.
 - .2 Exposed flush valve for urinal unit above shall be 0.5 L (0.125 US gal.), quiet action, exposed diaphragm flush, renewable seat, polished chrome plated finish, volume control, vandal resistant cover screw, metal "non hold open" handle, 1 in. FIP/copper sweat inlet adaptor angle check stop with protecting cap, adjustable 120 mm (4¾ in.)

plus or minus 11 mm (7/16 in.) inlet/valve outlet centers, vacuum breaker, 38 mm (1½ in.) dia. cover tube and wall flange, spud flange, and concealed spud nut. Delta Commercial 81T201, Sloan 186-0.125, Zurn Z6003AV-WS1.

- .3 Concealed power harvesting electronic "No Touch" flush valve unit for back spud U unit above shall be a safe 6 V system with fixed program-automatic 8 second blocking time, field adjustable flush delay setting, volume and sensing range, and manual over ride capability. Low battery alarm, 4 x AA battery backup. The flush valve shall be high efficiency 0.5 L (0.125 US gal.) per flush, factory set flow, concealed quiet action, diaphragm flush and renewable seat with wheel handle angle pressure loss check stop. Unit to be supplied with metal recessed box and vandal resistant stainless steel face, measuring approximately 305 mm x 305 mm (12 in. x 12 in.) for both valve and sensor housing. Sloan Solis 8152-1.28 SWB, concealed Flushometer, or equal.

2.3. LAVATORIES

- 2.3.1. Lavatories shown as type "L-1 – Commercial wall-mounted monolithic lavatory system. 1-4 stations, Corian or quartz construction. ADA compliant. Integrated sensor activated faucets and soap dispensers. 550mm (22") x 125mm (5") Depth x Height. Wall mounting with angle brackets or custom enclosures. Sloan DSG Splash Lab TSL.MON or equal..

- .1 Hard-wired electronic "no touch" faucet for lavatory unit above shall be a 100 mm (4 in.) centre set, solid cast brass body with integral proximity sensor, with vandal-resistant 0.5 USGPM (1.9 L) flow spray outlet, control module, solenoid, strainer, circuitry, tempered water supplied by mixing valve with back checks and stops housed in 250 mm (10 in.) Sq. recessed metal box with 300 mm (12 in.) Sq. V.P. face, located in wall under basin. Flexible conduit from control module to faucet and solenoid to be provided. Each unit shall be supplied with a 120/24 VAC 50 VA Transformer (15 VA power required for each unit). Delta Commercial 591T0258TR and ELAVT0008ARI with RP32508 transformer, Kohler K-13463/K-13478-A-CP Escutcheon with K-13480-NA power supply, Sloan ETF-600-A-VPB-MIX60-A with EL-154 transformer, Zurn Z6915-XL-CWB-F-MV-SH22-ALBOX with P6000-HW6 Power converter. Lavatories shown as type "L-2 - Wall hung (Barrier free design & general use)," tight space areas shall be 533 mm x 445 mm x 133 mm - 175 mm (21 in. x 17½ in. x 5¼ in. - 6-7/8 in.) deep, wall hung, vitreous china, rear overflow, for concealed arm support. Unit shall be provided with faucet holes to suit the faucet below. American Standard Murro 095x.000, Crane Serena 129, or Zurn Z5324-PED. Provide semi pedestal American Standard Murro 0059.020, Crane Serena 132, Kohler Pinoir K-2035 to cover exposed piping.
- .1 Faucet for lavatory unit above shall be 100 mm (4 in.) centre set, solid cast brass body with integral proximity sensor, with vandal-resistant 0.5 USGPM (1.9 L) flow spray outlet, control module, solenoid, strainer, circuitry, tempered water supplied by mixing valve with back checks and stops housed in 250 mm (10 in.) Sq. recessed metal box with 300 mm (12 in.) Sq. V.P. face, located in wall under basin. Flexible conduit from control module to faucet and solenoid to be provided. Each unit shall be supplied with a 120/24 VAC 50 VA Transformer (15 VA power required for each unit). Delta Commercial 591T0258TR and ELAVT0008ARI and RP32508 transformer, Kohler K-13463/K-13478-A-CP escutcheon with K-13480-NA power supply, Sloan ETF-600-A-VPB-MIX60-A with EL-154 transformer or Zurn Z-6915-XL-CWB-F-MV-SH22-ALBOX with P6000-HW6 Power converter. Faucet for lavatory unit above shall be single hole mount solid cast brass faucet, polished chrome plated finish, ceramic valve with high temperature rotational limit stop, vandal resistant 3½ in. (90 mm) OBC compliant metal lever handle with color index, standard spout less pop-up, and standard 0.5 USGPM (1.9 L) flow control aerator. American Standard 2000.100X.002, Delta Commercial 534LF-LPU, Zurn Z82200-XL-CP4, Kohler July K-P97282-4/K-20003 escutcheon plate.

- .3 Faucet for lavatory unit above shall be 200 mm (8 in.) centre, two handle widespread lavatory faucet, polished chrome plated finish trim, cast brass bodies, and ¼ turn ceramic disk cartridges, brass spout and trim, color indexed metal handles with vandal resistant screws, heavy duty goose neck spout less pop-up, 0.5 USGPM (1.9 L) laminar flow control moderator, and 100 mm (4 in.) OBC compliant cast brass handles. Chicago Faucet 786-FC-XK-317, Delta Commercial 27C2922, Kohler K-7303-K/K-16012-4, Zurn Z831A4-XL.
- 2.3.3. Drain for all lavatory units with exposed under counter installation shall be 32 mm (1¼ in.) size, polished chrome plated offset open grid, and cast brass lavatory waste strainer, 17 gauge tubular offset. Safety covers are to be supplied as per local codes. Delta Commercial 33T290, Kohler K-7131-A, McGuire 155WC, Zurn Z8746-PC.
- 2.3.4. Drain for all lavatory units with concealed under counter installation shall be 32 mm (1¼ in.) size, polished chrome plated inline open grid and cast brass lavatory waste strainer, 17 gauge straight tubular tailpiece. Delta Commercial 33T260, Kohler K-7129-A, McGuire 155A, Zurn Z8743-PC.
- 2.3.5. "P" trap for all lavatory units shall be polished chrome plated cast brass, adjustable body 32 mm (1¼ in.) size with cleanout plug, 17 gauge tubular wall bend. Safety covers are to be supplied as per local codes for exposed under counter installation. Delta Commercial 33T311, McGuire 8872C, Zurn Z8700-D-PC, Kohler K-8998.
- 2.3.6. Supplies for all lavatory units shall be a pair of chrome plated, heavy pattern angle lavatory supplies, lockshield, screw driver slot, stuffing box cartridge, 3/8 in. IPS brass inlet supply nipple, flexible braided stainless steel risers, and stainless steel wall flange. Delta Commercial 47T2512SD, McGuire H165LKN3RB, Zurn ZH8820-LR-LK-PC-3.
- 2.3.7. All lavatories for health care facilities shall have concealed overflows and laminar flow outlets. Modify specified trim model numbers above as required.
- 2.4. GENERAL SINK UNITS
- 2.4.1. Sinks shown as "S-1 - One Compartment Stainless Steel Sink (General use)" shall be stainless steel three hole sink, 200 mm (8 in.) centers, 520 mm x 508 mm x 203 mm (20½ in. x 20 in. x 8 in.) deep, counter mounted, back ledge, grade 18-8 type 302 stainless steel, single compartment, mirror finished rim, satin finished bowl, self-rimming with crumb cup strainer, and sound deadening. Aristaline LBS6808-1, Kindred QSL2020-8, Kohler K-3363-3 with K-8813 sink strainer, Architectural Metal Industries 1017-B-I or Novanni 1017EI.
- .1 Faucets for sink unit above shall be 200 mm (8 in.) centre, single control, brass body deckmount faucet, polished chrome plated finish, stainless steel rotating ball mechanism or ceramic disk cartridge, brass spout and trim, 200 mm (8 in.) swing spout, and 2.1 USGPM (7.9 L) vandal resistant flow aerator and vandal resistant 150 mm (6 in.) handle. American Standard 2021.600.002, Delta Commercial 100LF-HDF, Kohler K-15171-F, Zurn Z82300-XL-CP8-2M.
- 2.4.2. "P" trap for all sink units shall cast brass 38 mm (1½ in.) with union, cleanout, and escutcheon, Delta Commercial 33T360, McGuire 8912C, or Zurn Z8702BD-PC.
- 2.4.3. Supplies for all sink units shall be a pair of chrome plated, heavy pattern angle lavatory supplies, lockshield, screw driver slot, stuffing box cartridge, 3/8 in. IPS brass inlet supply nipple, flexible braided stainless steel risers, and stainless steel wall flange. Delta Commercial 47P2512SD, McGuire H165LKN5RB, Zurn ZH8820-LR-LK-PC-3.

2.5. UTILITY SINK UNITS

2.5.1. Janitor sinks shown as "JS-1 - Floor Mounted (Square Unit)" shall be 610 mm x 610 mm x 250 mm (24 in. x 24 in. x 10 in.) deep, floor mounted, precast terrazzo with integral drain and strainer. Stern-Williams MTB-2424, Acorn 242410.

- .1 Faucets for janitor sink unit above shall be 200 mm (8 in.) centers, two handle, cast brass wall mount service sink faucet, 2.1 USGPM (7.9 L), polished chrome plated finish, ¼ turn ceramic disk cartridge, rigid pail hook spout, integral stops, color indexed 70 mm (2¾ in.) metal handles with vandal resistant screws, plain spout complete with body mounted vacuum breaker, hose threaded outlet and 1220 mm (48 in.) hose and stainless steel hanger. Chicago Faucet 305-VBRXK, Delta Commercial 28C2083 with 28T911, Kohler K-8905, Zurn Z841L1-XL-SSI-HH.

3. Execution

3.1. INSTALLATION

- 3.1.1. Provide necessary plates, brackets, cleats, supports, etc., for rigidly securing fixtures in place. Accurately lay out all roughing piping, avoiding offsets.
- 3.1.2. Examine fixtures for defects. Remove and replace any fixture which, in the opinion of the Engineer's Representative, is damaged. Make necessary adjustments to ensure fixtures function as per manufacturer's operating criteria. Clean and polish all fixtures and trim upon completion.
- 3.1.3. Ensure wall-mounted fixtures with back water connections have an adjacent access door, unless the pipe space is sufficiently wide to allow the water connection to be made from within the pipe space. For this, pipe space shall be 600 mm (24 in.) minimum clear width.
- 3.1.4. Provide 120 V primary to Extra-low Voltage secondary transformers to power fixtures, as required based on fixture type. Provide cord with plug for primary side of each transformer where Electrical Drawings show receptacle(s) powering fixtures and coordinate need for cord with plug with Electrical Contractor. Install transformers and all secondary side wiring to fixtures. Where Electrical Drawings show fixtures being powered by direct connections, install so that Electrical Contractor only needs to terminate 120 V circuit at transformer.
- 3.1.5. Provide cleanouts in accordance with the requirements of Section 22 05 76.00 – CLEANOUTS.
- 3.1.6. Fixtures shall be installed symmetrical with wall tile pattern, unless otherwise dimensioned or shown on Architectural Drawings.

END OF SECTION

22 42 46.00 Fixture Carriers

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings and/or catalogue cuts of all items supplied in accordance with requirements of Section 20 05 03.00 - SHOP DRAWINGS.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Fixtures carriers shall be Jay R. Smith, Zurn, or Mifab, or Watts.

2.1.2. Carriers shall be furnished for all wall hung water closets, urinals, lavatories, service sinks and drinking fountains. Carriers shall be floor mounted and supported independently of the wall. Carriers shall be suitable for each particular fixture. Carrier feet shall not project beyond finished wall.

2.1.3. All fixture carriers with integral cast iron fittings shall be certified to CSA B70 "Cast iron soil pipe, fittings, and means of joining" as required by Authority Having Jurisdiction.

2.2. WATER CLOSET CARRIERS

2.2.1. Carriers for water closets shown as (FILL IN LIST OF TYPES HERE) shall be as described herein. Refer to Drawings for installation arrangement.

2.2.2. Carriers for water closets with single adjustable horizontal discharge shall be 100 mm (4") all coated cast iron fittings, rear anchor bolt factory assembled, face plate with rear anchor support, heavy duty legs, adjustable short cast iron nipple, plated hardware, cap nuts, test plug and protection cap. Jay R. Smith 0211Y-2-M51-95, Zurn Z1203-N(L/R)4-29, Mifab MC-10-3-6, Watts CA-101-(L/R)-M3-M12. Carriers for back to back water closets with adjustable horizontal discharge shall be 100 mm (4") all coated cast iron fittings, factory assembled face plate with heavy duty legs, adjustable short cast iron nipple, plated hardware, cap nuts, test plug and protection cap. Jay R. Smith 0211YD-2-95, Zurn Z-1203-ND4-29, Mifab MC-10D-6, Watts CA-101-D-M3. Carriers for water closets with single adjustable vertical stack discharge shall be 100 mm (4") all coated cast iron fittings, factory assembled face plate with rear anchor support, heavy duty legs, adjustable cast iron nipple, plated hardware, cap nuts, test plug and protection cap. Jay R. Smith 0230Y-2-M51-95, Zurn 1204-N4-29, Mifab MC-12-3-6, Watts CA-121-M3-M12.

- 2.2.5. Carriers for back to back water closets with adjustable vertical stack discharge shall be 100 mm (4") all coated cast iron fittings, factory assembled face plate with heavy duty legs, adjustable cast iron nipple, plated hardware, cap nuts, test plug and protection cap. Jay R. Smith 0230DY-2-95, Zurn 1204-ND4-29, Mifab MC-12D-3, Watts CA-121-D-M3-M12.
- 2.2.6. Carriers for water closets with single adjustable vertical stack discharge and offset fittings for compact installation shall be 100 mm (4") all coated cast iron fittings, factory assembled face plate with rear anchor support, heavy duty legs, adjustable cast iron nipple, plated hardware, cap nuts, test plug and protection cap. Jay R. Smith 0410(L/R)Y-2-M51-95, Zurn 1209-N(L/R)4-29, Mifab MC-15-3-6, Watts CA-151-(L/R)L-M3-M12.
- 2.2.7. Carriers for back to back water closets with adjustable vertical stack discharge and offset fittings for compact installation shall be 100 mm (4") all coated cast iron fittings, factory assembled face plate with heavy duty legs, adjustable cast iron nipple, plated hardware, cap nuts, test plug and protection cap. Jay R. Smith 0410DY-2-95, Zurn 1209-ND4-29, Mifab MC-15D-6, Watts CA-151-DL-M3.
- 2.2.8. Carriers for wheelchair use shown as shall be mounted 400 mm (16") above finished floor to rim of toilet.
- 2.3. URINAL CARRIERS
- 2.3.1. Carriers for wall hung urinals shown as (FILL IN LIST OF TYPES HERE) shall be all coated with block base feet supports and plate type system with bottom bearing plates. Jay R. Smith 637, Zurn Z-1222, Mifab M-32, Watts CA-321.
- 2.4. LAVATORY CARRIERS
- 2.4.1. Carriers for wall-hung lavatories shown as shall be all coated with rectangular steel uprights and welded block base feet support and plate. Jay R. Smith 800-M31, Zurn Z1224, Mifab MC-3, Watts CA-421.
- 2.4.2. Carriers for wall-hung lavatories shown as shall be all coated with rectangular steel uprights, welded block base feet support and concealed arms with locking device and levelling screws. Jay R. Smith 700-M31, Zurn Z1231, Mifab MC-41, Watts CA-411.
- 2.4.3. Carriers for barrier free wall-hung lavatories shown as shall be all coated with rectangular steel uprights, welded block base feet support and extended concealed arms with locking device and levelling screws. Jay R. Smith 700-27-M31, Zurn Z1231-79, Mifab MC-42, Watts CA-411-W.
- 2.5. MISCELLANEOUS CARRIERS
- 2.5.1. Carrier for clinic flushing rim service sink shown as shall be all coated factory assembled complete, with rectangular steel uprights with welded block base feet support with positioning frame 16 mm (5/8") bolts and C.P. bolt caps, 100 mm (4") 'TY' and adjustable cast iron nipple with bowl gasket. Jay R. Smith 0631Y-M31, Zurn Z1218-F4-CC, Mifab MC-62-4-V4-6, Watts CA-550-4-V4-M3.
3. Execution
- 3.1. INSTALLATION
- 3.1.1. Rigidly secure all fixture carriers to the floor using approved anchor bolts and inserts.
- 3.1.2. Verify the finished wall location and type of wall construction and elevation of finished floor before installation of carriers.

END OF SECTION

2 42 49.00 Hydrants (Plumbing Systems)

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings and/or catalogue cuts of all items supplied in accordance with requirements of Section 20 05 03.00 - SHOP DRAWINGS.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Hydrants shall be Jay R. Smith, Zurn, Mifab, or Watts, equal to the following series.

2.1.2. Ground hydrants shall be non-freeze, key operated with 19 mm (3/4 in.) hose connection, removable nylon or bronze seat, 19 mm (3/4 in.) IPS female inlet tailpiece, brass lower valve casting and brass hydrant head enclosed in a nickel-bronze surface access box with key operated hinged cover. Depth of bury shall be 1500 mm (5 ft.). Valve shall be encased in gravel from bottom to approximately 300 mm (12 in.) below grade. Carefully determine final grade elevation before setting hydrant. Jay R. Smith 5810NB, Zurn ZN1360, Mifab MHY-60, Watts HY-500.

2.1.3. Where ground hydrants are installed in earth above lower floors of a building (i.e. courtyards above basements, areas above buried parking, etc.), the valve and drain shall project into the ceiling space below. The drain shall be piped to the closest floor drain.

2.1.4. Provide wall hydrants as follows: non-freeze, key operated with 19 mm (3/4 in.) hose connection, removable nylon or bronze seat, 19 mm (3/4 in.) ground joint union inlet, brass operating parts and nickel bronze access box with polished cover. Provide length of wall sleeve that suits location. Jay R. Smith 5509QTNB, Zurn Z1300, Mifab MHY-20, Watts HY-725.

2.1.5. Interior wall hydrant hose bibb: concealed, moderate climate, anti-siphon, narrow wall hydrant for narrow wall installation. Complete with integral vacuum breaker. Bronze head, seat casting, and internal working parts. Complete with loose key. Standard 19 mm (3/4 in.) male hose connection, 90 degree connection with 360 degree swivel with 19 mm (3/4 in.) female / 25 mm (1 in.) male threads. Adjustable nickel bronze box furnished with hinged cover, cylinder lock. WATTS HY-450.

2.1.6. All hydrants shall be complete with vandal proof vacuum breaker, if backflow preventer is not provided.

3. Execution

3.1. NOT USED

END OF SECTION

22 47 13.00 Refrigerated Drinking Fountains and Bottle Fillers

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings and/or catalogue cuts of all items supplied in accordance with requirements of Section 20 05 03.00 - SHOP DRAWINGS.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Type "BF-1" Drinking Fountains: Wall hung fountain with stainless steel top, light grey vinyl covered steel enclosure, safety bubbler with front and side push bar activation, laminar flow bottle filler with sensor activation, filter with visual filter status indicator, 0.37 kW (1/2 hp) refrigeration unit complete with overload protection and operating controls factory wired. Unit shall be capable of cooling 0.0084 L/s (8 USGPH) from 26.6 deg. C. (80 deg. F.) to 10 deg. C. (50 deg. F.) with 32.2 deg. C. (90 deg. F.) room ambient temperature. ADA compliant and CSA C22.2 No. 120 "Refrigeration equipment" and NSF/ANSI/CAN 61 "Drinking Water System Components - Health Effects" & 372 "Drinking Water System Components - Lead Content" certified. Elkay LZS8WSLP.

3. Execution

3.1. INSTALLATION

3.1.1. Provide necessary plates, brackets, cleats, supports, etc., for rigidly securing fixtures in place. Accurately lay out all roughing piping, avoiding offsets.

3.1.2. Examine fixtures for defects. Remove and replace any fixture which, in the opinion of the Engineer's Representative, is damaged. Make necessary adjustments to ensure fixtures function as per manufacturer's operating criteria. Clean and polish all fixtures and trim upon completion.

END OF SECTION

23 05 49.00 Seismic Force Resisting Systems

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.1.2. Be responsible for all seismic resisting systems for all mechanical systems and equipment. Have one trade provide all seismic resisting systems for mechanical.

1.2. DEFINITIONS

1.2.1. Relevant Importance Category for the Building in accordance with the following codes:

.1 Ontario Building Code:

- .1 *Low*: buildings that represent a low direct or indirect hazard to human life in the event of structural failure.
- .2 *Normal*: all buildings except those listed in the Importance Categories Low, High and Post-disaster.
- .3 *High*: buildings that provide a greater degree of safety to human life than a Normal Importance Category Building, buildings that are likely to be used as post-disaster shelters, and manufacturing or storage facilities containing toxic, explosive or other hazardous substances in sufficient quantities to be dangerous to the public if released.
- .4 *Post-disaster*: buildings that are essential to the provision of services in the event of a disaster.

1.2.2. SFRS: Seismic Force Resisting System.

1.3. GENERAL DESCRIPTION

1.3.1. This section covers design, supply, and installation of complete SFRSs for all systems.

1.3.2. Fully integrate SFRS into and make compatible with noise and vibration controls in accordance with Section 20 05 48.00 - VIBRATION AND NOISE CONTROL.

1.3.3. Systems and equipment shall not be required to be operational during and after a seismic event.

1.3.4. Provide SFRS that during a seismic event prevents systems and equipment from causing personal injury and from moving from normal position.

1.3.5. Obtain the services of a Professional Engineer, licensed in the Province/Territory of the Place of the Work, and specializing in the design of SFRS, to provide the necessary design and details for a complete SFRS including system of structural supports and bracing of all mechanical equipment as required to comply with Part 4, Structural Design, of the Building Code. Require this Professional Engineer be responsible for ensuring that the installation conforms to the design.

1.4. SUBMITTALS

1.4.1. Submit Shop Drawings and Product data in accordance with Section 20 05 03.00 - SHOP DRAWINGS.

1.4.2. Include with submittals:

- .1 Full details of design criteria.
 - .2 Working drawings, materials lists, schematics, and full specifications for all components of each SFRS provided.
 - .3 Design calculations, including resisting loads resulting from seismic forces in accordance with SMACNA Seismic Restraint Manual and provincial or municipal building code.
 - .4 Separate Shop Drawings for each SFRS and devices for each system and equipment.
 - .5 Identification of location for each device.
 - .6 Schedules of types of SFRS equipment and devices.
 - .7 Details of fasteners and attachments to structure, anchorage loadings, and attachment methods.
 - .8 Installation procedures and instructions.
 - .9 Provide Shop Drawings designed and bearing the seal of a Professional Engineer licensed to practice in the appropriate discipline and in the Place of the Work.
- 1.5. WARRANTY
- 1.5.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
2. Products
- 2.1. MATERIALS
- 2.1.1. Provide SFRSs from a single manufacturer and from Kinetics, Mason, or Vibro-Acoustics.
- 2.1.2. Provide positive seismic and wind resisting on those systems and components required by the Building Code and the Authority Having Jurisdiction.
- .1 Refer to Code Data Matrix on Architectural Drawings as well as the Structural Drawings for seismic design criteria values prior to bid.
 - .2 Seismic design criteria mentioned above includes: Design Spectral response acceleration for short periods, $S_a(0.2)$; Site Classification; Acceleration based site coefficient, F_a ; Importance Factor for Earthquake Loads, I_E ; and Wind reference velocity pressure, q .
- 2.1.3. Provide SFRS for piping systems that is compatible with:
- .1 Expansion, anchoring and guiding requirements.
 - .2 Equipment vibration isolation and equipment SFRS.
- 2.1.4. Do not utilize cast iron, threaded pipe, and other brittle materials as part of SFRS.
- 2.1.5. Provide seismic resisting and flexible couplings for sprinkler systems in accordance with Section 21 13 00.00 - SPRINKLER SYSTEMS, and NFPA 13.
- 2.1.6. Ensure seismic control measures do not interfere with integrity of fire stopping.
- 2.2. SFRS FOR VIBRATION ISOLATED EQUIPMENT
- 2.2.1. Equipment installed on vibration isolation requiring seismic resisting – provide in accordance with Section 20 05 48.00 - VIBRATION AND NOISE CONTROL.

3. Execution

3.1. INSTALLATION

- 3.1.1. Install SFRS at least 25 mm (1 in.) from all other equipment, systems, and/or services.
- 3.1.2. Co-ordinate connections with all disciplines.
- 3.1.3. Install SFRS in accordance with the Seismic Professional Engineer's design.
- 3.1.4. Following the completion of the installation of the seismic resisting systems, have the designing engineer submit a stamped letter stating that the installation has been completed in accordance with the applicable Building Codes and their design. Require the engineer to complete and submit signed and sealed letters of assurance (e.g. Schedules, where applicable) and letters of compliance for all equipment that requires seismic resisting in accordance with latest codes, standards and requirements of the Authorities Having Jurisdiction.
- 3.1.5. Require engineer to include additional documentation to identify the equipment and device types and quantities that were reviewed to ensure that all components requiring seismic resisting were completed.
- 3.1.6. Require engineer to indicate in letters that "All mechanical equipment shown on the Smith and Andersen Drawings has been seismically resisted in accordance with the local Building Code."

END OF SECTION

23 05 93.13 Testing and Balancing Piping Systems

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. QUALITY ASSURANCE

1.2.1. The balancing under Section 23 05 93.23 - TESTING AND BALANCING AIR SYSTEMS and this Section shall be performed by the same balancing company.

1.2.2. Balancing companies shall be members of AABC or NEBB.

1.2.3. Acceptable balancing companies are limited to the following:

- .1 Design Test
- .2 Pro-Air Testing
- .3 VPG Associates
- .4 Airwaso
- .5 Leslie Danhart Inc.
- .6 Air Audit
- .7 Dynamic Flow Balancing Ltd.
- .8 Vital Canada Group Inc.
- .9 Verify Inc

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. NOT USED

3. Execution

3.1. GENERAL

3.1.1. Arrange for walk-through of site during project construction phase, prior to commencement of balancing, to confirm that all valves and appurtenances to fully balance and test the systems are available and accessible. Review Mechanical Contractor's proposed access door locations and sizes per Section 20 05 63.00 – ACCESS DOORS AND ACCESSIBILITY indicated on Shop Drawing and ensure that sufficient access is available.

3.1.2. A sample of a Test Verification Sheet is provided at the end of the section. Fill out this sheet or a similar one with all pertinent information for all tests called for in the Specification or required by code. Have the sheets signed by the Contractor and the Balancing Company to verify that the data recorded is correct.

- 3.1.3. Carry out leakage tests on sections of the Work and identify them by reference number on the test sheet and by description of the piping system. Indicate the reference identification number on the as-built drawings.
- 3.1.4. Test and balance the following systems:
 - .1 Refrigeration piping
 - .2 Computer Room A/C units and condensers
 - .3 Chillers and chilled water distribution
 - .4 Boilers and heating systems
 - .5 Water treatment systems
 - .6 Life safety and fire protection systems
 - .7 Plumbing systems
 - .8 Natural gas systems
 - .9 All process piping including gas, air nitrogen and vacuum
- 3.1.5. Read, fully understand and comply with all requirements of the Section 20 08 00.00 - COMMISSIONING.
- 3.1.6. Provide a schedule for all testing and balancing.
- 3.1.7. Test all plumbing systems in accordance with all applicable plumbing codes and the requirements of the authority having jurisdiction.
- 3.1.8. Test natural gas systems in accordance with CSA B149.1 "Natural gas and propane installation code".
- 3.1.9. Test all fire protection systems in accordance with all applicable NFPA codes.
- 3.1.10. Test compressed air system to a minimum of 125 % and a maximum of 150 % of pressure setting of relief valve, using nitrogen for 24 hours and ensure pressure drop does not exceed 10 % of the minimum pressure.
- 3.1.11. Test for vacuum at 1-1/2 times the operating vacuum.
- 3.1.12. For all plumbing systems over 100 psi system pressure and other systems not covered by codes noted above, test and prove tight over a period of 24 hours by a hydrostatic test. Remove vents and gauges and temporarily plug connections.
- 3.1.13. Utilize hydrostatic test pressure for steam and water systems as follows:
 - .1 1-1/2 times the system working pressure but not less than 1035 kPa (150 psig), or
 - .2 The maximum working pressure of expansion joints and vibration isolators.
- 3.1.14. Repair any leaks or defects and repeat the tests to the satisfaction of the Engineer's Representative.
- 3.1.15. On all radiant heating systems, provide a tag in accordance with Section 20 05 55.00 – VALVE TAGS AND CHARTS, securely fixed to the zone balancing valve to indicate the required flow rate. Where balancing valves are not located in the room served, also include on the tag the room(s) / area(s) served and the length of the loop.
- 3.1.16. After completion of the testing, rough balance the water systems and ensure all coils, convertors, etc., are operating to approximately design conditions to ensure freezing conditions will not occur anywhere. Adjust the circuits by means of balancing valves.
- 3.1.17. Confirm that appropriate balancing valves have been installed on all domestic hot water recirculation branch lines.

- 3.1.18. Obtain balance on water lines by inserting thermometers in thermometer wells provided for this purpose or between pipe and insulation at each balancing valve and adjusting flow until all thermometers read the same appropriate system temperature.
- 3.1.19. Co-ordinate with the balancing company to ensure all necessary valves for balancing the system are installed.
- 3.1.20. Ensure that all cooling coil drain pans drain freely and that no standing water remains.
- 3.1.21. Ensure access is provided to all valves and equipment that requires servicing.
- 3.1.22. Be responsible for all equipment operating to design conditions and trim impellers, etc., to provide the required conditions.
- 3.1.23. Correct any deficiencies in the mechanical systems which prevent balancing the system.
- 3.1.24. Do not commence insulation installation until testing report is submitted to Engineer's Representative and is reviewed by Engineer's Representative without requesting a resubmit.
- 3.1.25. Balance the entire water system to ensure all heat exchangers, etc., are operating to design conditions. Adjust the circuits by means of the balancing valves and record balance position.
- 3.1.26. Check each pump for design, working and shut-off head conditions and trim impeller on any pump that varies by more than 10 % from the design conditions until design conditions have been met.
- 3.1.27. Balance flow through all heat exchangers, chillers, boilers and other such equipment to ensure that the pressure drop through the equipment is within 10 % of the manufacturer's design conditions.
- 3.1.28. If the design conditions cannot be met by adjusting the balancing valves throughout the system, then change or trim pump impellers as required.
- 3.1.29. As part of initial balancing of coils, ensure that the pressure drops are within 10 % of the manufacturer's design conditions. When both the air and water systems are fully operational, take entering air and water and leaving air and water readings as close as possible to the peak design conditions to ensure the coil performance meets the design conditions. Only take coil water working conditions in conjunction with the air flow working conditions for the coil.
- 3.1.30. Adjust bleed-off from cooling tower, evaporative condensers, and similar equipment to prevent lime deposits. Record bleed-off rate.
- 3.1.31. Do not disconnect any control device. Furnish a list of adjusted set points. Commanding of control valves and entering of adjusted set points into the building automation system for testing and balancing purposes is performed under Section 23 09 00.00 - BUILDING AUTOMATION SYSTEM. Co-ordinate with Section 23 09 00.00 - BUILDING AUTOMATION SYSTEM.
- 3.1.32. Have Balancing Company witness all system tests and sign all test reports. Include one copy of all test reports in each copy of the balancing reports.
- 3.1.33. Co-ordinate to ensure that all necessary valves for control and balancing are installed in all locations required.
- 3.1.34. Be responsible for balancing the systems to obtain the design conditions, and repeat the balancing until the required conditions have been met.
- 3.1.35. At the time of final inspection, recheck in the presence of the Engineer's Representative random selections of data recorded in the certified report. Points or areas for recheck will be selected by the Engineer's Representative and be approximately 10 % of the report data.
- 3.1.36. A measured deviation of more than 10 % between the verification reading and the reported data shall be considered as failing the verification procedure.

- 3.1.37. A failure of more than 10 % of the selected verification readings shall result in rejection of the report as unacceptable.
- 3.1.38. In the event the report is rejected, rebalance all systems, submit new certified reports and make a re-inspection.
- 3.1.39. Following final acceptance of the certified reports by the Engineer's Representative, permanently mark the settings of all valves and other adjustable devices so that balance set position can be restored if disturbed at any time. For circuit balancing valves, record the valve position by the number of turns registered on the valve and lock the valve into that position. Do not mark such devices until after final acceptance.
- 3.1.40. Submit report showing the balanced temperatures at all systems.
- 3.1.41. Provide a digital copy of the final testing and balancing reports for review by the Engineer's Representative. Include copies of the final testing and balancing reports in the O&M Manuals. Ensure reports are complete with index pages and index tabs, and are certified by the Balancing Company. Prepare all diagrams as single line representation of a Mechanical system specifically prepared for this Project using a CAD system acceptable to Engineer's Representative.

TEST VERIFICATION SHEET - PIPING

Test Number: Date:

System:

Description and sketch of tested component

Starting test pressure Starting test temperature

Final test pressure Finish test temperature

Duration of test

Test performed by: (signature)

(Printed name)

(Company)

Test witnessed by: (signature)

(Printed name)

(Company)

Verified by: (signature)

(Printed name)

(Company)

Test witnessed by: (signature)

(Printed name)

(Company)

END OF SECTION

23 05 93.23 Testing and Balancing Air Systems

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. QUALITY ASSURANCE

1.2.1. The balancing under Section 23 05 93.13 - TESTING AND BALANCING PIPING SYSTEMS and this Section shall be performed by the same balancing company.

1.2.2. Balancing companies shall be members of AABC or NEBB.

1.2.3. Acceptable balancing companies are limited to the following:

- .1 Design Test
- .2 Pro-Air Testing Inc.
- .3 VPG Associates
- .4 Airwaso
- .5 Leslie Danhart Inc.
- .6 Air Audit
- .7 Dynamic Flow Balancing Ltd.
- .8 Vital Canada Group Inc.
- .9 Verify Inc.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. NOT USED

3. Execution

3.1. GENERAL

3.1.1. Arrange for walk-through of site during project construction phase, prior to commencement of balancing, to confirm that all dampers and balancing devices to fully balance and test the systems are available and accessible. Review Mechanical Contractor's proposed access door locations and sizes per Section 20 05 63.00 – ACCESS DOORS AND ACCESSIBILITY indicated on Shop Drawing and ensure that sufficient access is available.

3.1.2. A sample of a Test Verification Sheet is provided at the end of the Section. Fill out this sheet or a similar one with all pertinent information for all tests called for in the Specification or required by code. Have the sheets signed by the Contractor and the Balancing Company to verify that the data recorded is correct.

- 3.1.3. Carry out leakage tests on Sections of the Work and identify these Sections by reference number on the test sheet and by description of the duct system. Indicate the reference identification number on the as-built drawings.
- 3.1.4. Test and balance the following systems:
- .1 Computer Room A/C Units
 - .2 Air conditioning, ventilation and heating systems
 - .3 Miscellaneous ventilation or exhaust systems
 - .4 Life safety systems
 - .5 Air distribution (supply, return and exhaust)
 - .6 Miscellaneous systems on emergency power
 - .7 Heat pumps
- 3.1.5. Read, fully understand and comply with all requirements of the Section 20 08 00.00 - COMMISSIONING.
- 3.1.6. Provide a schedule for all testing and balancing.
- 3.1.7. Duct Pressure Tests
- .1 Perform pressure tests before ductwork is concealed or insulated.
 - .2 Follow SMACNA HVAC Air Duct Leakage Test Manual procedures.
 - .3 Provide blower and all test equipment.
 - .4 Test the percentage of ductwork indicated in the table below. If a test specimen fails to meet the specified air leakage criteria, modify fabrication methods to bring it into compliance and retest until acceptable duct air leakage is demonstrated. If pressure test fails any sample twice, increase percentage of ductwork tested as indicated in the rightmost column of the table below.
 - .5 Include as a minimum, 5 transverse joints, typical seams, an access door, 2 branch connections and 1 elbow in test samples.
 - .6 Ensure leakage amount does not exceed the allotted amount in the table below for the duct construction pressure class in question.
 - .7 Seal any leaks causing noise.
 - .8 Leakage Class:
- | Duct Construction Pressure Class | Rectangular Leakage Class | Round Leakage Class | Amount of Ductwork to be Tested | Percentage of Ductwork to be Tested if Test Fails any Sample Twice |
|----------------------------------|---------------------------|---------------------|---------------------------------|--|
| 10 in. w.g. | 4 | 2 | 100 % | N/A |
| 6 in. w.g. | 4 | 2 | 100 % | N/A |
| 4 in. w.g. | 4 | 2 | 25 % | 50 % |
| 3 in. w.g. | 8 | 4 | 25 % | 50 % |
| 1/2, 1, and 2 in. w.g. | 16 | 8 | 10 % | 20 % |
- .9 Submit testing report, including leakage calculations, as a submittal complying with the requirements of Section 20 05 03.00 – SHOP DRAWINGS.
- 3.1.8. Do not commence insulation installation until testing report is submitted to Engineer's Representative and is reviewed by Engineer's Representative without requesting a resubmit.

- 3.1.9. Refer to Section 23 31 13.00 - DUCTWORK AND SPECIALTIES for pressure ratings of ductwork and systems.
- 3.1.10. Test HEPA filter housings by pressure decay (ANSI/ASME N510) and ensure leakage does not exceed 0.2 % duct volume/minute at 2500 Pa (10 in. W.G.).
- 3.1.11. Test the entire system for noise, tightness of joints and proper functioning of the system. Make noise tests under minimum system pressure drop conditions (highest air velocities and clean filter conditions). Make all necessary alterations and repeat the tests until satisfactory operation is achieved.
- 3.1.12. Adjust minimum outside air controller and adjust return air and exhaust air damper linkages to approximately design air quantities, for both maximum and minimum conditions where required, to ensure freezing conditions will not occur.
- 3.1.13. Ensure all necessary manual dampers for balancing the systems are installed.
- 3.1.14. Itemize the testing equipment in the test reports. Ensure calibration of the test equipment is current before any tests are undertaken and document calibration dates in test reports.
- 3.1.15. Be responsible for all equipment operating to design conditions and change fan sheaves, etc., to provide the required conditions.
- 3.1.16. Install new filters for the measuring and balancing process. Provide filters in accordance with Section 23 41 16.00 - DISPOSABLE FILTERS or as noted in the relevant air handling system Specifications and schedules.
- 3.1.17. Ensure that all necessary manual dampers for balancing are installed in all locations required.
- 3.1.18. Balance the entire air systems including air volumes and control settings under maximum system pressure drop conditions (filter at replacement condition).
- 3.1.19. Measure, make final adjustments and report upon: the air volume at each variable volume box, diffuser, register and grille; the air quantity handled by each fan; the static pressure upstream and downstream of the fan; the fan speed; and the motor current.
- 3.1.20. Report upon the air flow at outside, return and exhaust air dampers under conditions of minimum outside air, for maximum and minimum volumes and maximum outside air, exhaust air and return air.
- 3.1.21. Only take coil working conditions in conjunction with the fluid flow working conditions for the coil.
- 3.1.22. Ensure air volumes measured are within plus or minus 5 % of those shown on Drawings for diffusers, grilles, registers, variable air volume boxes and fans, at both maximum and minimum volumes shown.
 - .1 Take duct traverse readings through the access ports provided. Where no access ports have been provided, make new holes as required. Reseal these holes after final readings with sheet metal cover plates and sealant. Duct tape is not acceptable.
 - .2 Where insulation is damaged, repair it including the vapour barrier in an approved manner. Duct tape is not acceptable.
- 3.1.23. Do not disconnect any control device. Command control devices and enter adjusted set points into the building automation system with tools and training that are furnished under Section 23 09 00.00 - BUILDING AUTOMATION SYSTEM.
- 3.1.24. In all cases where measurements show failure to comply with the Drawings and Specifications, change fan sheaves, etc., as required, and make new balancing measurements.
- 3.1.25. Ensure all thermostats and controls are set to give specified conditions and include settings in report.

- 3.1.26. For additional information on variable volume boxes, refer to Section 23 36 16.00 - VARIABLE VOLUME BOXES.
- 3.1.27. Witness all system tests and sign all test reports. Include one copy of all test reports in each copy of the balancing reports.
- 3.1.28. Set up fans on all systems to give the minimum discharge pressure required to overcome the resistance of the box, discharge ductwork and diffusers.
- 3.1.29. Be responsible for balancing the systems to obtain the design conditions and repeat the balancing until the required conditions have been met.
- 3.1.30. At the time of final inspection, recheck in the presence of the Engineer's Representative random selections of air quantities and fan data recorded in the certified report. Points or areas for recheck shall be selected by the Engineer's Representative and be approximately 10 % of the report data.
- 3.1.31. At the time of verification, measure space temperature and humidity in a representative number of rooms to verify performance. Tabulate these results and bind into certified report as an appendix.
 - .1 A measured flow deviation of more than 10 % between the verification reading and the reported data shall be considered as failing the verification procedure.
 - .2 A failure of more than 10 % of the selected verification readings shall result in rejection of the report as unacceptable.
 - .3 In the event the report is rejected, rebalance all systems, submit new certified reports and make a reinspection, all at no additional cost to the Owner.
- 3.1.32. Following final acceptance of the certified reports by the Engineer's Representative, permanently mark the settings of all valves, dampers, and other adjustable devices so that balance set position can be restored if disturbed at any time. Do not mark such devices until after final acceptance.
- 3.1.33. Provide a digital copy of the final testing and balancing reports for review by the Engineer's Representative. Include 3 copies of the final testing and balancing reports in the O&M Manual. Ensure reports are complete with index pages and index tabs. Prepare any diagram as single line representation of a Mechanical System specifically prepared for this Project using a CAD system acceptable to the Engineer's Representative.
 - .1 Submit a sample to the Engineer's Representative for review.

TEST VERIFICATION SHEET - DUCTWORK

Test Number:

Date:

System:

Description and sketch of tested component

Test pressure Surface area of ductwork under test

Duct Leakage (cfm) Allowable duct leakage (cfm)

Duration of test

Test performed by: (signature)

Verified by: (signature)

(Printed name)

(Printed name)

(Company)

(Company)

Test witnessed by: (signature)

Test witnessed by: (signature)

(Printed name)

(Printed name)

(Company)

(Company)

END OF SECTION

23 09 00.00 Building Automation System (BAS)

1. General

1.1. WORK INCLUDED

- 1.1.1. Provide all labour, materials, Products, equipment and services to supply, install, test and commission new additions and integrate into existing Building Automation System (BAS) with Direct Digital Control (DDC) for building mechanical and electrical systems as indicated on Drawings and described herein.
- 1.1.2. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
- 1.1.3. Conform to Section 23 09 23.00 - SEQUENCE OF OPERATION FOR BAS.
- 1.1.4. Conform to Section 23 31 13.00 - DUCTWORK AND SPECIALTIES.
- 1.1.5. Conform to Section 23 35 16.00 - ELECTRIC POWER GENERATOR.

1.2. RELATED SECTIONS

- 1.2.1. Section 01 60 00.00 - BASIC PRODUCT REQUIREMENTS.
- 1.2.2. Section 20 05 14.00 - WIRING AND STARTERS.
- 1.2.3. Section 20 05 63.00 - ACCESS DOORS AND ACCESSIBILITY.
- 1.2.4. Section 20 08 00.00 - COMMISSIONING.
- 1.2.5. Section 26 05 01.00 - ELECTRICAL GENERAL REQUIREMENTS.
- 1.2.6. Section 27 00 05.10 – GENERAL INSTRUCTIONS FOR COMMUNICATION SECTIONS

1.3. PROJECT SCOPE PHASE 1

- 1.3.1. Install new network riser for BAS and future connection of other building systems. Ensure network allows for Rapid Spanning Tree Protocol (RTSP)
- 1.3.2. Input/output wiring, if it is installed per this Specification, can be reused.
- 1.3.3. Install new controls for all floor unitary equipment and connect to the BAS.

1.4. SYSTEM OUTLINE

1.4.1. General

- .1 The intent of this specification is to provide a system that is consistent with BMS systems throughout the owner's facilities running the Niagara 4 Framework.
- .2 The documentation contained in this section and other Contract Documents pertaining to Building Automation System (BAS) is schematic in nature. The Contractor shall provide all required hardware and software necessary to implement the functions shown or implied in the Contract Documents.
- .3 System architecture shall fully support a multi-vendor environment and be able to integrate third party systems via existing vendor protocols including, as a minimum, BACnet™, LonTalk, KNX, and Modbus
- .4 System shall be capable of data export via native MQTT.

- .5 System architecture shall provide secure Web access using any of the current versions of Microsoft Internet Explorer, Mozilla Firefox, or Google Chrome browsers from any computer on the owner's LAN.
- .6 Control system to consist of high-speed, peer-to-peer network of microprocessor based DDC controllers and web-based operator interface.
- .7 Control system to consist of microprocessor based DDC controllers.
- .8 DDC controllers shall be based on open type protocols, BACnet as defined by ANSI/ASHRAE standard 135-2012 for potential future connection to Building Automation System (BAS).
- .9 Control system to consist of high-speed, peer-to-peer network of microprocessor based DDC controllers and integrate with existing BAS.
- .10 Each system, building floor plan and control device shall be displayed through point-and-click graphics.
- .11 Owner shall receive all Administrator level login and passwords for engineering toolset at first training session. The Owner shall have full licensing and full access rights for all network management, operating system server, passwords, engineering and programming software required for the ongoing maintenance and operation of the BMS.
- .12 BAS shall provide support for smart phones & portable devices via one or more of the current common standards: Apple iOS (iPhone, iPad), Android Open Source Project (Android devices), Windows Mobile Devices.
- .13 BAS to operate on building LAN communication infrastructure.
- .14 The intent of this Specification is to provide a system that is consistent with BMS systems throughout the Owner's facilities running the Niagara Framework. Any control vendor that shall provide additional BMS server software shall be unacceptable. Only systems that utilize the Niagara Framework shall satisfy the requirements of this section.
- .15 All control devices furnished with this Section shall be programmable directly from the Niagara Framework embedded toolset upon completion of this Project. The use of configurable or programmable controllers that require additional software tools for post-installation maintenance shall not be acceptable.
- .16 Any control vendor that shall provide additional BMS server software shall be unacceptable. Only systems that utilize Niagara 4 Framework shall satisfy the requirements of this section.
- .17 OPEN NIC STATEMENTS - All Niagara software licenses shall have the following NiCS: "accept.station.in=*"; "accept.station.out=*"and "accept.wb.in=*"and "accept.wb.out=*". All open NIC statements shall follow Niagara Open NIC specifications.
- .18 Connect existing BAS to new BAS

1.4.2. Functional Principals

- .1 BAS to control mechanical and electrical equipment as specified in CONTROL SEQUENCES, SCHEMATICS AND EQUIPMENT SCHEDULES.
- .2 Controls to control mechanical and electrical equipment as specified in CONTROL SEQUENCES
- .3 System architecture to be modular permitting expansion of application software, system peripherals and field hardware.

- .4 Each controller to operate independently by performing its own specified control, alarm management, operator I/O and historical data collection receiving information from input field devices and controlling output field devices to perform the control sequences.
- .5 DDC controller may control more than one system provided that points associated with those systems are connected to that same controller.
- .6 DDC controllers to be configured so that main inputs and outputs from any control loop are located in that same controller.
- .7 Global points used for control loop reset such as outdoor air temperature are exempt from this requirement.
- .8 DDC controllers to be capable of operating with local closed loop programming, independent from the server if communication is interrupted.
- .9 Where PID control loops are called for in the sequences, they are to be implemented within the controller.
- .10 BAS server shall perform global control programs and data consolidation and storage, communicating and obtaining data from all controllers and transmitting instructions to all controllers.
- .11 The supplied system must incorporate the ability to access all data including graphics, reports and alarm detection using standard Web Browsers without requiring proprietary operator interface and configuration programs. An Open Data Base Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a Supplier-installed server for all database access. Systems requiring proprietary database and user interface programs shall not be acceptable
- .12 Support for the exchange of Comma-Separated Value (CSV) files must be provided.

1.4.3. Mechanical Contractor to carry the cost of Controls Contractor.

1.5. BASE BUILDING BAS PROVIDER

1.5.1. Approved Suppliers And Manufacturers

Supplier	Manufacturer Product Line	Address/ Location	Contact
HTS Engineering Limited	Distech	115 Norfinch Drive, Toronto, ON M3N-1W8	Steven Davis P: (416) 661-3400 Fax: (416) 661-0100E: steve.davis@hts.com
Modern Niagara	Distech	8125 Hwy 50 Vaughan, ON L4H 4S6	Mark Paolozzi t: 416-749-6031 m: 416-771-2639 MPaolozzi@modernniagara.com lbTEstimating@modernniagara.com
Convergint	Webs Schneider	15 Marmac Dr Suite 100, Etobicoke ON M9W 1E7	Steven Chadwick O : 905-6028622 M : 905-9299015 E : Steven.chadwick@convergint.com

Supplier	Manufacturer Product Line	Address/ Location	Contact
		360 Elgin St. Brantford, On N5Z 2V1	Devin Cousineau Phone: 519-281-9132 Email: devin.cousineau@convergint.com
Voyager Buildings	Optimizer Advance Controller Suite	5800 Ambler Dr. Unit #210, Mississauga, ON L4W 4J4	Abhishek Khurana (905) 808-9505 akhurana@voyagerbuildings.com
Automated Controls & Energy Solutions Group	Optimizer Advance Controller Suite	5285 Solar Dr Unit 103, Mississauga, ON L4W 5B8	Gezim Berisha Tel: (289) 622 - 9998 Ext: 105 gberisha@acesolutionsgroup.ca
Advanced Energy Management Ltd.	Optimizer Advance Controller Suite	466 Morden Rd, Oakville, ON, L6K 3W4	Braedon Gunovski Mobile (647-326-3336) Email: bgunovski@aemltd.com

1.6. OPEN PROTOCOL STANDARD

- 1.6.1. Intention of this Specification is to provide an integrated, open protocol BAS, BACnet as defined by ANSI/ASHRAE Standard 135.
- 1.6.2. BACnet devices on the lower tier network to support all BACnet functional groups, standard application services and standard object types necessary, but not limited to provide reading and writing functionality of all analog and binary inputs and outputs and change-of-value initiation and reporting between BACnet devices on the network.
- 1.6.3. All BACnet devices to be BTL tested. Provide Protocol Implementation Conformance Statement (PICS) for all BACnet devices.

1.7. SYSTEM COMMUNICATION ARCHITECTURE

- 1.7.1. New Riser is to be installed for the BAS. Ensure riser allows for Rapid Spanning Tree Protocol (RTSP)The first tier of the BAS network shall be based on Ethernet (ISO 8802-3/IEEE 802-3) communications, providing a high-speed local area network for reliable peer-to-peer communications. Future connected systems shall have compatibility specifications to provide communication with the first tier LAN. The operator workstations shall also be supported on the high speed LAN Tier 1. Communication speed on first tier network shall be at rate of 10 Mbps or higher.
- 1.7.3. Tier 1 to be integrated into the IP Network. Coordinate with the Owner and communication service provider for required number of IP addresses, required number and location of Ethernet ports and subnets; identification of Internet socket port number requirements for external communication through Owner firewall.
- 1.7.4. Typical office floors field controllers, including but not limited to VAV, CAV, FCU, etc., shall be set up in a Daisy Chain configuration. Typical floor network shall not traverse floors.

- .2 If floor field controllers are IP-based and daisy-chained, the network shall be looped back around to the network switch from the last controller, in addition to a network connection at the first controller of the loop. As a result, the Field controllers in the loop will have 2 connections to the network switch for redundancy.
- 1.7.5. The BAS Contractor shall provide system software based on server/thin-client architecture, designed around the open standards of web technology. The BAS server shall communicate using Ethernet and TCP. Server shall be accessed using a web browser over Owner intranet and remotely over the Internet.
- 1.7.6. The intent of the thin-client architecture is to provide the operator(s) complete access to the BAS system via a web browser. The thin-client web browser Graphical User Interface (GUI) shall be browser and operating system agnostic, meaning it will support HTML5 enabled browsers without requiring proprietary operator interface and configuration programs or browser plug-ins. Microsoft, Firefox, and Chrome browsers (current released versions), and Windows as well as non-Windows operating systems.
- 1.7.7. DDC controllers shall have communication port for temporary connection to laptop computer or operator interface device to allow downloads, uploads and other commissioning and troubleshooting operations.
- 1.8. EQUIPMENT SUPPLIED FOR INSTALLATION UNDER OTHER SECTIONS
- 1.8.1. Automatic control valves except otherwise noted.
- 1.8.2. Temperature sensor wells.
- 1.8.3. Terminal unit controllers including transformers. Ship to terminal unit manufacturer's facility for factory installation.
- 1.8.4. Motorized Dampers except otherwise noted. Verify damper sizes and connection type with Sheet Metal Contractor prior to ordering.
- 1.8.5. Dampers except otherwise noted. Verify damper sizes and connection type with Sheet Metal Contractor prior to ordering.
- 1.9. BAS PERFORMANCE
- 1.9.1. Graphic Display: Display the selected graphic representation at Operator Interfaces with current point object data at a minimum rate of twenty points in ten seconds.
- 1.9.2. Graphic Refresh: Update the selected graphic representation at Operator Interfaces with current point object data at a minimum rate of twenty points in ten seconds.
- 1.9.3. Data Scan: Update point object data at controllers and Operator Interfaces with current point object data at a minimum rate of once every ten seconds.
- 1.9.4. Binary Object Command: Controlled device will react within five seconds of an operator initiated command on a binary point object.
- 1.9.5. Analog Object Command: Controlled device will start to react within five seconds of an operator initiated command on an analog point object.
- 1.9.6. Alarmed Object Display: Alarm will annunciate visually and audibly at Operator Interfaces within five seconds on local area networks and within forty-five seconds on wide-area networks from the time the object entered the alarmed state.
- 1.9.7. Program Execution Rate: Provide ability to execute programs at a minimum rate of once every five seconds. Provide execution rates suitable for processes controlled.

- 1.9.8. PID Execution Rate: Provide adjustable execution rates for proportional-integral-derivative (PID) loops; update the controlled variable and command the controlled device at this same rate. Provide execution rates suitable for processes controlled.
- 1.9.9. Display and Report Accuracy: Provide minimum accuracy for point object data displayed at Operator Interfaces, reported to printers, reported to data files to Table 1: Display and Report Accuracy.

Table 1: Display and Report Accuracy.	
Point Object	Accuracy
Room Air Temperature	+/-0.2 deg. C (+/-0.36 deg. F) from actual
Duct Air Temperature	+/-0.2 deg. C (+/-0.36 deg. F) from actual
Outside Air Temperature	+/-0.2 deg. C (+/-0.36 deg. F) from actual
Dew Point Temperature	+/-1.5 deg. C (+/-2.7 deg. F) from actual
Water Temperature	+/-0.2 deg. C (+/-0.36 deg. F) from actual
Relative Humidity	+/-2 % of actual for 20% to 80% RH at 25 deg. C (77 deg.F)
Water Flow	+/-1.2 % of actual for 3.0 to 30.0 ft/s
Air Flow, Terminal Unit	+/-5.0 % of actual
Air Flow, Fan Bell and Duct	+/-5.0 % of actual
Air Flow, Pressurized Space	+/-3.0 % of actual
Air Pressure, Duct	+/-0.45 % of scale length
Air Pressure, Room	+/-0.45 % of scale length
Fluid Pressure (other than air)	+/-0.45 % of scale length (see Note 1)
Electrical (current, voltage, power)	+/-1.2 % of actual (see Note 2)
Carbon Monoxide	+/-3.2 % of actual
Carbon Dioxide	+/-3.2 % of actual
Note 1: For both absolute and differential pressure.	
Note 2: Does not include utility grade meters.	

- 1.9.10. Control Tolerance: Maintain controlled variable to control tolerance from set point to Table 2: Control Tolerance.

Table 2: Control Tolerance.		
Controlled Variable	Range	Control Tolerance from Set Point
Room Temperature		+/-0.6 deg. C (+/-1.1 deg. F)
Duct Temperature		+/-0.6 deg. C (+/-1.1 deg. F)
Humidity		+/-5 % RH
Air Flow		+/-1.0 % of scale length
Air Pressure	0-1500 Pa (0-6 in. w.g.)	+/-1.0 % of scale length

	-25 to 25 Pa (-0.1 to 0.1 in. w.g.)	+/- 10.0 % of scale length
Fluid Pressure (other than air)		+/- 1.0 % of scale length

1.10. SUBMITTALS

1.10.1. Product Data and Shop Drawings:

- .1 Within 30 days of award of contract, before start of construction, submit completely engineered and coordinated shop drawing package.
- .2 Before start of construction, submit completely engineered and coordinated shop drawing package including graphics samples
- .3 Submittals in printed format and as amended below.
- .4 Provide drawing files through Email to Client and S+A Representative.
- .5 Riser Diagrams: Indicate: communication wire paths and connections to network devices; power wire and ground wire connections to Operator Interfaces and network devices; wire types and port types with manufacturer's model numbers; communication protocol and communication speed for network segments; power panel and breaker designations; wire terminal designations; addresses for network devices; room designations.
- .6 Specifications and Instructions: Indicate: dimensions, capacities, electrical characteristics, mechanical characteristics, environmental characteristics, performance characteristics, finishes. Circle model number for Products provided or furnished. General catalogue sheets are not acceptable. Provide installation instructions.
- .7 System Flow Diagrams: Indicate: control devices, control device designation, control device range, control device fail-safe position, point object type, point object name, point object address. Indicate flow directions for gases and liquids relevant to the controlled process. Indicate hardwired interlocks between control devices and equipment. Indicate the location of field control devices.
- .8 Products Schedule: Indicate: Product designation, Product name, Product manufacturer, Product model number, Product data sheet reference number, quantities. Provide quantities required under the Work.
- .9 Valve Schedule: Indicate: system designation, service, medium, quantity, reference drawing, valve type, pipe configuration, fail position, pipe size, valve body size, valve design flow, valve design pressure drop, actual valve pressure drop, design Cv, valve Cv, design close-off, valve close-off, control type, control signal, connection type, valve model number.
- .10 Damper Schedule: Indicate: system designation, control device designation, duct dimensions, blade width, blade type, damper model number, calculated torque, actuator torque, actuator model number, actuator quantity, actuator fail-safe position, provisions for edge and blade seals and actuator mounting configuration.
- .11 Room Schedule: Indicate: controller object name, controller address, controller model number, application designation, room designation, VAV air volume set points, and sensor model numbers.
- .12 Cabinet Layouts: Interior: Indicate: orientation of contents including controllers, transformers, cable trays, terminal strips, relays, control devices, labels. Exterior: Indicate: orientation of gauges, displays, switches, labels.

- .13 Wire Details: Indicate: connections between control devices, controllers and equipment; connections to sources of power and grounds; control device designations, control device terminal designations, control device location; equipment terminal designations; cabinet terminal strip designations; wire designations. For control devices shown on multiple Drawings, indicate the control device with the same designation on all Drawings. Differentiate between manufacturer installed wire and field installed wire.
 - .14 Sequence of Operation: Provide a complete description of operation to Section 23 09 23.00 - SEQUENCE OF OPERATION FOR BAS. Provide description of operation for interlocks that directly connect to the Work. Indicate references to the system flow diagram by control device designation or point object name.
 - .15 Custom Application Programs (Algorithms): Provide in printed format to Section 23 09 23.00 - SEQUENCE OF OPERATION FOR BAS. Provide comments that describe the details of program functions.
 - .16 Flow Diagrams for Custom Application Programs (Algorithms): Provide in printed format to Section 23 09 23.00 - SEQUENCE OF OPERATION FOR BAS.
 - .17 Points Schedule: Indicate: input points, output points and virtual points for each controller. Indicate: point object address, point object name, point object description, point object alarm limits. List points in ascending order based on point object address.
 - .18 Submit floor plan drawing indicating the coverage of Thermostats sensors where applicable or a spreadsheet to convey the same information.
- 1.10.2. Samples:
- .1 Provide with submittal under Part 1: Product Data and Shop Drawings for approval by the Owner and/or Consultant:
 - .1 Graphic Representations: Conceptual layouts in printed format of images and point objects for systems under Part 3: Execution, Operator Interface. Indicate or explain which other graphic representations are directly accessed.
 - .1 Typical terminal unit floor plan graphic that shows conditions on occupied floor.
 - .2 Typical equipment room floor graphic.
 - .3 Typical graphic for each system and terminal unit.
 - .4 Typical navigation menu.
 - .5 One sample graphic for each equipment type.
 - .6 One sample graphic for chilled water system.
 - .7 One sample graphic for hot water system.
 - .2 Test Forms: In printed format for test forms under Part 3: Execution, Testing and Commissioning.
 - .3 Products: As specified under Part 3: Execution, Control Devices.
- 1.10.3. Work Schedule:
- .1 Provide a schedule of the Work within four weeks of contract award. Indicate: intended sequence of tasks, start dates, task durations, and delivery dates for material and equipment requiring long lead times, restraints on Work by other trades or situations.
 - .2 Provide monthly updated Work Schedule indicating percentage complete and revisions to expected delivery dates.
- 1.10.4. Values Schedule:

- .1 Provide a schedule of separate system prices that comprises the price of the Work of this Section within four weeks of contract award. In addition to the system price, indicate material and labour prices separately for the system. Indicate each mechanical and electrical system as a separate price. Indicate terminal unit systems of the same type on a floor as a separate system price for the respective floor. Include the price for communication networks and power networks allocated proportionately to the separate system prices. Indicate the Operator Interfaces as a separate system price. Include all costs associated with the Work of the system in the separate system price.
 - .2 The Values Schedule provides the basis for progress payments.
- 1.10.5. Project as-built documents:
- .1 Operation and Maintenance Manuals:
 - .1 Provide two copies in printed format for review by the Consultant at least ten weeks before the projected Substantial Completion date.
 - .2 Provide 2 copies of corrected manuals in printed format and three copies on Email to Client and S+A Representative within three weeks following completion of Acceptance Test under Part 3: Execution. Provide manuals in hard cover three-ring binders with index page and indexing tab per section.
 - .3 Sections:
 - .1 Contact Information: Provide names, addresses, 24-hour telephone numbers of service representatives and installing Subcontractors.
 - .2 Operation: Provide Owner operating manuals for Operator Interfaces, Controller Resident Software, DDC Controllers, Advanced Application Controllers, Specific Application Controllers, control devices, compressed air system. For Custom Application Programs (Algorithms) Editor, provide a reference manual for the language syntax that describes each function.
 - .3 Engineering, Installation and Maintenance: Provide manuals for design and installation of point objects, controllers, and control devices. Provide instructions for calibrating, troubleshooting and replacing controllers and control devices.
 - .4 Software: Provide complete original issue media and release notes for Operator Interfaces.
 - .5 Preventive Maintenance Procedures: Provide for Operator Interfaces, controllers, control devices. Provide a schedule of tasks; indicate dates for inspection, maintenance and calibration; indicate the pages in the engineering, installation and maintenance manuals that list the procedures.
 - .6 Replacement Parts List: Indicate: manufacturer name, manufacturer model number, Supplier name, Supplier address, Supplier telephone number.
 - .7 Certificates: Provide original issue certificates for installation, maintenance and calibration.
 - .8 Test Forms: Provide copies of test forms completed under Part 3: Execution, Testing and Commissioning.
 - .9 Provide certificate of pressure test under Part 3: Execution, Control Air Tubing.
 - .10 Provide licenses, guarantees and warranty documents for Products and systems.
 - .2 As-built Product data and Shop Drawings:

- .1 Provide drawing files through Email to Client and S+A Representative.
 - .2 Points Schedule: For points schedule generated under Part 1: Submittals, Product Data and Shop Drawings, indicate operating conditions for point object data; list point objects by system designation and alphabetically by point object name.
 - .3 Time-of-Day (TOD) Schedules: Indicate: objects assigned to the TOD Schedule, Occupied Mode times.
 - .3 As-built floor plans:
 - .1 Maintain on the Project site as-built conditions on one full-size set of Contract Drawings, referred to as marked-up drawings; indicate on these drawings as-built locations for: control devices, cabinets, network devices with network address, communication networks by type and address, connection points to communication networks for Operator Interfaces, power networks, conduit paths, junction boxes, Operator Interfaces.
 - .2 Submit three copies of marked-up drawings to Consultant for review within three weeks following successful completion of Acceptance Test under Part 3: Execution. Revise Contract Drawings to match the approved marked-up drawings; revise using AUTOCAD Release 12 or higher format and submit three copies as full-size in printed format and two copies electronically in a means discussed in as-built product data and Shop Drawings.
 - .4 Software Backup:
 - .1 Provide with as-built Product data and Shop Drawings.
 - .2 Provide three copies of complete BAS databases on Email to Client and S+A Representative.
 - .5 Training Manuals:
 - .1 Provide a course outline, and one copy in printed format of training manuals provided under Part 3: Execution, Instruction and Training at least six weeks prior to the first class. Modify the course outline and training materials to suit Owner's requirements and as requested by the Consultant.
- 1.11. WARRANTY
- 1.11.1. Warrant the Work free from defects in accordance with the requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS and as amended below.
- 1.11.2. Adjust, repair or replace defects and failures in the Work at no additional cost during the warranty period and without reduction in service to the Owner. Provide warranty service during normal business hours and within 24 hours of the Owner's request for service.
- 1.11.3. Provide warranty service by factory trained service representatives of the Supplier.
- 1.11.4. Replace Operator Interface software, Controller Resident Software, controller firmware and database files with revisions that correct deficiencies or defects during the warranty period at no charge to the Owner. Notify the Owner of changes and schedule the installation. Update Operation and Maintenance Manuals with firmware release notes.
- 1.11.5. Prior to testing date under Part 3: Execution, Acceptance Test, update firmware in controllers to latest revisions at no additional cost to the Owner; update Operation and Maintenance Manuals with firmware release notes.
- 1.11.6. During the warranty period check the tuning of each control loop once during heating season and once during cooling season; notify the Owner when this Work is to occur. Forward to the Consultant documentation indicating observations and adjustments made.

- 1.11.7. Warrant Products that are reconditioned under the Work to the same requirements as new Products.
- 2. Products
 - 2.1. MATERIALS
 - 2.1.1. Existing Products: To Part 3: Execution, Existing Products.
 - 2.1.2. New Products: Non-beta versions currently under manufacture and have been applied in similar installations for a minimum period of one year.
 - 2.1.3. Revisions: Latest available revision for Operator Software, Controller Resident Software and controller firmware at start of Warranty.
 - 2.1.4. Revisions: Latest available revision for Controller Resident Software and controller firmware at start of Warranty.
 - 2.1.5. Replacement Parts: Readily available and not scheduled for discontinuation at time of Total Project Completion.
 - 2.1.6. Expansion: Expandable through additional inputs and outputs and to card access, security, fire alarm, lighting control systems and other building systems.
 - 2.2. NETWORK
 - 2.3. BAS
 - 2.3.1. The Tier 1 network shall have the following minimum capabilities:
 - .1 The communication protocols utilized for peer-to-peer communications in Tier 1 will be BACnet IP. Use of a proprietary communication protocol for peer-to-peer communications in any Tier is not allowed.
 - .2 High speed data transfer for alarm reporting, point log reporting and uploading/downloading of programs.
 - .3 Single or multiple node failure reporting.
 - .4 Message and alarm buffering to prevent data loss.
 - .5 Rapid Spanning Tree Protocol (RTSP)
 - .6 Error detection, correction and re-transmission to ensure data integrity.
 - .7 Synchronization of the real time clocks in the Building Controllers and Advanced Application Controllers.
 - .8 Employ a device count capacity license model that supports expansion capabilities.
 - .9 Shall be enabled to support and shall be licensed with the following Open protocol drivers (client and server) by default:
 - .1 BACnet, MODBUS
 - 2.3.2. Provide a network that exceed the following capabilities:
 - .3 Data transfer rate of at least 10 Mbit/s for alarm reporting, point log reporting and uploading/downloading of programs.
 - .4 Single or multiple node failure reporting.
 - .5 Error detection, correction and re-transmission to ensure data integrity.

- .6 Synchronization of the real time clocks in the Building Controllers and Advanced Application Controllers.
- 2.3.3. Message and alarm buffering to prevent data loss shall be provided within the IP controllers.
- 2.3.4. Coordinate with base building local area network provider to ensure connectivity of all BAS devices and allocation of network ports.
- 2.3.5. A failure of any component or controller on the base building local area network shall not interrupt the execution of communication on this network.
- 2.3.6. Provide full communication capability across all systems including the base building local area network so that all BAS specified downloading, uploading, data transmission, control commanding, alarm handling and programming is achieved smoothly and transparently.
- 2.3.7. Review location and quantity of communication hub ports required for connection of lower tier networks to the Tier 1 network. Coordinate and arrange use of ports with Base Building Local Area Network Contractor.
- 2.3.8. BAS Network shall have an extra 25 % capacity for future expansion on all tiers.
- 2.3.9. Remote Network Access: For Local Area Network installations, provide access to the LAN from a remote location, via the Internet. The Owner shall provide a connection to the Internet to enable this access via high speed cable modem, asynchronous digital subscriber line (ADSL) modem, ISDN line, T1 Line or via the customer's Intranet to a corporate server providing access to an Internet Service Provider (ISP). Customer agrees to pay monthly access charges for connection and ISP.
- 2.3.10. Remote Network Access: For Local Area Network installations, provide access to the LAN from a remote location, via the Internet. The Owner shall provide a connection to the Internet.
- 2.4. CENTRAL SERVER
- 2.4.1. Provide industry standard hardware that meets or exceeds DDC System manufacturer recommended specifications and that can achieve response times required by Specification Section 1.11 BAS PERFORMANCE.
- 2.4.2. Minimum Computer Configuration (Hardware Independent).
 - .1 Central Server. Owner shall provide a dedicated BAS server with configuration that includes the following components as a minimum:
 - .2 Processor: Intel® Xeon® 4th Gen (or better), Intel® Core® i-series 12th Gen (or better), AMD® Ryzen® 5 Gen 3 (or better)
 - .3 Memory: 16 GB DDR4 minimum, 32 GB or more recommended for larger systems
 - .4 Hard Drive: SSD 512 GB minimum, more recommended depending on archiving requirements
 - .5 Network Support: Ethernet adapter (10/100/1000 Mb with RJ-45 connector)
 - .6 Video: 1080p (1920 x 1080) minimum resolution
 - .7 Operating System: Windows 11 x64-bit; Windows Server 2025; Linux x64-bit: RedHat Enterprise Linux 9.x, Ubuntu 24.04 LTS
 - .8 Browser: Chrome, Firefox, Microsoft Edge
 - .9 Mobile Browser: Safari on iOS, Chrome on Android
 - .10 Relational Database (optional): MS SQL Server 2022; MySQL Server 9.0
 - .11 Container Engine (for Containerized Supervisors): Docker, Inc.

- 2.4.3. Provide industry standard hardware that meets or exceeds DDC System manufacturer recommended specifications
- 2.4.4. Hard Disk to be capable of storing system software, one year of archive trend data at 15minute intervals and system database that is not less than twice the size of the database required when system is accepted. Provide additional external storage space if required.
- 2.4.5. Minimum server configuration to be the equivalent of current DELL or IBM small business server class computers.
- 2.4.6. Support Multi-Tasking and multi-user, TCP/IP network, Graphic Display Building Editor, Application software.
- 2.4.7. Operating system shall be Windows 10 LTSC using version 2019 or the latest compatible version.
- 2.4.8. Server shall include dual redundant power supplies. Server shall include data redundant hard disks (RAID).
- 2.4.9. All servers will be a 19-inch rack mountable.
- 2.5. OPERATOR INTERFACE
 - 2.5.1. Operator Software:
 - .1 Ensure new BAS addition is compatible with existing BAS. The integration to be seamless. If existing BAS is available remotely, new addition to also have the exact same experience and capabilities.
 - .2 Storage: Store trend data in Owner's server. Maintain twelve consecutive months of trend data on the Server for benchmark data. Store Analog data at 15 minute intervals and digital data when there is a change of value.
 - 2.5.2. NIAGARA ANALYTICS – GENERAL
 - .7 Provide a fault detection and analytic framework that utilizes a high-performance calculation engine. The engine shall permit real-time data to be combined with historical data using a set of wire and property sheets. The visual programming interface shall be used to define the algorithms (formulas) that analyzes the real-time and trend data collected from the BMS. At a minimum, Analytics for BMS fault detection and diagnostics, including sub-system alarm suppression as described in ASHRAE Guideline 36-2021 shall be provided.
 - .8 The output from the analysis shall be able to be visualized in charts, graphs and dashboards and be used as inputs to standard Niagara logic. Faults shall be prioritized according to the associated system, location, and the level of cost avoidance.
 - .9 When applied to historical and real-time data, the framework algorithms shall provide the following analysis features:
 - .10 An open and extensible analytical environment that can easily customized.
 - .11 Analytic tools that apply to any data types available from building sub-systems.
 - .12 The ability to set-up complex analysis without custom programming.
 - .13 Support for third party API visualization application programs

2.6. 3RD PARTY MANUFACTURER INTERFACE.

- 2.6.1. 3rd party manufacturer controllers included but not limited to chillers, boilers, variable frequency drives, power monitoring, medical gasses to be based on the open system communication (BACnet) for seamless integration with BAS. Include network connection from BAS to 3rd party manufacturer controllers.
- 2.6.2. If 3rd party manufacturer controllers are based on different open system standard than BAS, it is the responsibility of BAS Contractor to provide the appropriate interface for integration of that 3rd party manufacturer controller to BAS.
- 2.6.3. If open system controllers are not available, include all appropriate hardware equipment and software to allow bi-directional data communication between the BAS and 3rd party manufacturers' control panels.

2.7. CONTROLLER RESIDENT SOFTWARE

- 2.7.1. The software resides in Building Controllers and Advanced Application Controllers and is edited by means of the Operator Interface.
- 2.7.2. Security:
 - .1 Definition: Multiple operators are assigned access levels, and independent user login names and passwords are configurable.
 - .2 Processing: Automatically log off operator after an adjustable period of inactivity.
- 2.7.3. Alarms and Events:
 - .1 Definition: Alarm limits, alarm limit differentials, states and reactions shall be adjustable.
 - .2 Processing: Alarm and event messages are independently configured to route to network devices. Enable and disable alarms and events manually by the operator and automatically through Custom Application Programs.
- 2.7.4. Trends:
 - .1 Definition: Create, delete and modify trends. Title blocks, legends, sampling interval and start and stop time shall be configurable.
 - .2 Storage: Trend data is retrieved by the Operator Interface.
 - .3 Create trend logs for all AI/AO/BI/BO of the BAS. Analog points to be at 15 minute intervals and Digital points to be at Change of Value.
- 2.7.5. Time-of-Day (TOD) Schedules:
 - .1 Definition: Create, delete and modify TOD Schedules. Assign objects to TOD Schedules based on function and location.
- 2.7.6. Custom Application Programs (Algorithms):
 - .1 Definition: Create, delete and modify programs and program statements.
 - .2 Syntax Capabilities:
 - .1 Analog and binary point objects.
 - .2 Conditional statements (IF, THEN, ELSE, ELSE IF) using compound Boolean relations (AND, OR and NOT) and comparisons (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL).
 - .3 Floating-point arithmetic using operators for addition, subtraction, division, multiplication and square root; absolute value and minimum/maximum value arithmetic functions.

- .4 Predefined objects representing date, time of day, day of week, month of year and elapsed time.
 - .5 Create, delete and modify custom function blocks.
- 2.7.7. Maintenance Messages: Display at Operator Workstations. Indicate equipment name and maintenance required based on equipment run time, starts, and calendar date limits.
- 2.7.8. PID Control: PID (proportional-integral-derivative), PI and P algorithms for direct acting and reverse acting. Analog output is time-varying. Output control device is adjustable by the operator. Set point and gains are adjustable.
- 2.7.9. Optimal Start/Stop: Delay equipment start-up to latest possible time which will allow building space to reach target conditions by occupancy time. Advance shut-down of equipment to earliest possible time and maintain space target conditions until the end of occupancy time.
- 2.7.10. Enthalpy Economizer Control: Control outside, return and exhaust dampers based on inside and outside enthalpy comparisons.
- 2.7.11. Electrical Demand Management: Manage electrical demand by monitoring power consumption. If consumption exceeds operator adjustable level system to be capable of adjusting set-points, de-energizing low priority equipment and taking other pre-programmed actions as described in SEQUENCES OF OPERATION.
- 2.7.12. Chiller Optimization: sequence chillers and other chilled water plant equipment and reset chilled water and condenser water control set points, to provide cooling at minimum cost.
- 2.7.13. Load Reset: use the zone with the greatest load to reset the set-point of heating or cooling source.
- 2.7.14. Morning Warm-Up: compare outside and space temperatures and if outside air temperature is less than desired space temperature, run the system before occupancy with fully closed outside dampers until space temperature is satisfied.
- 2.7.15. Night Cool Down: compare outside and space temperatures and if outside air temperature is less than desired space temperature, run the system during unoccupied hours with outside dampers fully opened until space temperature is satisfied.
- 2.7.16. Equipment Sequencing: Sequence equipment with lead - leg, duty - standby and priority assignment based upon runtime or operator command as described in SEQUENCES OF OPERATION.
- 2.7.17. Staged Starts: Operator selectable time delays between starts for equipment on power restoration or scheduled start.
- 2.7.18. Anti-Short Cycling: Minimum on and minimum off times for equipment.
- 2.7.19. Dead-band Switch: Cycle a binary point object based on controlled point object and set point for direct acting and reverse acting. Differentials are adjustable.
- 2.7.20. Equipment Run Time Totalization: Accumulated run time expressed in unit hours and operator adjustable high runtime alarms.
- 2.8. DDC CONTROLLERS
 - 2.8.1. General
 - .1 Input/Output Interface
 - .1 Minimum Spare I/O Capacity: Controllers to have minimum 20% spare capacity or at least one of each type of I/O available on the controller. This does not apply to Application Specific Controllers
 - .2 Controllers to be swappable without disconnecting the wiring.

- .3 Controllers to continue to provide control functions in event of network communications failure.

2.9. DDC CONTROLLERS

2.9.1. General

- .1 Input/Output Interface:
 - .1 Analog Inputs:
 - .1 Signal: 4 to 20 mA, 0 to 10 VDC, thermistor, RTD.
 - .2 Binary Inputs:
 - .1 Detect dry contact closure.
 - .2 Wetting Current: Supplied by the controller.
 - .3 Pulsed Inputs:
 - .1 Detect pulse of dry contact closure.
 - .2 Pulse Frequency: Compatible with input device.
 - .3 Wetting Current: Supplied by the controller.
 - .4 Analog Outputs:
 - .1 Signal: 4 to 20 mA, 0 to 10 VDC. Provide range and zero adjustment.
 - .2 Accuracy Rating: +/- 1% of scale length.
 - .5 Binary Outputs:
 - .1 Triac: Rated for 0.5 A at 24 VAC
 - .2 Relay: NO or NC configuration, rated for 3 A at 24 VAC
 - .3 Provide secondary relay for higher loads.
 - .6 Minimum Spare I/O Capacity: Controllers to have minimum 20% spare capacity or at least one of each type of I/O available on the controller. This does not apply to Application Specific Controllers.
- .2 Controllers that perform scheduling operations to have on board real-time clock.
- .3 Controllers to continue to provide control functions in event of network communication failure.
- .4 Controllers to be swappable without disconnecting the wiring.
- .5 Immunity to Power: Rated for 90% to 110% of nominal voltage.

2.9.2. Building Controllers (BC):

- .1 Independent, networked, microprocessor-based for all internetwork control strategies.
- .2 Reside on Ethernet Tier 1 BAS network.
- .3 Manage connected input and output control devices; transmit real and virtual point object data to distributed controllers and Operator Interfaces and provide global strategy and direction.
- .4 Continuous monitoring of processor, memory and communication circuits; assume a predetermined failure mode for abnormal conditions; assume a failsafe operating mode for failed communication with objects.
- .5 Communicates to card access, security, fire alarm, lighting control systems.
- .6 Service communication port for communication with Portable Operator Terminals.

- .7 Memory: Non-volatile EEPROM for firmware. Seventy-two hours battery backed memory for object database and custom application programs.
 - .8 Each BC to support firmware upgrades without need to replace hardware.
 - .9 Environment: Suitable for anticipated ambient conditions.
 - .10 Serviceability: LEDs for power, communication and processor status.
- 2.9.3. Advanced Application Controllers (AAC):
- .1 Independent, networked, microprocessor-based.
 - .2 Reside on lower tier BAS network (BACnet or LON).
 - .3 Manage connected input and output control devices; transmit real and virtual point object data to distributed controllers and Operator Interfaces.
 - .4 Continuous monitoring of processor, memory and communication circuits; assume a predetermined failure mode for abnormal conditions; assume a failsafe operating mode for failed communication with objects.
 - .5 Service communication port for communication with Portable Operator Terminals.
 - .6 Memory: Non-volatile EEPROM for firmware. Seventy-two hours of battery backed memory for object database and custom application programs.
 - .7 Each AAC to support firmware upgrades without need to replace hardware.
 - .8 Environment: Suitable for anticipated ambient conditions.
 - .9 Serviceability: LEDs for power, communication and processor status.
- 2.9.4. Application Specific Controllers (ASC):
- .1 Microprocessor-based networked. Non-adjustable programs with operator adjustable settings for customized operation within equipment design limits.
 - .2 Reside on lower tier BAS network (BACnet or LON).
 - .3 Service communication port for communication with Portable Operator Terminals.
 - .4 Memory: Non-volatile EEPROM memory for firmware and program data.
 - .5 Environment: Suitable for anticipated ambient conditions.
 - .6 Serviceability: LEDs for power, communication and processor status.
- 2.10. POWER SUPPLIES AND LINE FILTERING
- 2.10.1. Provide a separate power supply for every Building Controller, Advanced Application Controller and Application Specific Controller for terminal units.
- 2.10.2. Power Supplies:
- 2.10.3. Power Supply Voltage: 24 V, unless indicated otherwise on Drawings.
- 2.10.4. Type: Enclosed; Class 2 current-limiting, or over-current protection in primary and secondary circuits for Class 2 service to the National Electrical Code.
- 2.10.5. Applied Loads: To 80% of rated capacity.
- 2.10.6. DC Power Supplies: Regulated output.
- 2.10.7. Built in over voltage and over current protection.
- 2.10.8. Able to withstand 150% current overload for at least 3 seconds without trip or failure.
- 2.10.9. Power Line Filtering: Provide internal or external transient voltage and surge suppression for workstations and controllers.

2.11. CABINETS

- 2.11.1. Type: NEMA rated and suitable for installed environment.
- 2.11.2. Door: Hinged with key-lock latch with common key for all cabinets; provide duplicate keys; for Application Specific Controllers provide screwed tight slide-off cover.
- 2.11.3. Controllers, transducers and relays mounted on backing board or DIN rails within inner section behind hinged doors.

2.12. CONTROL DEVICES

- 2.12.1. For smoke dampers, and combination smoke and fire dampers, refer to the requirements of Section 23 31 13.00 – DUCTWORK AND SPECIALTIES.
- 2.12.2. Motorized Control Dampers:
 - .1 Sizing:
 - .1 Dimensions: As indicated. Maximum damper section size: 1200 mm x 1500 mm (48 in. x 60 in.). For dampers larger than the section maximum, use an assembly of multiple, equally sized sections.
 - .2 Two-position: Parallel blade.
 - .3 Modulating: Opposed blade. Parallel blade dampers may be used for return air and bypass applications.
 - .2 Frame: 125 mm x 25 mm x 3 mm (5 in. x 1 in. x 0.125 in.) 6063T5 extruded aluminum with mounting flanges on both sides.
 - .3 Blades: Airfoil shape, 6063T5 extruded aluminum, maximum 150 mm (6 in.) depth.
 - .4 Seals:
 - .1 Blade Edge: Extruded thermoplastic rubber (TPR) suitable for -58 deg. C to 135 deg. C (-72 deg. F to 275 deg. F), mechanically locked in place and easily replaceable in the field.
 - .2 Blade Jamb: Spring-loaded stainless steel.
 - .5 Bearings: Molded synthetic.
 - .6 Linkage: Corrosion resistant steel and concealed in the frame.
 - .7 Drive Shaft: Corrosion resistant steel of square or hexagon shape.
 - .8 Axle: Corrosion resistant steel.
 - .9 Leakage: Maximum 40.6 L/s/sq m (8 CFM/sq ft) at 1.0 kPa (4 in. w.g.) of differential pressure across fully closed damper when tested to AMCA Standard 511.
 - .10 Make and Model: Ruskin CD-50 or equivalent.
- 2.12.3. Motorized Control Dampers (Thermally Insulated):
 - .1 Sizing:
 - .1 Dimensions: As indicated. Maximum damper section size: 1524mm x 1829 mm (60 in. x 72 in.). For dampers larger than the section maximum, use an assembly of multiple, equally sized sections.
 - .2 Two-position: Parallel blade.
 - .3 Modulating: Opposed blade. Parallel blade dampers may be used for return air and bypass applications.
 - .2 Frame: 125 mm x 25 mm x 3 mm (5 in. x 1 in. x 0.125 in.) 6063T6 extruded aluminum with mounting flanges on both sides.

- .3 Blades: Airfoil shape, 6063T6 extruded aluminum, maximum 150 mm (6 in.) depth, injected with high density polyurethane foam insulation with thermal isolation gap.
 - .4 Seals:
 - .1 Blade Edge: Mechanically fastened extruded Ruskiprene suitable for -43 deg. C to 85 deg. C (-45 deg. F to 185 deg. F), and easily replaceable in the field.
 - .2 Blade Jamb: Ribbed extruded Ruskiprene.
 - .5 Thermal Efficiency Ratio: 345 % or higher.
 - .6 Linkage: Corrosion resistant steel and concealed in the frame.
 - .7 Drive Shaft: Corrosion resistant steel of square or hexagon shape.
 - .8 Axle: Corrosion resistant steel.
 - .9 Leakage: Maximum 40.6 L/s/sq m (8 CFM/sq ft) at 1.0 kPa (4 in. w.g.) of differential pressure across fully closed damper when tested to AMCA Standard 511.
 - .10 Make and Model: Ruskin TED-50 or equivalent.
- 2.12.4. Actuators For Dampers, Electronic:
- .1 Actuator Type: Modulating, except as indicated below for VAVs.
 - .2 Control Signal: Compatible with BC, AAC and ASC.
 - .3 Floating control signal is acceptable only for VAV damper application.
 - .4 Operating Time: Maximum 120 seconds throughout the full rotation.
 - .5 Angle of Rotation: Adjustable between 0° to 90°.
 - .6 Stall protection: Mechanical or electronic.
 - .7 Actuators shall have electronic overload protection or digital rotation sensing circuitry to prevent actuator damage throughout the entire rotation.
 - .8 Failsafe:
 - .1 For VAV terminals, refer to Section 23 36 16.00 – VARIABLE VOLUME BOXES.
 - .2 For generator applications, refer to Section 23 35 16.00 – ELECTRIC POWER GENERATOR.
 - .3 For other applications, drive damper to fail position in 15 seconds.
 - .9 Manual Override: Crank type. External gear release for fail in place actuators.
 - .10 Position Indicator: Reversible for clockwise or counter-clockwise rotation; set the 0 degrees mark to the failsafe position.
 - .11 Torque: To damper manufacturer's requirements to provide complete compression of seals between frame and blades and for smooth control.
 - .12 Provide 2 adjustable SPDT auxiliary switches to prove open-closed.
- 2.12.5. Control Valves:
- .1 Characteristics, materials and pressure ratings suitable for the application; refer to schedules.
 - .2 Flow Characteristic:
 - .1 Water:
 - .1 Two-way: Equal percentage.
 - .2 Three-way: A Port: Equal percentage. B Port: Linear or modified linear.
 - .3 Sizing Water Valves:
 - .1 Two-position: Line size with full ports.

- .2 Two-way Modulating: Non Radiation: Pressure drop equal to the pressure drop through the coil or 27 kPa (4 psi), whichever is greater. Radiation: Pressure drop equal to 7 kPa (1 psi).
- .3 Three-way Modulating: Non Radiation: Pressure drop equal to the pressure drop through the coil or 27 kPa (4 psi), whichever is greater. Radiation: Pressure drop equal to 7 kPa (1 psi).
- .4 Butterfly Valves:
 - .1 Type: High-performance (HPBV).
 - .2 Make and Model: Dezurik BHP or equivalent.
 - .3 Tee-fitting: Provide for three-way application; with motor mounting bracket and linkage hardware.
- .5 Valves 12 mm (1/2 in.) through 50 mm (2 in.):
 - .1 Screwed ANSI Class 250 bronze body.
- .6 Valves 62 mm (2-1/2 in.) and Larger:
 - .1 Water temperature less than 121 deg. C (250 deg. F) at 1035 kPa (150 psi) or less than 93.2 deg. C (200 deg. F) at 1139 kPa (165 psi): Flanged ANSI Class 125 cast iron body.
 - .2 Water temperature greater than 121 deg. C (250 deg. F) at 1035 kPa (150 psi) or greater than 93.9 deg. C (200 deg. F) at 1138 kPa (165 psi): Flanged ANSI Class 250 cast iron body or ANSI Class 300 cast steel body.
- .4 Sizing Steam Valves:
 - .1 Two-position: Pressure drop equal to 10% to 20% of inlet pressure.
 - .2 Modulating: Pressure drop equal to 50% of inlet pressure.
 - .3 Leakage: ANSI Class IV.
 - .4 Materials:
 - .1 Stems: Stainless steel.
 - .2 Plugs and Seats: Brass or steel.
 - .3 Packing: PTFE for steam.
 - .5 Rangeability: 40:1 minimum.
- 2.12.6. Pressure Independent Control Valves:
 - .1 Factory fabricated of type, body material, and pressure class based on maximum pressure and temperature rating of the piping system, unless otherwise indicated.
 - .2 Calibrated Balancing Valves and Automatic Flow-Control Valves shall not be required on devices where pressure independent control valves are installed.
 - .3 The control valves shall accurately control the flow from 0 to 100% full rated flow with an equal percentage flow characteristic.
 - .4 Each control valve shall be individually flow tested and factory verified to deviate no more than $\pm 5\%$ through the operating pressure range. A calibrated performance tag shall be provided with each valve (optional for 1/2" [15mm]) listing the measured flow rate in 10° rotation increments.
 - .5 Valve bodies 2" [50mm] and smaller shall be brass. Valve bodies 3" [80mm] thru 8" [200mm] shall be ductile iron. All internal parts shall be brass, carbon steel, stainless steel or Teflon®. Plastic internal parts are not acceptable

- .6 Control valve rangeability shall be 100:1 minimum.
 - .7 Warrant all components for a period of 5 years from the date of Substantial Performance of the Work.
 - .8 The actuator shall be the same manufacturer as the valve, integrally mounted to the valve at the factory, or shall be provided with universal mounting plate to allow installation of actuators meeting system electrical and valve torque requirements.
 - .9 If valves have additional features such as energy management or temperature monitoring, these aspects are to be fully integrated into BAS using BACnet IP or MS/TP. All available information to be communicated to BAS.
 - .10 All necessary low-voltage power requirements for the valves should be provided.
- 2.12.7. 6-way control valves and actuators
- .1 Construction: Size 13 mm to 19 mm (1/2 in to 3/4 in)
 - .1 Body: forged brass
 - .2 Ball: chrome plated forged brass
 - .3 Stem: chrome or nickel plated forged brass or stainless steel
 - .4 Seat: PTFE
 - .5 O-rings: EDPM
 - .6 Pressure rating: minimum 1586 kPa (230 psi) with minimum close off pressure of 345 kPa (50 psi)
 - .7 Temperature rating: 6 deg. C (43 deg. F) to 82 deg. C (180 Deg. F)
 - .2 Option 1:
 - .1 Actuator: 6 way control valve, 90 degrees range, manual over-ride, 24 VAC, fail in place operation. First 30 degrees opens source A, next 30 degrees valve is closed, final 30 degrees opens source B.
 - .1 Flow characteristics: Linear
 - .2 Pair with a pressure independent balancing control valve to achieve equal percentage characteristics for both flow streams.
 - .2 Manufacturers:
 - .1 Victaulic TA Series 76W 6 way valve with TA M106 CO Actuator; and
 - .2 Victaulic TA-Modulator pressure independent balancing control valve
 - .3 Option 2:
 - .1 Actuator: 6 way control valve, 90 degrees range, manual over-ride, 24 VAC, fail in place operation. First 30 degrees opens source A, next 30 degrees valve is closed, final 30 degrees opens source B.
 - .1 Flow characteristics: Linear using characterized ball valve.
 - .2 Select valve flow coefficient (Cv) for each source separately and specifically for this application.
 - .2 Manufacturers:
 - .1 Siemens: 599 Series 6-way ball valve.
 - .2 Belimo: 6-Way Characterized Control Valves (CCV)
- 2.12.8. Actuators for Control Valves, Electronic:
- .1 Type: Modulating, proportional flow control.
 - .2 Control Signal: Compatible with BC, AAC and ASC.

- .3 Floating control signal is not acceptable.
 - .4 Operating Time: Maximum 120 seconds throughout the full rotation.
 - .5 Mounting: Corrosion resistant hardware.
 - .6 Stall Protection: Electronic overload or digital rotation sensing.
 - .7 Failsafe: Fail in place for terminal reheat coils; fail open for all other heating valves; fail open for critical cooling valves (e.g. server or IT rooms), fail closed for all other cooling valves. Spring return to fail position within 15 seconds. Battery or capacitor return are not acceptable. Refer to Sequence Of Operation for alternate fail positions as may be required.
 - .8 Manual Override: Crank type. External gear release for fail in place actuators.
 - .9 Position Indicator: Provide. Indicate valve open and closed positions.
 - .10 Sound level: Provide actuator with 30 dBA maximum sound level where valves are located within or near bedrooms. Provide additional acoustic cover as may be required to meet acoustic requirements in these areas. Confirm acoustic cover will not result in overheating of actuator. Coordinate cover to fit within radiator cabinets as may be required.
 - .11 Close-off Pressure:
 - .1 Water:
 - .1 Two-way: 150% of total system head.
 - .2 Three-way: 300% of the pressure differential between ports A and B at design flow, or 100% of total system head.
 - .2 Steam: 150% of inlet pressure.
- 2.12.9. Electric Relays:
- .1 Type: General purpose; enclosed coil; diodes provided for inductive switched loads; override button; LED "energized" indicator; plug-in type base.
 - .2 Contact rating, configuration and coil voltage suitable for application.
 - .3 Regulatory: UL listed.
- 2.12.10. Damper End Switches:
- .1 Type: Lever operated activated by blade position.
 - .2 Electrical Contacts: Rated for 10 A resistive, 6 FLA at 120 VAC.
 - .3 Regulatory: UL listed.
- 2.12.11. Level Switches:
- .1 Type: Float.
 - .2 Electrical Contacts: Rated for 10 A resistive, 6 FLA at 120 VAC.
 - .3 Mounting: Outside of measured fluid.
 - .4 Enclosure: NEMA rated for the application.
- 2.12.12. Ultrasonic Level Transmitter:
- .1 Service: Compatible fluids. Not for use with powder and bulk solids.
 - .2 Accuracy: $\pm 0.2\%$ of maximum range.
 - .3 Resolution: 0.079" (2 mm).
 - .4 Output Signal: 4 to 20 mA (Two-wire).
 - .5 Temperature Compensation: Automatic.

- .6 Enclosure Rating: NEMA rated for the application.
- .7 Failsafe: On lost echo after 30 seconds, user selectable to 4, 20, 21, 22 mA or last signal.
- .8 Display: 6 character LCD.
- .9 Agency Approvals: CE compliance, FM approved.
- 2.12.13. Low Limit Electromechanical Thermostat:
 - .1 Type: Vapour Pressure; minimum 6000 mm (20 ft.) of capillary; actuated by any 300 mm (12 in.) of capillary element; manual reset upon activation.
 - .2 Electrical Contacts: Double-pole double-throw (DPDT), snap-acting; rated for 10 A resistive, 6 FLA at 120 VAC.
 - .3 Adjustable Set Point: Range: -1 deg. C to 13 deg. C (30 deg. F to 55 deg. F) and set to 1.67 deg. C (35 deg. F).
 - .4 Regulatory: UL listed.
- 2.12.14. High Limit Electromechanical Thermostat:
 - .1 Type: Bimetallic sensing; manual reset upon activation.
 - .2 Mounting: Air stream.
 - .3 Electrical Contacts: Single-pole single-throw (SPST), normally closed, snap-acting; rated for 10 A resistive, 6 FLA at 120 VAC.
 - .4 Adjustable Set Point: Range: 38 deg. C to 66 deg. C (100 deg. F to 150 deg. F) and set to 57 deg. C (135 deg. F).
- 2.12.15. Electromechanical Thermostat:
 - .1 Wall Mount:
 - .1 Provide samples of covers to Part 1: Submittals, Samples.
 - .2 Low Voltage:
 - .1 Type: 24 VAC, bimetal-operated, mercury-switch; adjustable or fixed anticipation heater; vented ABS plastic concealed cover.
 - .2 Set Point: Range: 13 deg. C to 30 deg. C (55 deg. F to 85 deg. F); 1 deg. C (2 deg. F) maximum differential.
 - .2 Line Voltage:
 - .1 Type: Bimetal-actuated open contact, or bellow-actuated enclosed snap-switch type, or equivalent solid state type; anticipation heater; vented metal concealed cover.
 - .2 Electrical Contacts: Rated for 10 A resistive, 6 A FLA at 120 VAC.
 - .3 Set Point: Range: 13 deg. C to 30 deg. C (55 deg. F to 85 deg. F); 1 deg. C (2 deg. F) maximum differential.
 - .4 Regulatory: UL listed.
- 2.12.16. Digital Thermostat:
 - .1 Digital thermostats shall be 7-day programmable digital type suited for the application.
 - .2 Standalone terminal units shall utilize a digital thermostat where shown on Drawings.
 - .3 Digital thermostat shall have user selectable engineering units (F or C) and set point adjustment.
 - .4 Digital thermostat shall support automatic daylight savings time switchover.

- .5 Digital thermostat shall support automatic and manual heat/cool changeover when applicable.
 - .6 Digital thermostat shall support temporary set point adjustment with automatic return to normal operation.
- 2.12.17. Temperature Sensors:
- .1 General Requirements:
 - .1 Temperature sensors shall be of the resistance type, two-wire 1000 ohm nickel RTD, two-wire 1000 ohm platinum RTD or two-wire 10,000 ohm thermistor.
 - .2 Space Temperature Sensors:
 - .1 Stainless Steel plate sensors or white-plate sensors For installation throughout the facility where local control is not required (such as corridors or lobby) unless otherwise noted.
 - .3 Space Temperature Sensors With Adjustable Set-Point, Override and Display:
 - .1 Key pad or slider for temperature set-point adjustment.
 - .2 LED display.
 - .3 Timed override request push button with LED status for activation of after-hours operation.
 - .4 For installation only where indicated on Drawings, controls diagrams or sequences of operations.
 - .4 Covers for Wall Mount Sensors:
 - .1 Overrides: Exposed set point adjustment and override button.
 - .2 Communication Port: For communication between Portable Operator Terminals and ASC controllers.
 - .5 Averaging Temperature Sensors:
 - .1 Minimum 1.5 m (5 ft) of capillary per 1 sq m (10 sq ft) of duct cross-section.
 - .2 Provide multiple sensors where single averaging element is unable to be positioned to provide complete duct or plenum traverse.
 - .6 Outside Air Temperature Sensors:
 - .1 Outside air temperature sensors shall be designed to withstand the environmental conditions to which they will be exposed.
 - .2 The sensors shall be provided with a solar shield.
 - .3 Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.
 - .7 Duct Temperature Sensors:
 - .1 Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
 - .2 Probe length shall be no less than 1/3 of the duct width or diameter.
 - .3 For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.
 - .8 Thermowells:
 - .1 Brass or Type 316 stainless steel suitable for the application.
 - .2 Heat transfer compound compatible with sensing element.
 - .9 Guards for Sensors and Thermostats:

- .1 Materials: Heavy gauge steel.
- 2.12.18. Relative Humidity Sensors:
 - .1 Sensors shall be calibrated to NIST standards.
 - .2 Sensing Element:
 - .1 Type: Thin film capacitance.
 - .3 Transmitter:
 - .1 Range: 0 to 100% RH.
 - .2 Signal: 4 to 20 mA or 0-10 VDC with span and zero adjustment.
 - .4 Accuracy Rating: +/- 2 % of output reading.
 - .5 Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure.
 - .6 Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.
- 2.12.19. Pressure Sensors:
 - .1 General:
 - .1 Sensing Element:
 - .1 Type: Capacitance sensing.
 - .2 Materials: Suitable for continuous contact with measured medium.
 - .2 Transmitter:
 - .1 Range: Not to exceed two times the operating pressure.
 - .2 Signal: 4 to 20 mA or 0-10 VDC; with zero and span adjustment.
 - .3 Accuracy Rating: +/- 1.0 % of full scale.
 - .4 Response Time: Maximum 0.5 seconds.
 - .3 Isolation Valve: Between process connection and sensor.
 - .1 Capable of withstanding 100% overpressure without damage
 - .4 Air Static Pressure Sensors:
 - .1 Sensing Element:
 - .1 Type: Capacitance sensing with pitot tube sensing tips screwed securely to duct.
- 2.12.20. Submersible Pressure Sensor:
 - .1 The sensor housing shall be made from high strength stainless steel or titanium for pressure ranges 1.25 times the maximum system pressure and compatible with a wide range of liquids.
 - .2 The sensor shall be vented through the cable to correct for barometric pressure changes.
 - .3 Sensor over range protection shall be two times rated pressure.
 - .4 Accuracy shall be +/- 0.25% of the full scale or better.
 - .5 Available control signals shall be 2-10 VDC or 4-20 mA.
- 2.12.21. AC Current Sensing Switches:
 - .1 Type: Self-powered solid-state with split-core.
 - .2 Electrical Contacts: Rated for 1 A resistive at 30 VAC/DC.

- .3 Insulation Rating: 600 VAC.
- .4 Adjustable trip point with LED status indicator.
- 2.12.22. AC Current Transducers:
 - .1 Type: Self-powered or loop-powered solid-state with split-core.
 - .2 Amperage Range: Motors: Factory calibrated to LRA; Switchgears: Factory calibrated to design load.
 - .3 Insulation Rating: 600 VAC.
 - .4 Signal: 4 to 20 mA or 0-10 VDC; internal zero and span adjustment.
 - .5 Accuracy Rating: +/- 2 % of full scale.
 - .6 Regulatory: UL listed or CSA approved.
- 2.12.23. CO2 Sensors:
 - .1 Sensor shall employ non-dispersive infrared technology (NDIR).
 - .2 Accuracy shall be +/- 75 ppm over 0-1500 ppm range.
 - .3 Response time shall be less than 1 minute.
 - .4 Sensor shall have field selectable 0-10 VDC and 4-20 mA outputs.
 - .5 Power voltage shall be 20-30 VDC/AC.
 - .6 Operating temperature range shall be 0°C to 50°C.
 - .7 The sensor shall be wall mount.
- 2.12.24. Gas Detection System:
 - .1 Gas Detection Controller:
 - .1 Use: Centralized gas detection monitoring with real-time gas reading, selective alarm activation
 - .2 Enclosure: NEMA 4X Polycarbonate - ABS
 - .3 Power Requirement: 17-27 Vac, 24-38 Vdc, 500 mA
 - .4 Network: Three Modbus channels for up to 96 transmitters and an optional BACnet/LON/IP output; Communication Line Up to 609 m (2000 ft.) per channel
 - .5 Alarm Levels: fully programmable alarm levels; Time Delays 0, 30 sec., 45 sec., 1-99 minutes before and after alarm
 - .6 Outputs: 4 DPDT relays (alarms and/or fault) at 5 A, 30 Vdc or 250 Vac (resistive load); 65dBA buzzer
 - .7 Display: 122 x 32 dot matrix LCD display
 - .8 Operating Humidity Range: 0-95% RH, non-condensing
 - .9 Operating Temperature Range: -20 to 50°C (-4 to 122°F)
 - .10 Certifications: CAN/CSA C22.2 No 61010-1
 - .11 Conforms to: ANSI/UL 61010-1; IEC 61010-1 Including Amendments A1:1992 + A2:1995 and National Deviations (Canada, US)
 - .12 Make and Model: Honeywell 301C, Belimo Opera Model 6000, or equivalent.
 - .2 Wired or Stand-Alone Gas Transmitter:
 - .1 Use: Wall mounted, wired gas detector transmitter used in conjunction with controller

- .2 Power Requirement: 24 Vac nominal (17-27), 50/60 Hz, 0.35A; 24 Vdc nominal (20-38Vdc)
- .3 Network: Modbus RS-485; BACnet MS/TP master
- .4 Display: 8 character, 2 line backlit LCD
- .5 Visual Indicators: Green LED; Power, Amber LED 1: Alarm/ Fault, Amber LED 2: Alarm/ Fault
- .6 Audible Alarm: >85 dBA at 3m (10ft)
- .7 Relay Output: Network 1 DPDT relay, 5A @ 250Vac; 5A @ 30 Vdc; Stand Alone 2x DPDT relay, 5A @ 250Vac; 5A @ 30 Vdc
- .8 Sensing Technology: Toxic = Electrochemical; Combustibles = Catalytic; Oxygen = Diffusion fuel cell
- .9 Accuracy: Toxic, Combustibles, Oxygen = +/- 3%
- .10 Detection Range: Carbon Monoxide = 0 - 250 ppm; Nitrogen Dioxide (NO₂) = 0-10 ppm; Oxygen = 0-1 ppm; Combustibles = 0-100% LEL;
- .11 Certified to: CAN/CSA C22.2 No. 61010-1
- .12 Conforms to: ANSI/UL 61010-1
- .13 Sensors Make and Model: Honeywell E3 Point, Belimo Opera Model 6000, or equivalent.

2.12.25. Refrigerant Gas Detection System:

- .1 Gas Detection Controller /Expansion Module - Inside Mechanical Room
 - .1 Use: Centralized Stand Alone refrigerant gas detection monitoring main controller with real-time gas reading, selective alarm activation
 - .2 Power Requirement: 22-27 Vac, 29-38 Vdc, 2A max @ 29Vdc
 - .3 Up to 20 gas transmitters, Digital Communication Modbus RS-485 Line, Up to 61 m (200 ft.) from the controller.
 - .4 Alarm Levels: 3 fully programmable alarm levels
 - .5 Outputs: 4 DPDT form C relays (alarms and/or fault) at 5 A, 30 Vdc or 250 Vac (resistive load); 65dBA buzzer, 3 Outputs at 24 Vdc @ 250 mA each
 - .6 Integral Strobe/Horn: STAS flashing LED/105dBA, 4-28V, 2800Hz (RFSA)
 - .7 Display: 122 x 32 dot matrix backlit LCD display
 - .8 Visual Indicators: - Green LED - Normal Operation
 - .9 Red LED Gas Alarm A, B, and C
 - .10 Yellow LED: Fault/Service
 - .11 The Controller/expansion module must provide all the functionalities necessary to comply with current ASHRAE 15 guidelines and CSA B-52 Mechanical Codes.
 - .12 Manual Fan Start/Stop operation
 - .13 Audible Alarm with a silence key to acknowledge
 - .14 Visible Alarm
 - .15 Operating Humidity Range: 0-95% RH, non-condensing
 - .16 Operating Temperature Range: 0°C to 40°C (32°F to 100°F)
 - .17 Enclosure rating: NEMA 4X, ABS - Polycarbonate - indoor
 - .18 Certifications: CAN/CSA C22.2 No 61010-1

- .19 Conforms to: ANSI/UL 61010-1; IEC 61010-1 Including Amendments A1:1992 + A2:1995 and National Deviations (Canada, US)
- .20 Make and Model: Honeywell 301EM RFSA or equivalent
- .2 Gas Detection Remote Annunciator Panel: Outside Mechanical Room
 - .1 Use: Remote Annunciator / Slave display panel located outside each entrance to Mechanical room
 - .2 Power Requirement: 22-27 Vac, 50 or 60 Hz, 29-38 Vdc, 2.0 A max @ 24 Vdc
 - .3 Up to 10 remote Annunciator panels can be connected to the main refrigerant gas detection Controller; Digital Communication Modbus RS-485 up to 304m (1000 ft)
 - .4 The remote annunciator panel must provide all the functionalities necessary to comply with Current ASHRAE 15 and CSA B-52 Mechanical Codes. This includes a key for manual "fan start" only operation, strobe/horn audible visual alarm on top of the unit
 - .5 Display 122 x 32 dot matrix backlit LCD display
 - .6 Visual Indicators: - Green LED - Normal Operation
 - .7 Red LED Gas Alarm A, B, and C
 - .8 Yellow LED: Fault/Service
 - .9 The Remote annunciator panel will indicate the exact concentration of refrigerant gas as displayed on the 301EMRFSA Main Controller and the refrigerant gas detected. The LCD display screen will indicate multiple alarm levels for each sensing point
 - .10 Operating Temperature Range: 0°C to 40°C (32°F to 100°F)
 - .11 Enclosure rating: NEMA 4X, ABS - Polycarbonate - indoor
 - .12 Certifications: CAN/CSA C22.2 No 61010-1
 - .13 Conforms to: ANSI/UL 61010-1; IEC 61010-1 Including Amendments A1:1992 + A2:1995 and National Deviations (Canada, US)
 - .14 Make and Model: Honeywell 301EM RP RFSA or equivalent
- .3 Wired Refrigerant Gas Transmitter:
 - .1 Use: Wall mounted, wired refrigerant gas detector transmitter used in conjunction with 301EMRFSA controller, Diffusion Type with no internal sample pump or filter maintenance required
 - .2 Power Requirement: 8.5 - 12.5 Vdc, 1A@10 Vdc Maximum
 - .3 Network: Modbus RS-485
 - .4 Sensing Technology: NDIR (Non Dispersive Infrared)
 - .5 Accuracy: ±10ppm @ 50 ppm / ±40 ppm @ 500 ppm
 - .6 Detection Range: Refrigerants 0-1000 ppm
 - .7 Resolution: 1 ppm
 - .8 Response Time (T90) 15 seconds
 - .9 Operating Temperature Range: 0°C to 40°C (32°F to 100°F)
 - .10 0 to 95% RH (non-condensing)
 - .11 Enclosure NEMA 4X ABS/Polycarbonate - Indoor
 - .12 Certified to: CAN/CSA C22.2 No. 61010-1

- .13 Conforms to: ANSI/UL 61010-1
- .14 Make and Model: Honeywell 301IRFS sensors or equivalent.
- 2.12.26. Natural gas generator room gas detection system:
 - .1 Provide natural gas detection system for natural gas generator room as required by CSA B149.1 "Natural gas and propane installation code."
- 2.12.27. Electromagnetic Water Flow Meters:
 - .1 Provide an Electromagnetic Flow Meter complete with integral or remote transmitter.
 - .2 Include with transmitter a backlit graphic display and keypad, housed in a CSA Type 4X enclosure, displaying instantaneous flow rate and totalized flow rate. Provide 24 VDC input voltage. Provide 4-20 mA output signals and programmable pulse.
 - .3 Select the flow meter size based on the minimum and maximum flow range for the application.
 - .4 Provide connections to the piping with ANSI class 150 flanges (ANSI class 300 where required).
 - .5 All wetted materials: 316 stainless steel; liner: ebonite for low temperature service, PTFE for hot water service.
 - .6 Each flow meter: individually wet-calibrated and accurate to within $\pm 0.2\%$ of reading from 0.5 m/s (1.64 fps) to 10 m/s (33 fps) velocity and ± 0.001 m/s (0.004 fps) at flow rates below 0.5 m/s (1.64 fps). Provide a certificate of calibration with each flow meter.
 - .7 Provide flow meter that is capable of measuring bi-directional flow.
 - .8 For installations in non-metallic pipe, provide an internal grounding electrode which eliminates the need for external grounding rings.
 - .9 Factory program each flow meter for its specific application, and make re-programmable using the integral keypad on the converter (no special interface device or computer required).
 - .10 Make and Model: Badger ModMAG M2000, ONICON F-3000 Series Electromagnetic Flow Meter or equivalent.
- 2.12.28. Ultrasonic Water Flow Meters:
 - .1 Provide an Ultrasonic Flow Meter complete with integral or remote transmitter and transducers.
 - .2 Include with transmitter a backlit graphic display and keypad, housed in a CSA Type 4X enclosure, displaying instantaneous flow rate and totalized flow rate. Provide 24 VDC input voltage. Provide 4-20 mA output signals and programmable pulse.
 - .3 Select the flow meter size based on the minimum and maximum flow range for the application.
 - .4 Provide self-aligning mounting hardware including pipe clamps and mounting bracket for the line size and material specified.
 - .5 Provide transducers that are non-wetted utilizing transit time velocity measurement.
 - .6 Provide each flow meter individually NIST calibrated and accurate to within $\pm 1.0\%$ of reading from 0.46 m/s (1.5 fps) to 12.2 m/s (40 fps) velocity. Provide a certificate of calibration with each flow meter.
 - .7 Provide flow meter that is capable of measuring bi-directional flow.
 - .8 Factory program each flow meter for its specific application, and make re-programmable using the integral keypad on the converter (no special interface device or computer required).

- .9 Make and Model: Badger Dynasonics TFX-5000, ONICON F-4300 Series Electromagnetic Flow Meter or equivalent.
- 2.12.29. BTU Meters:
 - .1 Have a single manufacturer build and calibrate the entire BTU metering system and ensure that system consists of a flow meter, two temperature sensors, a BTU meter, temperature thermo wells, and all required mechanical installation hardware. Provide a certificate of NIST (U.S. National Institute of Standards and Technology) traceable calibration with each system. Provide manufacturer's two-year warranty to cover all equipment.
 - .2 Provide BTU meter that provides the following information via both an integral LCD, and via network communications (protocol conforming to BACnet or LON): Energy Total, Energy Rate, Flow Total, Flow Rate, Supply Temperature and Return Temperature. Factory program each BTU meter for its specific application, and make re-programmable using the front panel keypad (no special interface device or computer required).
 - .3 Provide either an electromagnetic flow meter or an ultrasonic flow meter as specified above.
 - .4 Temperature sensors: loop-powered current based (mA) sensors and bath-calibrated and matched (NIST traceable) for the specific temperature range for each application. The calculated differential temperature used in the energy calculation: accurate to within 0.08 deg. C. (0.15 deg. F.) including the error from individual temperature sensors, sensor matching, input offsets, and calculations.
 - .5 Make and Model: Badger FC5000/TFX-5000, ONICON System-10 BTU Meter or equivalent.
- 2.12.30. Gas Sub Meters:
 - .1 Provide rotary or diaphragm gas meters complete with integral or remote transmitter.
 - .2 Provide programmable pulse transmitter output signal.
 - .3 Provide temperature compensated meters for better accuracy.
 - .4 Provide meters that comply with ANSI B109 family of standards.
 - .5 Provide meters that are Measurement Canada accredited.
 - .6 Provide meters to suit pressures and flow rates indicated.
 - .7 Make: Elster, Roots Dresser, or equivalent.
- 2.12.31. Energy Meters:
 - .1 The energy meter shall conform to ANSI C12.1 metering accuracy standards.
 - .2 The energy meter shall consist of a meter and CTs calibrated together as a system.
 - .3 Accuracy shall be +/- 1% from 2-100 % of rated current.
 - .4 The energy meter shall not require annual recalibration.
 - .5 The energy meter shall derive operating power from its metering connection and shall not require separate control power connection.
 - .6 The energy meter electronics shall automatically correct for CT phase reversal.
 - .7 LCD display shall show accumulated kWh, Amps, Voltage.
 - .8 The energy meter shall have a pulse output with selectable pulse output rates.
 - .9 The energy meter shall meet UL and cUL specifications.
- 2.12.32. Air Flow Stations (Fan Bell Mouth):

- .1 The measuring device shall consist of air flow traverse probes mounted on the fan bell mouth. The probes shall contain multiple total and static pressure sensors placed at concentric area centers along the exterior surface of the cylindrical probe and internally connected to their respective averaging manifolds. Sensors shall not protrude beyond the surface of the probe, not be adversely affected by particle contamination normally present in building system airflows. The fan inlet air flow traverse probes (two per inlet) shall have dual end support swivel brackets suitable for mounting in the fan inlet bell and symmetrical averaging signal takeoffs and fittings and shall be of aluminum construction with hard anodized finish. The fan inlet airflow traverse probes shall not induce a measurable pressure drop, nor shall the sound level with the system be amplified by its presence in the fan inlet bell. The probes shall be capable of producing steady, non-pulsating signals of total and static pressure, without need for flow corrections or factors, with an accuracy of +/- 3% of actual flow over a fan operating range of 6 to 1 capacity turndown.
- .2 Velocity pressure transmitter shall be selected to suit the system working pressures and shall meet the following performance requirements:
 - .1 Calibrated accuracy within +/- 0.25% of span.
 - .2 Repeatability within 0.05% of output.
 - .3 Dead bank & hysteresis not detectable or measurable.
- .3 Square root extractor and multiplier shall meet the following performance requirements:
 - .1 Calibrated Accuracy: +/- 0.5% of flow.
 - .2 Hysteresis: Not detectable.
 - .3 Repeatability: 0.05% of output.
 - .4 Response: 0.5 seconds.
 - .5 Multiplier: Adjustable 0.3 to 2.8.
- .4 Provide a control panel that shall contain all control equipment. Each panel shall have a hinged door, latch and lock.
- .5 Transmitter shall provide a 4 to 20 mA or 0 to 10 VDC signal proportional to flow to the BAS. The signal shall be converted to L/S (CFM) by the BAS.
- .6 The fan inlet airflow traverse probes and velocity pressure transmitter shall be Air Monitor Corporation VOLU-probe/FI and Veltron II.
- .7 Acceptable equal shall be Ebtron Gold Series:
 - .1 The air sensors shall be self heated thermistors and epoxy encapsulated temperature sensors. The heated element shall determine velocity and the other shall provide a reference temperature signal to the velocity sensor to compensate for temperature changes in the air flow. There shall be a minimum of two sensors per type, per inlet.
 - .2 Individual flow sensors shall transmit digital flow/temperature information to a microprocessor based control panel which shall total/average signals and output flow signals (L/S or CFM) to the host DDC panel. The signals shall be linear 0 to 10 VDC or 4 to 20 mA.
 - .3 The velocity linearity shall be 2% of reading, with a repeatability of 3% scale, over a fan operating range of 6 to 1 capacity turndown. The station shall not induce a measurable pressure drop or increase the sound emitted by the system.
 - .4 A control panel shall be provided with an alpha numeric display of the air volumes and temperature of the points monitored. A keypad or PC link shall allow remote monitoring, trouble shooting or system reconfiguration.

2.12.33. Air Flow Stations (Duct Mount):

- .1 Fan air volume measuring device shall be either rectangular or round as indicated. Unit shall have 14 gauge galvanized sheet steel casing, flanged for installation to duct or plenum as applicable, with aluminum honeycomb equalizer and air straightening grid with copper static pressure sensors and total pressure sensors, installed in a grid pattern to provide total coverage of the device. Unit shall be capable of reading volumes within 1% for a velocity range of 800 to 4000 feet per minute (4 to 20 m/s).
- .2 Velocity pressure transmitter shall be selected to suit the system working pressures and shall meet the following performance requirements:
 - .1 Calibrated Accuracy: +/- 0.25% of span.
 - .2 Repeatability: 0.05% of output.
 - .3 Dead band & hysteresis: Not detectable.
- .3 Square root extractor and multiplier shall meet the following performance requirements:
 - .1 Calibrated Accuracy: +/- 0.5% of flow.
 - .2 Hysteresis: Not detectable.
 - .3 Repeatability: 0.05% of output.
 - .4 Response: 0.5 seconds.
 - .5 Multiplier: Adjustable 0.3 to 2.8.
- .4 Control panel shall be industrial standard wall mounted and shall contain all control equipment. Each panel shall have a hinged door, latch and lock.
- .5 Flow measuring device and velocity pressure transmitter shall be Air Monitor Corporation Fan-Evaluator and Veltron II.
- .6 Acceptable equal shall be Ebtron Gold Series:
 - .1 Each thermal flow sensor shall contain two individual sensing elements. One element shall determine velocity and the other shall provide a reference signal to the velocity sensor to compensate for temperature in the air flow. Each flow sensor shall operate independently and shall not affect any other flow sensors in the stations.
 - .2 Thermal flow sensor operation shall not be affected by dust particles in quantities typical to HVAC applications. The thermal flow sensors shall be mounted in aluminum probes for duct mounting and adjustable steel struts for fan inlet mounting. The number of sensors and probes shall be selected to provide maximum accuracy.
 - .3 Individual flow sensors shall transmit digital flow/temperature information to a microprocessor based control panel which shall total/average signals and output flow signals L/S (CFM) to the host DDC panel. The signals shall be linear 0 to 10 VDC or 4 to 20 mA. The velocity linearity shall be 2% of reading, with a repeatability of 3% of scale, over a fan operating range of 6 to 1 capacity turndown. The station shall not induce a measurable pressure drop or increase the sound emitted by the system.
 - .4 A control panel shall be provided with an alphanumeric display of the air volumes and temperatures of the points monitored. A keypad or P.C. link shall allow remote monitoring, trouble shooting or system reconfiguration.

2.13. WIRE AND CONDUIT

- 2.13.1. Conduit: Electrical metallic tubing EMT with compression type fittings in dry locations; cold rolled steel zinc coated or zinc coated rigid steel with threaded fittings in wet locations or where exposed to weather.
- 2.13.2. Outlet boxes: Dry locations: sherardized or galvanized drawn steel 100 mm (4 in.) square or octagon with suitable raised cover; Exposed to Weather: threaded hub cast aluminum boxes with gasket plate.
- 2.13.3. Junction boxes: Sized according to number, size and position of entering raceway; type: suitable for the environment.
- 2.13.4. Wire:
 - .1 Network:
 - .1 Per base building network requirements, coordinate with Owner/network manager
 - .2 If applicable, refer to Division 27
 - .2 Analog Input, Output: Stranded 18 gauge copper twisted shielded.
 - .3 Binary Input, Output: 18 gauge, minimum insulation rating of 600 volts.
 - .4 Class 2: FT-6 without conduit in ceiling plenums; FT-4 in conduit for all other cases.
 - .5 Plenum rated wiring to be used.

3. Execution

3.1. GENERAL

- 3.1.1. Install all controllers, cabinets, control devices and power supplies in readily accessible locations providing adequate ambient conditions for its specified application and to the Canadian Electrical Code.
- 3.1.2. Install Products to manufacturer's installation instructions.
- 3.1.3. Install parallel to building walls and floors unless indicated or specified or required by manufacturer's installation instructions.
- 3.1.4. Mechanical Contractor shall install all in-line devices such as temperature wells, pressure taps, airflow stations, etc.

3.2. COORDINATION

- 3.2.1. Submittals: To Part 1: General, Submittals.
- 3.2.2. Integrate and coordinate Work under this section to controls and control devices provided or installed by others.
- 3.2.3. Each Supplier of control Product to configure, program, start-up and commission that Product to satisfy requirements of Sequence of Operation regardless of where within Contract Documents Product is described or specified.
- 3.2.4. Resolve compatibility issues between control Product provided under this section and those provided under other sections or divisions of this Specification.

3.3. EXISTING PRODUCTS

- 3.3.1. This scope only applies to the Products that have become redundant as a result of this scope

- 3.3.2. Performance: During construction check and verify reused existing Products are operational. For existing Product that is not operational submit a proposal to replace existing Product for approval by the Consultant. Generally, Products which will potentially become redundant as a result of this scope of Work will only be reused if it meets the standards of this Specification.
- 3.3.3. Existing Products: Existing products are not approved for reuse under the Work..
- 3.3.4. Existing Wiring: Neatly coil, cap, identify and contain unused within cabinet(s).
- 3.3.5. Existing Cabinets: Remove from site and discard.
- 3.3.6. Existing Sensor Wells: Reuse, modify for proper fit and function.
- 3.3.7. Existing Electric Thermostats: Remove from site and discard.
- 3.3.8. Existing Sensors and Transmitters: Remove from site and discard.
- 3.3.9. Existing DDC Controllers: Remove from site and discard.
- 3.3.10. Existing Dampers, Electric Damper Actuators and Linkages: Remove from site and discard.
- 3.3.11. Existing Control Valves and Electric Valve Actuators: Remove from site and discard.
- 3.4. WIRING AND CONDUIT
 - 3.4.1. Wire shall be neatly tie wrapped to conduit mounted to the building structure but must be installed at right angles or parallel to the building. Loose wiring shall only be allowed over a distance of 1500 mm (5 ft.) but must not pass over lighting fixtures.
 - 3.4.2. Wiring in Equipment Room, between floors, or between concrete walls shall be installed in conduit. Exposed wiring will not be accepted. Conduit shall be installed at right angles or parallel to the building walls.
 - 3.4.3. Should it become necessary to splice field wiring it shall be soldered. If soldering is not possible, approved B type crimp connectors are an acceptable alternative. Wire nuts and Marr connections are not acceptable. Provide a 500 mm (20 in.) loop length at all splices.
 - 3.4.4. Conceal conduit within finished shafts, ceilings, and walls as required. Install exposed conduit parallel with or at right angles to the building walls.
 - 3.4.5. Plug or cap unused conduit openings and stubs with compatible fittings.
 - 3.4.6. Route all conduit to clear beams, plates, footings and structural members except through column footings and grade beams.
 - 3.4.7. Provide watertight seals at penetrations through outside foundation walls.
 - 3.4.8. Support conduit 25 mm (1 in.) and smaller to the building with one-hole non-perforated malleable iron or steel pipe straps. Suspend conduits larger than 1 in. on pipe racks with splitting hangers and rods.
 - 3.4.9. Maintain caps on conduit openings throughout construction.
 - 3.4.10. Where conduit is attached to vibrating or rotating equipment, install and anchor flexible metal conduit with a minimum length of 450 mm (18 in.) and a maximum length of 900 mm (36 in.) in such a manner that vibration and equipment noise will not be transmitted to the rigid conduit.
 - 3.4.11. Where exposed to weather or in damp or wet locations, provide waterproof flexible conduit.
 - 3.4.12. Fill conduit to maximum of 60% of its capacity. Provide a pull rope within the conduit when the installation is complete. Bend conduit to a radius of greater than 3 times the conduit diameter to a maximum of three 1/4 bends permitted between pull boxes.
 - 3.4.13. Wire within cabinets shall be installed in a plastic tray with a cover. Terminate wires to field-removable, modular terminal strips.

- 3.4.14. All field sensors shall be provided with a flexible conduit connection minimum length of 450mm (18 in.) and an enclosure for the electrical connections.
- 3.5. POWER WIRING
- 3.5.1. Power for section 23 09 00.00 - Building Automation System (BAS) shall be provided under Electrical Division 26 at 120 VAC 60 Hz single phase and shall terminate in junction boxes installed where shown on Electrical and/or Mechanical Drawings. Wiring and conduit from these boxes to control devices being electrically powered to be provided by section 23 09 00.00 - BUILDING AUTOMATION SYSTEM (BAS).
- 3.5.2. Where power for equipment is fed from MCC, 120 VAC power for Section 23 09 00.00 - BUILDING AUTOMATION SYSTEM (BAS) shall also be fed from the MCC from the 120 VAC section. Wiring and conduit from the MCC to control devices being electrically powered to be provided by section 23 09 00.00 - BUILDING AUTOMATION SYSTEM (BAS).
- 3.6. COMMUNICATION WIRING
- 3.6.1. Install communication wiring per controls manufacturer recommendations as to type of wire used and segment lengths.
- 3.6.2. Install communication wiring in conduit and raceways separated from other wiring.
- 3.6.3. Verify entire network's integrity following cable installation using appropriate tests for each cable.
- 3.6.4. Each run of communication wiring to be continuous length without splices.
- 3.1.34. Provide data cables in conduit back to the closest data/telecom closet/room to allow all BAS head end equipment to connect to the network and all BAS controllers in the building as applicable to the project.
- 3.1.35. Ensure data cables are coordinated with requirements of BAS equipment based on submitted Shop Drawings.
- 3.6.5. Graphics: Generate graphic representations for systems under Section 23 09 23.00 - SEQUENCE OF OPERATION FOR BAS and as follows:
- .1 Building elevation in three dimensions; indicate: floors and mechanical rooms.
 - .2 Floor plans: Indicate: Equipment rooms; point object data for temperature, humidity and pressure. Directly access graphic representation for terminal systems.
 - .3 Equipment Rooms: Indicate locations for systems.
 - .4 Systems: Indicate: Equipment, service connections, point object data, set points, reset schedules. Highlight point objects under operator command.
 - .5 Graphic representations link to and display graphic representations for associated systems.
- 3.7. CONTROL DEVICES
- 3.7.1. Provide or furnish control devices as indicated on the Drawings and to the requirements of this Section and to execute sequence of operation under Section 23 09 23.00 - SEQUENCE OF OPERATION FOR BAS.
- 3.7.2. Provide or furnish control devices as indicated on the Drawings and to the requirements of this Section and to execute sequence of operations.
- 3.7.3. Motor Operated Dampers (Insulated and Uninsulated):

- .1 Furnish motor operated dampers for installation under Section 23 31.13.00 - DUCTWORK AND SPECIALTIES. Provide supervision on site during installation.
 - .2 Install in areas maintained above freezing.
 - .3 Install insulated motor operated dampers on all systems that connect with (or transfer air to/from) the exterior ambient environment and operate intermittently (i.e. time of day schedule, temperature sensor controlled, etc.).
- 3.7.4. Actuators for Dampers, Electronic:
- .1 Mounting: Direct coupled to drive shaft or jackshaft using a V bolt design.
- 3.7.5. Combination Smoke and Fire Damper and Smoke Damper Positions:
- .1 Monitor the positions of combination smoke and fire dampers and smoke dampers (e.g. open or closed) on the BAS based on damper end switches. Combination smoke and fire dampers, smoke dampers, and end switches are provided under Section 23 31 13.00 – DUCTWORK AND SPECIALTIES. Coordinate termination of wires with Fire Alarm Contractor, as the fire alarm system will also be monitoring the damper positions.
- 3.7.6. Control Valves:
- .1 Furnish control valves for installation under Section 22 11 13.00 - PIPE, VALVES AND FITTINGS (EXCEPT PLUMBING). Provide supervision on site during installation.
- 3.7.7. Actuators for Control Valves, Electronic:
- .1 Factory install or field install actuator to valve body.
 - .2 Low Limit Electromechanical Thermostat:
 - .3 Install hardwire interlocked to supply fan starter for respective system.
 - .4 Provide according to Section 23 09 23.00 - SEQUENCE OF OPERATION FOR BAS.
 - .5 Shut down the fan when duct temperature is equal to or less than 1.67 deg. C (35 deg. F).
 - .6 Install to adequately cover potential areas of low level stratification. Provide one low-limit thermostat for each 2.8 sq M (25 sq ft) of duct cross section. Mount sensing element on plastic clips.
- 3.7.8. High Limit Electromechanical Thermostat:
- .1 Install hardwire interlocked to fan starters for respective system.
 - .2 Shut down the fans when duct temperature is equal to or greater than 51.7 deg. C (125 deg. F).
 - .3 Provide one high-limit thermostat for each 3.7 sq M (40 sq ft) of duct cross section.
- 3.7.9. Electromechanical Thermostats and Temperature Sensors:
- .1 Furnish sensing wells for installation under Section 22 11 13.00 - PIPE, VALVES AND FITTINGS (EXCEPT PLUMBING). Provide supervision on site during installation.
 - .2 Samples: Provide for wall mount type to Part 1: Submittals, Samples.
 - .3 Wall Mount Type:
 - .1 Cover Colour: White.
 - .2 Install to furred-in columns and permanent walls on concealed junction boxes supported by wall framing or surface mount 1.2 m (4 ft) above finished floor. Installation to mobile and temporary partitions is not acceptable.

- .3 Installation to exposed architectural concrete columns and walls is not acceptable, unless otherwise indicated or specified. For installation to concrete, set conduit in place before pouring of concrete.
- .4 Single Point Type, Duct:
 - .1 Provide sufficient contact with process fluid to measure average conditions.
 - .2 Apply pipe sealing compound to plug thread.
- .5 Single Point Type, Pipe:
 - .1 Provide sufficient contact with process fluid to measure average conditions.
 - .2 Install with heat conducting fluid in wells.
- .6 Outdoor Type:
 - .1 Install to north side of building away from sources of heat such as lamps and exhaust vents; to greater than 1500 mm (5 ft) above horizontal surfaces.
 - .2 Where indicated or specified for installation in outside air intake, locate so as not to be affected by exhaust air flow or reverse flow.
 - .3 Provide solar shield. Install shield to open downward.
 - .4 Seal interior of conduit at penetration through exterior wall.
- 3.7.10. Guards for Thermostats and Temperature Sensors:
 - .1 Provide for wall mount sensors and thermostats where indicated on the Drawings.
 - .2 Samples: Provide to Part 1: Submittals, Samples.
- 3.7.11. Air Static Pressure Sensors:
 - .1 Duct Mount: Pipe the high-pressure tap to the duct using a pitot tube.
 - .2 Building Static: Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building and install with a shielded static air probe to reduce pressure fluctuations caused by wind.
 - .3 The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
- 3.7.12. Wet/Wet Differential Pressure Sensors:
 - .1 Differential pressure sensors shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.
- 3.7.13. Relative Humidity Sensors:
 - .1 Install to requirements for Electric Thermostats and Temperature Sensors.
- 3.7.14. AC Current Sensors and Transducers:
 - .1 Install in motor starter cabinet.
- 3.7.15. CO Sensors:
 - .1 Mount the sensor between 900 mm (35.44 in.) and 1200 mm (47.24 in.) above finished floor.
 - .2 For parking garage applications, set low limit at 50 ppm and high limit at 100 ppm.
 - .3 Provide sufficient number of sensors for full coverage of the monitored area.
- 3.7.16. NO2 Sensors:
 - .2 Use two sensors per zone, mount one of the sensors 305 mm (1 ft.) from the floor and the other 305 mm (1 ft.) from the ceiling.

- .1 For parking garage applications, set low limit at 1 ppm and high limit at 3 ppm.
- .2 Provide sufficient number of sensors for full coverage of the monitored area.
- 3.7.17. Water Flow Meters and BTU Meters:
 - .1 Install the meter in either the supply or return pipe of the system to be measured following the manufacturer's written instructions.
 - .2 Provide isolation valves upstream and downstream of the meter.
 - .3 Provide suitable mating flanges and any required reducer/expander.
- 3.7.18. Gas Meter Connection:
 - .1 This Contractor shall provide connection from BAS to standard output of a gas meter transducer provided by local authorities.
- 3.7.19. Air Flow Sensors, Fan Bell Mouth:
 - .1 Coordinate installation of air flow sensors to inlet of fans with fan manufacturer.
- 3.7.20. Refrigerant Gas Detection System:
 - .1 Provide complete and operational system in accordance with CSA B52 "Mechanical Refrigeration Code."
 - .2 Provide refrigerant vapour detector(s) in areas where refrigerant from a leak is most likely to concentrate and have detectors activate at a value no greater than the corresponding Occupational Exposure Limit (OEL), 25% of the Lower Flammability Limit (LFL), or ammonia limits described in CSA B52.
 - .3 Provide multiple detectors where leaks are likely to concentrate in multiple locations including but not limited to:
 - .1 High and Low elevations where multiple refrigerants may stratify to different heights.
 - .2 At each ventilation exhaust inlet where airflow patterns direct leaks to multiple locations.
 - .4 Provide remote annunciator panels outside of each entrance to the Mechanical Room.
- 3.7.21. Air Flow Sensors, Duct Mount:
 - .1 Furnish duct mount air flow sensors for installation under Section 23 31 13.00 - DUCTWORK AND SPECIALTIES. Provide supervision on site during installation.
- 3.8. IDENTIFICATION
 - 3.8.1. All wires shall be tagged at both ends. The tagging shall identify the device it is connected to. Use of the point object name is acceptable.
 - 3.8.2. All wires passing through a junction box shall be tagged with the device identity or its termination point.
 - 3.8.3. The junction boxes shall be tagged "BAS" with a sequential number suffix.
 - 3.8.4. Label wires, control devices, controllers.
- 3.9. TESTING AND COMMISSIONING
 - 3.9.1. Test and commission the BAS prior to the Demonstration and Acceptance Test.
 - 3.9.2. Test and commission the BAS prior to the Demonstration.
 - 3.9.3. Prepare test forms which shall identify each test. The forms shall be sub-divided into:

- .1 points, controllers
- .2 programs, loops, networks and graphics.
- 3.9.4. Upon completion of the installation, the Control System Contractor shall load all system software and start-up the system. The Control System Contractor shall perform all necessary calibration, testing and de-bugging and perform all required operational checks to insure that the system is functioning in full accordance with these Specifications.
- 3.9.5. Device tests shall identify and confirm successful completion of the following:
 - .1 Device installation.
 - .2 Device identification.
 - .3 Device calibration.
 - .4 Device operation.
 - .5 Wiring to device, connection details and wire type.
 - .6 Validation of the device signal at the controller.
- 3.9.6. Controller tests shall identify and confirm successful completion of the following:
 - .1 Controller installation.
 - .2 Power source and grounding.
 - .3 Make, model and serial number, software revisions.
- 3.9.7. Software tests shall identify and confirm successful completion of the following:
 - .1 Custom application programs.
 - .2 Alarm reporting.
 - .3 Trending and reports.
 - .4 Energy management programs.
- 3.9.8. Loop tuning tests shall identify and confirm successful completion of the following:
 - .1 Loop input signal.
 - .2 Loop output signal.
 - .3 Set point adjustment.
 - .4 Device response.
 - .5 Control response.
- 3.9.9. Network communication tests shall identify and confirm successful completion of the following:
 - .1 Primary network communication function.
 - .2 Secondary network communication function.
 - .3 Alarm reporting function.
 - .4 Operator communication.
- 3.9.10. Dynamic graphics tests shall identify and confirm successful completion of the following:
 - .1 All graphics.
 - .2 All point objects per graphic.
 - .3 All set-points per graphic.

3.10. DEMONSTRATION

- 3.10.1. When all tests have been completed and the documentation completed, request a meeting with the Consultant and Owner. Provide at this meeting a demonstration that all systems on the BAS are operating. At the successful conclusion of this demonstration the Consultant will allow the Acceptance Test to begin.
- 3.10.2. When all tests have been completed and the documentation completed, request a meeting with the Consultant and Owner. Provide at this meeting a demonstration that all systems on the controls are operating.
- 3.10.3. At the discretion of the Consultant and Owner, demonstrate up to 10% of the tests described in Part 3: Execution, Testing and Commissioning and witnessed by the Consultant and Owner. Should any test fail then the BAS Contractor shall retest the failed components or functionality.

3.11. BAS MAINTENANCE AND SERVICE (ALTERNATIVE PRICE) INCLUDE IN BID FORM.

- 3.11.1. Provide full BAS maintenance and service for one year after the warranty expires.
- 3.11.2. Assign a fully trained BAS service technician to perform all contract activities as described below with one backup person.
- 3.11.3. Service to include but not to be limited to: full day site visit once a week to perform system maintenance and service Work that is not urgent, including preparation of the visit report.
- 3.11.4. Scheduled preventive maintenance inspections will provide those services required to maintain the system at maximum performance and reliability levels and may include, but not be limited to the following: analyze, adjust, calibrate all sensors, diagnostic LEDs, printers, power supplies, work stations, controllers, input/output points, communication cabling, transmitters, transducers, damper and valve actuators, instrumentation and accessories directly pertaining to the Building Automation System.
- 3.11.5. Conduct inspections and thorough preventive maintenance routine on each piece of covered equipment. In addition, make tests and adjustments to ensure efficient and reliable operation of other major components.
- 3.11.6. Check and confirm control system sequence of operation to insure optimum system efficiency and economy. Monitor the operation of all systems connected to BAS and optimize the operation of those systems for better comfort and energy savings over the duration of operation and service contract.
- 3.11.7. Prepare a report on system operation once a month.
- 3.11.8. A log of each loop tested and each control sequence verified shall be reviewed with the Owner.
- 3.11.9. As part of the service, provide 24/7 contact number for service calls. Maximum response time to be 4 hours.
- 3.11.10. Provide a price for a one-year service agreement based on the above requirements to come in to effect upon the completion of the warranty period. Show this price as separate line item: Service Agreement.
- 3.11.11. Not included in the contract is the following: any customer initiated changes and additions to the system

END OF SECTION

23 09 23.00 Sequence of Operation for BAS

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS and SECTION 23 09 00.00 - BUILDING AUTOMATION SYSTEM (BAS).

1.1.2. The locations of all sensors shall be discussed with and approved by the Owner and/or Engineer's Representative, before installation. Locations shown are approximate only, and are given to assist the Contractor in pricing only, and shall not be construed as being the final approved location.

1.1.3. The control sequence descriptions are complementary. Provide detailed sequences of operation and all points required to implement the sequences.

1.1.4. All settings and set points listed in this Section shall be variable and Operator adjustable without the need to create or modify Custom Application Programs.

1.1.5. All set points and reset schedules shall be visual on the associated dynamic graphic.

1.1.6. Where the project includes an existing BAS, ensure that any upgrades to the existing BAS for this project scope does not negatively impact existing BAS infrastructure. Maintain the functionality of existing controls not revised by this scope of work.

1.2. WARRANTY

1.2.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. GENERAL APPLICATION PROGRAMS

2.1.1. Provide a specific set of programs to achieve automated, operator independent control of facility sub-systems.

2.1.2. Refer to SECTION 23 09 00.00 - BUILDING AUTOMATION SYSTEM (BAS) for software programs.

3. Execution

3.1. GENERIC THERMAL ZONES

3.1.1. Applicable Systems:

- .1 Single zone systems
- .2 VAV boxes
- .3 Fan-powered boxes

3.1.2. Setpoints

- .1 Provide zone temperature setpoints as follows:

Zone Type or Name	Occupied Heating	Occupied Cooling	Unoccupied Heating	Unoccupied Cooling
VAV	22 deg. C	24 deg. C	16 deg. C	32 deg. C
Fan-Powered Boxes	22 deg. C	24 deg. C	16 deg. C	32 deg. C
Fan Coils	22 deg. C	24 deg. C	16 deg. C	32 deg. C
Residential Suite	22 deg. C	24 deg. C	20 deg. C	26 deg. C
Gymnasium	20 deg. C	20 deg. C	18 deg. C	26 deg. C
Pool	29 deg. C	29 deg. C	29 deg. C	29 deg. C
Pool Change Room	26.5 deg. C	26.5 deg. C	26.5 deg. C	26.5 deg. C
Arena	15.5 deg. C	15.5 deg. C	12 deg. C	15.5 deg. C
Arena Change Room	22 deg. C	22 deg. C	15 deg. C	22 deg. C
Mech/Elec Rooms	18 deg. C	30 deg. C	18 deg. C	30 deg. C
Networking/IT Rooms	18 deg. C	24 deg. C	18 deg. C	24 deg. C

- .2 Determine the active setpoint by the operating mode of the zone group.
 - .1 Provide the occupied set points during occupied mode, warm-up mode, and cooldown mode.
 - .2 Provide the unoccupied set points during unoccupied mode, setback mode, and setup mode.
- .3 Provide zone relative humidity setpoints as follows:

Zone Type or Name	Occupied Heating	Occupied Cooling	Unoccupied Heating	Unoccupied Cooling
VAV	__% RH	__% RH	__% RH	__% RH
Fan-Powered Boxes	__% RH	__% RH	__% RH	__% RH
Fan Coils	__% RH	__% RH	__% RH	__% RH
Residential Suite	__% RH	__% RH	__% RH	__% RH
Gymnasium	__% RH	__% RH	__% RH	__% RH
Pool	60 % RH	60 % RH	50 % RH	50 % RH
Arena	1.7 deg. C dew point	1.7 deg. C dew point	1.7. deg. C dew point	1.7 deg. C dew point

- .4 Provide zone CO2 concentration setpoints as follows:

Occupancy Category	CO2 Setpoint (ppm)	Occupancy Category	CO2 Setpoint (ppm)
Daycare	1,000	Office Space	900
Classroom (age 5-8)	850	Reception	1,650
Lecture Classroom	1,305	Conference/Meeting	1,600
Restaurant/Dining	1,400	Lobby/Prefunction	1,500
Breakrooms	1,200	Library	800
Retail	1,050	Health Club (Aerobics)	1,700
		Health Club (Weights)	1,200

3.2. DOMESTIC HOT WATER TANKS AND RECIRCULATION PUMP

3.2.1. Normal Operation:

- .1 The BAS shall monitor each domestic hot water tank temperature.

- .2 The controls provided with each domestic hot water tank shall maintain tank temperature set-point.
- .3 The BAS shall modulate the domestic water mixing valve to maintain the domestic hot water supply temperature.
- .4 During occupied hours, domestic hot water recirculation pump shall run continuously.
- .5 The BAS shall monitor the DHW supply temperature at the outlet of the tank and at a remote location downstream in the domestic water system as indicated on site by the Consultant.
- .6 During unoccupied hours, the BAS shall start the domestic hot water recirculation pump when the remote supply temperature falls below the minimum supply water set-point (initially set at 37.8 deg. C. (100 deg. F.)).
- .7 The BAS shall stop the domestic hot water circulator when the remote temperature is maintained at a minimum of 51.7 deg. C. (125 deg. F.) for 10 minutes.

3.2.2. Alarms:

- .1 Domestic Water Recirculation Pump (DWRPST) from current sensor.
- .2 Domestic Hot Water Tank Temperature (DHWTT) out of range.
- .3 Domestic Hot Water Supply Temperature (DHWST) out of range.

3.3. ERV UNIT CONSTANT VOLUME

3.3.1. Applicable Systems: ERV-1

3.3.2. System Start:

- .1 The ERV shall be started based on schedule or by operator command at the BAS terminal.

3.3.3. Normal Operation:

- .1 ERV shall run continuously during occupied hours.

3.3.4. System Stop:

- .1 System stop shall be initiated by schedule or by operator command at the BAS.

3.3.5. Alarms:

- .1 Supply Fan Status (SFST) from current sensor.
- .2 Exhaust Fan Status (EFST) from current sensor.

3.4. EXHAUST FAN

3.4.1. Applicable Systems: EF-1, EF-2

3.4.2. System Start:

- .1 System start shall be initiated by space temperature demand or through time schedule. Upon signal to start the system, the exhaust damper shall open, when the damper end switch makes, the fan shall start.

3.4.3. Normal Operation:

- .1 Exhaust fan shall cycle to maintain Space Temperature (SPCT) at set-point (adjustable), or shall run continuously during occupied hours.

3.4.4. System Stop:

- .1 System stop is initiated when space temperature is satisfied or through time schedule. Upon signal to stop the system, the exhaust fan shall stop and the exhaust damper shall close.

3.4.5. Schedule:

- .1 To be determined by the Owner.

3.4.6. Alarms:

- .1 Exhaust Fan Status (EFST) from current sensor.
- .2 Space Temperature (SPCT) out of range.

3.5. HEATING WATER PLANT WITH TWO BOILERS(EXISTING) AND GLYCOL HEAT EXCHANGER

3.5.1. System Start:

- .1 Lead/lag pump P-HTG-1/2 shall be enabled when Outside Air Temperature (OAT) is less than -5°C (23 deg. F) for more than 30 minutes.
- .2 The Glycol Pump (P-HTG-3/4) and Glycol Control Valve (GCV) shall be enabled when P-HTG-1/2 is enabled.
- .3 H

3.5.2. Normal Operation:

- .1 The lead Hot Water Secondary Pump (HWSP) shall run continuously when the outside air temperature is below system enable set-point.
- .2 The lead boiler primary pump shall start and when the flow is proven, the lead boiler shall modulate to maintain Hot Water Supply Temperature (HWST) at set-point based on Outside Air Temperature (OAT) as per following:

Outdoor Air Temperature (OAT)	12.8°C (55 deg. F)	-15°C (5 deg. F)
Hot Water Supply Temperature (HWST) Set-Point	43.3°C (110 deg. F)	82.2°C (180 deg. F)

- .3 The lag boiler and its pump shall be enabled if system load requires the second boiler.
- .4 Lead and lag boilers shall change on a weekly basis.
- .5 The lead glycol pump shall run continuously when the system is enabled. Lead and lag glycol pumps shall change on a weekly basis.
- .6 Glycol Control Valve (GCV) shall modulate to maintain Glycol Supply Temperature (GLYST) at set-point.

3.5.3. System Stop:

- .1 The system shall be disabled when Outside Air Temperature (OAT) rises above 18.3°C (65 deg. F).

3.5.4. Alarms:

- .1 Boiler General Alarms (BGAL) from boiler panels.
- .2 System pumps (PST) from current sensors.
- .3 Hot Water Supply Temperature (HWST) out of range.
- .4 Hot Water Return Temperature (HWRT) out of range.
- .5 Glycol Supply Temperature (GLYST) out of range.

.6 Glycol Return Temperature (GLYRT) out of range.

3.6. LIGHTING CONTROL

3.6.1. Applicable Systems:

3.6.2. System Start:

.1 Lighting zones shall be activated through time schedule.

3.6.3. Normal Operation:

.1 Lighting zones shall be on during occupied hours.

3.6.4. System Stop:

.1 Lighting zones shall be deactivated through time schedule.

.2 Lighting zones can be overridden on by a local override switch for an adjustable time period.

3.6.5. Schedule:

.1 To be determined by the Owner.

3.6.6. Alarms:

.1 Lighting Zone Status.

3.7. MISCELLANEOUS MONITORING POINTS (CONTROL DIAGRAM CDXX)

3.7.1. Miscellaneous Points:

- .1 Outdoor Air Temperature.
- .2 Fire Pump.
- .3 Fire Alarm.
- .4 Compressor Status.
- .5 Compressed Air Pressure.
- .6 Domestic Water Pump.
- .7 Domestic Water Pressure.
- .8 OEM Control Panel General Alarm.
- .9 Gas Meter.
- .10 Water Meter, main and tenant.
- .11 Energy Meter.
- .12 Cooling Tower Make-Up.
- .13 Steam Boiler Make-Up.
- .14 Steam Pressure.
- .15 Electrical Meter.
- .16 Sump Water Level.
- .17 Sump Pump.

3.8. RTU CONSTANT VOLUME 100% OUTSIDE AIR WITH HEAT WHEEL

3.8.1. Applicable Systems: RTU-1, RTU-2

3.8.2. System Start:

- .1 System start is initiated by operator command at the BAS or through time schedule. Upon signal to start the system, Exhaust Air Damper opens (EAD). Open position end switch (EADES) enables exhaust fan to start when exhaust air damper is fully opened. Exhaust Fan starts (EFSE) with the VSD at minimum position and a time delay of 30 seconds is initiated before the supply fan start signal is initiated. Upon the signal to start the supply fan, Outdoor Air Damper opens (OAD). Open position end switch (OADES) enables the supply fan to start when outdoor air damper is fully opened with the VSD at minimum position.
- .2 DX Cooling, Heat Pump and Heat Wheel shall be enabled when system fans are running.

3.8.3. Normal Operation:

- .1 The supply air static pressure control loop shall maintain the supply air static set-point of 0.3125 kPa (1.26 in. w.g.) by modulating the supply fan variable speed drive. The static sensor shall be located 2/3 down the supply ductwork.
- .2 The fan tracking control loop shall maintain the set-point air volume between the supply air and return air by modulating the return fan variable speed drive.
- .3 BAS shall modulate heat wheel speed through Heat Wheel Variable Speed Drive (HTWVSD) to maintain heat wheel Leaving Air Temperature (LAT) at 12.8°C (55 deg. F) (adjustable).
- .4 DX Cooling shall cycle to maintain Supply Air Temperature (SAT) at 12.8°C (55 deg. F) in cooling mode.
- .5 Heat pump shall cycle to maintain Supply air temperature (SAT) at 21.1°C (70°F). Glycol heating coil shall enable when ambient air temperature falls below -5°C (23°F) for greater than 5 minutes in heating mode.
- .6 Supply Air Humidity (SAH) and Return Air Humidity (RAH) shall be monitored by BAS.
- .7 Heat wheel frost control mode: if frosting conditions are calculated to occur using Return Air Humidity (RAH), Return Air Temperature (RAT), Outdoor Air Temperature (OAT) and Heat Wheel Leaving Air Temperature (HTWLAT), heat wheel speed shall be modulated to maintain Heat Wheel Leaving Air Temperature (HTWLAT) above calculated set-point.
- .8 Heat wheel standby mode: heat wheel shall be rotated at minimum speed one and a half rotation once per day when not in use.

3.8.4. System Stop:

- .1 System stop is initiated by operator command at the BAS or through time schedule. Upon signal to stop the system, the supply and exhaust fans shall stop. Outdoor and Exhaust Air Dampers (OAD, EAD) shall close. DX Cooling and Gas Heating shall be disabled. Heat Wheel (HW) shall be disabled.

3.8.5. Schedule:

- .1 System operates continuously.

3.8.6. Alarms:

- .1 Supply Fan Feedback (SFFB) from variable speed drive.
- .2 Exhaust Fan Feedback (EFFB) from variable speed drive.
- .3 Supply Fan VSD in manual override.
- .4 Exhaust Fan VSD in manual override.
- .5 Supply Air Temperature (SAT) out of range.
- .6 Safety alarms: low plenum air temperature (FZ), high plenum supply and exhaust air temperatures (F), high supply air static pressure (SAHP).

- .7 Supply and Exhaust Pre Filters (PFPD) dirty at 250 Pa (0.036 psi) pressure drop.

3.9. ELECTRIC FORCE FLOW HEATER

3.9.1. Applicable Systems: FFH-1, FFH-2, FFH-3

3.9.2. System Start:

- .1 System shall be enabled only in winter mode.
- .2 System start shall be initiated by space temperature demand. Upon signal to start the system, supply fan shall start. Heating coil valve shall be enabled.

3.9.3. Normal Operation Winter Mode:

- .1 Supply Fan (SFSS) shall cycle and resistive heating (HCV) shall modulate to maintain Space Temperature (SPCT) at set-point.

3.9.4. System Stop:

- .1 System stop is initiated when space temperature is satisfied. Upon signal to stop the system, the supply fan shall stop. Heating coil valve shall be closed.
- .2 System shall be disabled in summer mode.

3.9.5. Alarms:

- .1 Supply Fan Status (SFST) from current sensor.
- .2 Space Temperature (SPCT) out of range.

3.10. VRF FANCOIL SYSTEM WITH SUPPLEMENTARY HEATING

3.10.1. Applicable Systems: FCU-XX-XX, CU-X

3.10.2. System Start:

- .1 System start is initiated by operator command at the BAS, through normal time schedule or by input at the local controller

3.10.3. Normal Operation:

- .1 VRF Fan coils will provide primary source of heating and cooling depending mode of operation. Heat pump system to operate in specified mode heating or cooling based on outdoor air setpoint (adjustable).
- .2 When supplementary heating is enabled as determined by the local thermostat, the VRF controller shall enable the supplementary heating equipment to act as the second stage of heating. If the space temperature setpoint is not met in 5 minutes (adjustable), the perimeter heating control valve shall be modulated to maintain space temperature at setpoint. The VRF shall operate continuously during this time.

3.10.4. System stop:

- .1 System stop is initiated through a signal or time schedule.

3.10.5. Schedule:

- .1 To be determined by owner.

3.10.6. Alarms:

- .1 Space temperature out of range for greater than 10 minutes.

3.11.

END OF SECTION

23 21 13.23 Piping, Valves & Fittings (Except Plumbing)

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.1.2. All gate, globe and check valve shall be approved under Canadian Interprovincial Regulations for the Construction and Inspection of Boilers, Tanks, and Appurtenances.

1.1.3. Provide Shop Drawings in accordance with Section 20 05 03.00 - SHOP DRAWINGS for all valves, appurtenances, and grooved components.

1.1.4. All steel pipe and fittings shall be manufactured in North America. Off-shore pipe shall not be accepted on site. Pipe shall be clearly marked as being manufactured in North America or it shall be removed from site.

1.2. WARRANTY

1.2.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Use pipes, fittings and valves as shown below unless specifically shown or specified otherwise.

2.2. HIGH TEMPERATURE AND/OR PRESSURE WATER

2.2.1. High temperature heating water 121 deg. C. (250 deg. F.) at 1035 kPa (150 psi) and over, and heating water at 93.3 deg. C. (200 deg. F.) at 1138 kPa (165 psi) and over and chilled and condenser water less than 66 deg. C. (150 deg. F.) above 1380 kPa (200 psi).

2.2.2. Pipe 300 mm (12 in.) and larger, black steel ASTM A53, 12 mm (1/2 in.) wall, plain ends, ANSI B36.10.

2.2.3. Pipe 65 mm (2-1/2 in.) to 250 mm (10 in.), black steel ASTM A53, Schedule 80, plain ends, ANSI B36.10.

2.2.4. Pipe 50 mm (2 in.) and smaller, black steel ASTM A53, Schedule 80, threaded, ANSI B36.10.

2.2.5. Fittings 300 mm (12 in.) and larger, black steel ASTM A234, 12 mm (1/2 in.) wall, butt-welding, ANSI B16.9.

2.2.6. Fittings 65 mm (2-1/2 in.) to 250 mm (10 in.), black steel ASTM A234, Schedule 80, butt-welding ends, ANSI B16.9.

2.2.7. Fittings 50 mm (2 in.) and smaller, malleable iron ASTM A197, 2070 kPa (300 psi) WSP, threaded, ANSI B16.3.

2.2.8. Flanges 65 mm (2-1/2 in.) and larger, forged steel ASTM A181, 2070 kPa (300 psi) WSP ANSI B16.5. Use only weld neck flanges with butterfly valves.

2.2.9. Union 50 mm (2 in.) and smaller, malleable iron ASTM A197, 2070 kPa (300 psi) WSP, with bronze to iron ground joint, ANSI B16.3.

- 2.2.10. Flange accessories for high temperature hot water:
- .1 Gasket, 1.5 mm (1/16 in.) Asbestos free, Aramid fibres with nitrile binder suitable for 205 deg. C. (400 deg. F.) continuous maximum temperature at 6880 kPa (1000 psi), equal to Garlock Blue-Gard 3000.
 - .2 Bolts, alloy steel ASTM A193, ANSI B16.5, nuts, hexagonal, steel ASTM A307.
- 2.2.11. Strainers 65 mm (2-1/2 in.) and larger, cast iron 1720 kPa (250 psi) WSP flanged.
- 2.2.12. Strainers 50 mm (2 in.) and smaller, cast iron 1720 kPa (250 psi) WSP, threaded.
- 2.2.13. Gate valves 65 mm (2-1/2 in.) and larger, 2060 kPa (300 psi) WSP, cast steel O.S. and Y, ANSI B16.5 Flanges, shall be Crane #33XUF, Kitz 300 SCLS, Bonney Forge 3-11-RF, Beric 103RF, NCI #GF03RF or Jenkins J1010B8F.
- 2.2.14. Gate valves 50 mm (2 in.) and smaller, bronze 1380 kPa (200 psi) WSP, rising stem, threaded shall be Crane #424, Jenkins #2270UJ, Toyo 314, Beric 501T, NCI #GTVA-TBZ3333U or Kitz 37.
- 2.2.15. Globe valves 65 mm (2-1/2 in.) and larger, 2060 kPa (300 psi) WSP, cast steel metal disc, renewable seat, ANSI B16.5 Flanges, shall be Crane 151XU, Kitz 300 SCJS, Bonney Forge 3-31-RF, Beric 203RF, NCI #SL03RF or Jenkins J1042B2.
- 2.2.16. Globe valves 50 mm (2 in.) and smaller, bronze 1380 kPa (200 psi) WSP, renewable seat and plug, threaded shall be Crane #212P, Jenkins #2050J, Toyo 214, Beric 502T, NCI #GLBA-TBZ3443U or Kitz 17S.
- 2.2.17. Check valves 65 mm (2-1/2 in.) and larger, 2060 kPa (300 psi) WSP, cast steel, swing check, ANSI B16.5 Flanges, shall be Crane #159XU, Kitz 300SCOS, Bonney Forge 3-61-RF, Beric 303RF, NCI #CS03RF, or Jenkins J1025B2.
- 2.2.18. Check valves 50 mm (2 in.) and smaller, bronze 1380 kPa (200 psi) WSP swing check, threaded shall be Crane #36, Jenkins 4449J, Toyo 360, NCI #CKVA-TBZ3330 or Kitz 19.
- 2.2.19. Drain valves for blow-off of sediment from strainers, pipe drainage and tank drainage, shall be 19 mm (3/4 in.) size 250 WSP or 4130 kPa (600 psi) WOG ball valve with bronze body, stainless steel ball and stem, multifilled seats and packing, male threaded garden hose end, brass cap and chain shall be Apollo 70-140-64.
- 2.2.20. Butterfly valves maybe used as an alternative to gate valves only and shall be carbon steel body, one-piece shaft, top and bottom bearings, stainless disc with stainless steel trim with combination TFE and Titanium seat. Body with threaded lugs suitable for 2070 kPa (300 psi) flanges. Bubble-tight shut-off to 1965 kPa (285 psi) pressure in either direction when the piping and connecting flange is removed from one side of the valve.
- .1 Valves 100 mm (4 in.) and smaller with lever operator with lock. Valves 150 mm (6 in.) and larger with worm gear manual operator with indication of valve opening.
 - .2 Valves shall be shall be Dezurik Model BHP, WKM, Keystone Model K-LOK, Flowseal or Hills-McCanna Model McCannalock.
- 2.2.21. Butterfly valves maybe used as an alternative to gate valves only and shall be ANSI Class 300, carbon steel body, one-piece 17-4 shaft, top and bottom bearings, stainless disc, RTFE packing and seats. Body with threaded lugs suitable for 2070 kPa (300 psi) flanges. Bubble-tight shut-off to 5102 kPa (740 psi) pressure in either direction when the piping and connecting flange is removed from one side of the valve.
- .1 Valves 100 mm (4 in.) and smaller with lever operator with lock. Valves 150 mm (6 in.) and larger with worm gear manual operator with indication of valve opening.
 - .2 Valves shall be shall be WKM B5313-02-S02-11-HL, Flowseal 3DA121RTG-40J for lever operator and WKM B5313-02-S02-11-WG, Flowseal 3DA121RTG-30J for gear operator.

2.3. LOW TEMPERATURE AND/OR PRESSURE WATER

- 2.3.1. Heating water less than 121 deg. C. (250 deg. F.) at 1035 kPa (150 psi), or heating water less than 93.2 deg. C. (200 deg. F.) at 1139 kPa (165 psi), and chilled and condenser water less than 65.6 deg. C. (150 deg. F.) at 1380 kPa (200 psi).
- 2.3.2. Pipes 300 mm (12 in.) and larger, black steel ASTM A53, 9.5 mm (0.375 in.) wall, plain ends, ANSI B36.10.
- 2.3.3. Pipes 65 mm (2-1/2 in.) to 250 mm (10 in.) ASTM A53, Schedule 40, plain ends, ANSI B36.10.
- 2.3.4. Pipes 50 mm (2 in.) and smaller, black steel ASTM A53, Schedule 40, threaded, ANSI B36.10.
- 2.3.5. Pipes 100 mm (4 in.) and smaller, alternative for entire system for heating water, chilled water and condenser water in hard-tempered copper ASTM B88, Type L, plain ends. All joints made with 95-5 tin-antimony or tin-silver solder.
- 2.3.6. Pipe runouts to all induction and fan coil units and similar equipment soft temper copper ASTM B88, Type L, plain ends, size as shown, but minimum size of runouts 19 mm (3/4 in.). All joints made with 95-5 tin-antimony or tin-silver solder.
- 2.3.7. Fittings 300 mm (12 in.) and larger, black steel ASTM A234, 9.5 mm (0.375 in.) wall, butt-welding ends, ANSI B16.9.
- 2.3.8. Fittings 65 mm (2-1/2 in.) to 250 mm (10 in.) black steel ASTM A234, Schedule 40, butt-welding ends, ANSI B16.9.
- 2.3.9. Fittings 50 mm (2 in.) and smaller, malleable iron ASTM A197, 860 kPa (125 psi) WSP threaded, ANSI B16.3.
- 2.3.10. Flanges 65 mm (2-1/2 in.) and larger, forged steel ASTM A181, 1035 kPa (150 psi) WSP, ANSI B16.1. Use only weld neck flanges with butterfly valves.
- 2.3.11. Fittings alternative for entire system for heating water, chilled water and condenser water: wrought copper or cast bronze, solder, joint, ANSI B16.22.
- 2.3.12. Unions 50 mm (2 in.) and smaller malleable iron ASTM A197, 1035 kPa (150 psi) WSP, with bronze to iron ground joint, ANSI B16.3.
- 2.3.13. Flange accessories for heating water and condenser water:
 - .1 Gasket, 1.5 mm (1/16 in.) Synthetic fibres with rubber binder suitable for 205 deg. C. (400 deg. F.) continuous maximum temperature at 3440 kPa (500 psi), equal to Garlock Multi-Swell 3760.
 - .2 Bolts, hexagonal head machine with hexagonal nut, steel ASTM A307, ANSI B18.2.
- 2.3.14. Flange accessories for chilled water, gasket, cloth inserted rubber ring, bolts, hexagonal head machine with hexagonal nut, steel ASTM A307, ANSI B18.2.
- 2.3.15. Strainers 65 mm (2-1/2 in.) and larger, cast iron 860 kPa (125 psi) WSP, flanged.
- 2.3.16. Strainers 50 mm (2 in.) and smaller, cast iron 1720 kPa (250 psi) WSP, threaded.
- 2.3.17. Strainers 50 mm (2 in.) and smaller, for copper pipes bronze 860 kPa (125 psi) WSP, threaded. Mueller #351M.
- 2.3.18. Gate valves 65 mm (2-1/2 in.) and larger, cast iron 860 kPa (125 psi) WSP, bronze mounted, O.S. and Y ANSI B16.1 Flanges, shall be Crane #465 1/2, Jenkins #454J, Toyo 421, NCI #GTVA-FCI-1333HW or Kitz 72.
- 2.3.19. Gate valves 50 mm (2 in.) and smaller, bronze 1035 kPa (150 psi) WSP rising stem, threaded shall be Crane #431, Jenkins #2810J, Toyo 298, NCI #GTVA-TBZ2333 or Kitz 42.
- 2.3.20. Globe valves 65 mm (2-1/2 in.) and larger, cast iron 860 kPa (125 psi) WSP, bronze mounted, renewable composition disc, ANSI B16.1 Flanges shall be Crane #351, Jenkins #2342, Toyo 400A, NCI #GLBA-FCI-1333HW or Kitz 76.

- 2.3.21. Globe valves 50 mm (2 in.) and smaller, bronze 1035 kPa (150 psi) WSP, renewable composition disc, threaded shall be Crane #7TF, Jenkins #106-B, Toyo 221, NCI #GLBA-TBZ2360 or Kitz 9.
- 2.3.22. Butterfly valves maybe used as an alternative to gate valves only and shall be iron body, one-piece alloy steel shaft, top and bottom bearings, bronze disc or iron disc with stainless steel trim, resilient elastomer replaceable seat with integral reinforcing ring or keyed to body. Body with threaded lugs. Bubble-tight shut-off to 1035 kPa (150 psi) pressure in either direction when the piping and connecting flange is removed from one side of the valve.
- .1 Valves 100 mm (4 in.) and smaller with lever operator with lock.
 - .2 Valves 150 mm (6 in.) and larger with worm gear manual operator with indication of valve opening.
 - .3 Butterfly valves shall be shall be DeZurik Model BGS, Keystone Model 222-784, Bray Series 31, Challenger Model 20-CN4E, Apollo 143, Kitz 6122EL/G, Centerline 200, or Crane 44.
- 2.3.23. Check valves 50 mm (2 in.) and smaller bronze 860 kPa (125 psi) WSP, swing check, screwed cover, screwed shall be Crane #37, Jenkins #4092, Toyo 236, NCI CKVA-TBZ2331 or Kitz 22.
- 2.3.24. Check valves 65 mm (2-1/2 in.) and larger ANSI Class 150, 1030 kPa (150 psi) WSP, dual flapper retainers design with carbon steel body and stainless steel check, renewable disc and seat for flanged installation, shall be Velan-Proquip model BDD10-1B or DUO CHEK II H15SMF-201, NCI/SSI #150WTCT, or Mueller 72-DHH-3-H.
- 2.3.25. Drain valves for blow-off of sediment from strainers and tank drainage shall be 19 mm (3/4 in.) size 4140 kPa (600 psi) WOG ball valve with bronze or forged brass body, solid ball, virgin Teflon seat and packing, male threaded garden hose end, brass cap and chain shall be Watts B6000, Toyo 5046, Kitz 58CC or Apollo 78-100.
- 2.3.26. Float type eliminators, designed for a minimum of 1035 kPa (150 psi) water pressure with steel or cast iron body having removable flanged top, stainless steel or copper float and stainless steel valve and level mechanism.
- 2.3.27. As an alternative on vertical in-line pumps suction elbow may be combination elbow and strainer. Strainer perforations shall be as specified for Y strainers. Blow-off valves shall be provide in all sizes. Sizes of elbow strainer shall suit the pump suction size. Elbow shall be cast iron. Elbow shall be sized to suit pipe.
- 2.3.28. Radiation and fan coil shut off valves shall be Dahl Model 11042FXUN radiator valve suitable for 1720 kPa (250 psi) at 121 deg. C. (250 deg. F.). Lockshield balance valves shall be Dahl Model 13.013M.
- 2.3.29. Ball valves for heating water and chilled water 50 mm (2 in.) and smaller shall be bronze body 4140 kPa (600 psi) WOG, virgin Teflon seat, solid ball, TFE stem packing and thrust washer, 1/4 turn open-closed operation. All components to be replaceable in-line. Solder end valves are not acceptable. All ball valves shall be complete with stem extensions. Ball valves shall be Watts No. B-6800, Toyo 5050, Kitz 62, or Apollo 82-100-04.
- 2.3.30. Ball valves for heating water and chilled water 50 mm (2 in.) and smaller shall be bronze or forged brass 4140 kPa (600 psi) WOG, virgin Teflon seat, solid ball, TFE system packing and thrust washer, 1/4 turn open-close operation. All ball valves shall be complete with stem extensions. Ball valves shall be Watts B6000, Toyo 5044A, Kitz 58/59, NCI 600FP-T/600FP-S or Apollo 70-100/200-04.

- 2.3.31. Flow balancing valves shall have meter connection for attaching to a portable meter. Each connection shall have positive shut-off valves. Each valve shall be capable of precise flow measurement, accurate flow balancing and positive shut-off. Adjustment shall be by multiple turns of the handle for Vernier type setting and shall have a hidden memory feature for tamper-proof setting.
- .1 For all valves 65 mm (2-1/2 in.) and larger, provide flanged or grooved as follows: Flanged: Victaulic / TA Hydronics Series 788 flanged, Nexus UltraMB MBF, or IMI Hydronic Engineering STAF; Grooved: Victaulic / TA Hydronics Series 789 grooved, Nexus UltraMB MBG, or IMI Hydronic Engineering STAG.
 - .2 For valves 50 mm (2 in.) and smaller, provide screwed as follows: Victaulic / TA Hydronics Series 787, Nexus UltraMB, or IMI Hydronic Engineering STAD.
 - .3 Provide a portable flow measuring meter, complete with hoses and carrying case to suit each size of valve provided. Meter shall be computerized, differential pressure type for direct reading of flow rate in either GPM or L/s.
- 2.3.32. As an alternative to Standard Details (MSD-765.02) for reheat coil installation provide preassembled coil pipe and fitting assembly with flow balancing valve, unions, air vent, temperature and pressure port, and serviceable strainer with isolation valves. Victaulic Series 799 Koil-Kit complete with 78K-STADK flow balancing valve, 78-UP union plus air vent and PT port, and 78Y with 20 mesh Y-strainer/ball valve/drain & coil hoses or Red & White complete with 9517/9519 flow balancing valve, 92STC Combination ball valve, Y-strainer, drain & test port, 92UTFM brass union, air vent and PT port, SSB stainless steel flexible hoses. Automatic air vent piped to drain shall be used if branch take-off is above the main. Stainless steel hose sizes to be determined by Contractor. Coordinate control valve with Controls Contractor.
- 2.4. GROOVED PIPE AND FITTINGS
- 2.4.1. For systems less than 120 deg. C. (248 deg. F.) at 2068 kPa (300 psi) or as specified.
- 2.4.2. Grooved pipe and fittings may be used for hot water, chilled water, hot or chilled glycol, and condenser water systems.
- 2.4.3. Pipes 50 mm (2 in.) to 250 mm (10 in.) black steel ASTM A53, Schedule 40 cut or roll grooved.
- 2.4.4. Pipes 300 mm (12 in.) and larger black steel ASTM A53, 9.5 mm (0.375 in.) wall, cut or grooved.
- 2.4.5. Couplings shall consist of two ASTM A536 grade 65-45-12 ductile iron housing segments, ASTM D2000 pressure responsive elastomer gasket, and ASTM A449 zinc-electroplated steel bolts and nuts.
- .1 Sizes 300 mm (12 in.) and smaller:
 - .1 Rigid Type: Housings shall be cast with torque-absorber and shift-limiting slant bolt pads to provide rigidity and system support and hanging in accordance with ANSI B31.1 and B31.9 and to prevent mis-assembly due to overshift.
 - .1 50 mm (2 in.) through 300 mm (12 in.): Installation-Ready, for direct stab installation without field disassembly, with grade EHP gasket rated to 121 deg C. (250 deg. F). Victaulic Style 107V.
 - .2 As an alternative provide Victaulic Zero-Flex Style 07.
 - .2 Flexible Type: For use in locations where vibration attenuation and stress relief are required or in a Victaulic riser design. Three flexible couplings may be used in lieu of a flexible connector. The couplings shall be placed in close proximity to the source of the vibration. Victaulic Style 177N or 77.

- .2 Size 350 mm (14 in.) and larger: Victaulic AGS Series with lead-in chamfer on housing key and wide width flush seal gasket.
 - .1 Rigid Type: Housing key shall fill the wedged shape AGS groove and provide rigidity and system support and hanging in accordance with ANSI B31.1 and B31.9. Victaulic Style W07.
 - .2 Flexible Type: Housing key shall fit into the wedge shaped AGS groove and allow for linear and angular deflection. Victaulic W77.
- 2.4.6. Fittings 50 mm (2 in.) to 250 mm (10 in.) cast ductile iron ASTM A536 grade 65-45-12.
- 2.4.7. Fittings 300 mm (12 in.) and larger full flow cast fitting. Factory fabricated steel fittings to ASTM Grade B may only be used with the approval of Engineer's Representative.
 - .1 350 mm (14 in.) and larger shall be complete with Victaulic 'AGS' grooved ends.
- 2.4.8. Branch connections: ductile iron ASTM A535; Victaulic Style 920, 920N, or 72.
- 2.4.9. Flanges; ductile iron ASTM A536 for sizes 50 mm (2 in.) to 600 mm (24 in.); Victaulic Style 741/W741.
- 2.4.10. Gaskets: EPDM conforming to ASTM D-2000, temperature range -34 deg. C. to 110 deg. C. (-30 deg. F. to 230 deg. F.).
 - .1 EHP conforming to ASTM D-2000, temperature range -34 deg. C to 121 deg. C. (-30 deg. F. to 250 deg. F.).
- 2.4.11. Valves 50 mm (2 in.) to 300 mm (12 in.): ductile iron Body to ASTM A536, EPDM pressure-responsive seat, electroless-nickel coated ductile iron disc, with stem offset from the disc centerline to provide complete 360-degree circumferential seating for temperatures up to +110 deg. C. (+230 deg. F.), for bubble-tight service to 2065 kPa (300 psi). Victaulic Vic-300 MasterSeal.
 - .1 Butterfly Valves 350 mm (14 in.) to 600 mm (24 in.): Ductile iron body to ASTM A536, EPDM disc mounted seal, PPS (polyphenylene sulphide) coated ductile iron disc, and stainless steel stem. (Stem shall be offset from the disc centerline to provide full 360- degree circumferential seating). Rated for temperatures up to + 110 deg. C. (+230 deg. F.), for bubbletight service to 2065 kPa (300 psi). Victaulic AGS Vic-300.
- 2.4.12. Check valves 65 mm (2-1/2 in.) to 300 mm (12 in.): ductile iron ASTM A536 EPDM coated disc spring loaded design for non-slam operation. Victaulic Series 716.
 - .1 Check valves 350 mm (14 in.) to 600 mm (24 in.): Ductile iron body to ASTM A395, dual stainless steel disc(s), with stainless steel spring and shaft, rated for temperatures up to +110 deg. C. (+230 deg. F.), for service to 1575 kPa (230 psi) Victaulic Series W715.
- 2.4.13. Strainers 50 mm (2 in.) to 600 mm (24 in.): ductile iron ASTM A536 with type 304 stainless steel screen. Victaulic Style 730/732 and W730/W732.
- 2.4.14. As an alternative on vertical in-line pumps, suction elbow may be suction diffusers. Victaulic 731-D.
- 2.4.15. As an alternative to Standard Details for pumps, piping may be manufactured vibration isolation pump drop assemblies 50 mm (2 in.) to 300 mm (12 in.). Includes flow control, vibration-isolation flexible couplings, access ports for gauges and thermowells, isolation and check valves, strainer or suction guide and an integral flanged pump connection. Victaulic Series 380, 381, 382 or 383.
- 2.4.16. All grooved Products, including couplings, fittings, valves and specialty items shall be Victaulic.
- 2.4.17. For other system components refer to Low Temperature and/or Pressure Water Article.

2.7. PLAIN END PIPE COUPLINGS AND FITTINGS

- 2.7.1. For systems 120 deg. C. (248 deg. F.) at 2068 kPa (300 psi).
- 2.7.2. Plain end couplings fittings may be used for hot water, chilled water, hot or chilled glycol, and condenser water systems.
- 2.7.3. Pipes 12 mm (1/2 in.) to 50 mm (2 in.) black steel ASTM A53 "Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless," Schedule 40.
- 2.7.4. Couplings and fittings shall be ASTM A536 "Standard Specification for Ductile Iron Castings" grade 65-45-12 ductile iron housing segments, ASTM D2000 "Standard Classification System for Rubber Products in Automotive Applications" pressure responsive elastomer gasket, and ASTM A449 "Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use" zinc-electroplated steel bolts and nuts.
- 2.7.5. Gaskets: EPDM conforming to ASTM D2000 "Standard Classification System for Rubber Products in Automotive Applications," temperature range -34 deg. C. to 120 deg. C. (-29 deg. F. to 248 deg. F.).

2.8. WELDING

- 2.8.1. Pipe welding shall be in accordance with:
 - .1 ANSI/ASME B31.1
 - .2 ANSI/ASME Boiler and Pressure Vessel Code, Section IX.
 - .3 TSSA
 - .4 Authorities Having Jurisdiction
 - .5 CSA B51 - Boiler, Pressure Vessel and Pressure Piping Code
- 2.8.2. Ensure complete penetration of deposited metal with base metal. Manufacturer shall provide filler metal suitable for use with base metal. Keep inside of fittings free from globules of weld metal. All welded pipe joints shall be made by the fusion welding process employing a shielded metallic arc process (SMAW). The use of a gas metal arc welding process (GMAW/ MIG) for pipe welding is not permitted. Inside of pipe shall be free of excessive reinforcement. The use of backing plates is not acceptable. Tack welds, if used, must be of the same material and made by the same procedure as the completed weld. Otherwise, remove tack welds during the welding operation.
- 2.8.3. In no cases shall Schedule 40 or standard weight pipe be welded with less than three passes including one stringer/ root, one filler and one lacer. Schedule 80 pipe shall be welded with not less than four passes including one stringer/ root, two filler and one lacer/ cap.
- 2.8.4. Each weld shall be uniform in width and size throughout its full length. In addition, the cover pass (final weld layer) shall be free of coarse ripples, grooves, overlaps, abrupt ridges and valleys/ under cut. The surface smoothness of the finished weld shall be suitable for the proper interpretation of non-destructive examination of the weld.
- 2.8.5. Each weld layer or pass shall be visually free of slag, inclusions, cracks, porosity and lack of fusion. Grinding to meet this criteria and elimination of defects and surface preparation of welds shall be done in a manner as not to gouge, groove or reduce the adjacent base material thickness below the minimum required.
- 2.8.6. All butt welds shall be full penetration with uniform crown, with reinforcement blending smoothly into the base material. Concavity on the root side of a single welded circumferential butt weld is permitted with the resulting thickness of the weld at least equal to the thickness of the thinner member of the sections being joined.

- 2.8.7. Socket welds shall have a gap of approximately 1.5 mm (1/16 in.) minimum to 3 mm (1/8 in.) maximum between the bottom of the socket and the end of the pipe prior to welding.
- 2.8.8. Visually inspect all welds for compliance with this section. Welds found to be lacking penetration, or containing excessive porosity or cracks must be removed and replaced with an original quality weld as specified herein.
- 2.9. PIPE COATINGS
- 2.9.1. For carbon steel piping: primer coated with an epoxy coating, 5 mil thickness or manufacturer's recommended thickness, whichever is more stringent.
- 2.9.2. For stainless steel piping: coated with an epoxy primer, 5 mil thickness or manufacturer's recommended thickness, whichever is more stringent, and an epoxy finish coat, 5 mil thickness or manufacturer's recommended thickness, whichever is more stringent.
- 2.10. GENERAL REQUIREMENTS FOR PIPE SYSTEMS
- 2.10.1. Where a branch at least two pipe sizes smaller connects into a main, welding fittings of Bonney Forge, full flow fittings or other approved manufacturer may be used.
- 2.10.2. For chilled, condenser and low temperature heating water, where a branch at least two pipe sizes smaller connects into a main, branch may be mitred and welded to main.
- 2.10.3. Use Y pattern strainers with screens of type 304 stainless steel or Monel with approximately 1 mm (1/32 in.) perforations for sizes 100 mm (4 in.) and smaller, and approximately 3 mm (1/8 in.) perforations for larger sizes. Provide a valved blow-off connection in all caps 65 mm (2-1/2 in.) and larger. Maximum pressure drop with clean screen shall not exceed 7 kPa (1 psi) with water velocity through inlet pipe of 1.5 m/s (5 ft./s). For 50 mm (2 in.) and larger pipe size all heads retaining the basket shall be bolted. For 38 mm (1-1/2 in.) and smaller pipe heads shall be gasketed with straight threads.
- 2.10.4. Solder end globe, angle and gate valves, sizes 50 mm (2 in.) and smaller, are acceptable if it can be shown that they are similar in design and construction to the valves specified.
- 2.10.5. Except where special features are required or unless otherwise approved, all globe, gate and check valves shall be of one manufacturer, with the manufacturer's name and the pressure rating clearly marked on the outside of the valve body.
- 2.10.6. Strainers shall be Colton Industries or Mueller.
- 2.10.7. Air vents shall be Bell and Gosset, Taco, Sarco, Watts, Zurn, or Maid-O-Mist.
- 2.10.8. Manufacture air separators in an ISO recognized facility. Factory test each unit per Hydraulic Institute standards at the factory of origin. Provide tangential type air separator with flanged or grooved inlet and outlet connections. Provide the vessel shell diameter as three times the nominal inlet/outlet pipe diameter. Provide inlet and outlet connections of the same size. Design, construct, and stamp the unit for the system design pressure class in accordance with ASME Boiler and Pressure Vessel Code. Supply the separator with automatic air vent, and connect the vent connection into the bottom of the compression tank for air control systems.

- 2.10.9. Manufacture air and dirt separators in an ISO recognized facility. Factory test each unit per Hydraulic Institute standards at the factory of origin. Provide air and dirt separator with flanged or grooved inlet and outlet connections. Provide the vessel shell diameter as three times the nominal inlet/outlet pipe diameter and provide the separator complete with coalescing media. Provide air and dirt separator that allows access for removal and cleaning of coalescing media. Provide bottom of air and dirt separator with dirt chamber and ball valve for dirt purge. Provide separator with inlet and outlet connections of the same size. Design, construct and stamp the separator for the system design pressure class in accordance with ASME Boiler and Pressure Vessel Code. Supply the separator with automatic air vent and connect the vent connection into the bottom of the compression tank for air control systems. Provide air and dirt separator from one of the following manufacturers: Spirotherm Spirovent, Xylem Bell & Gossett, Taco, or Armstrong.
- 2.11. BUFFER TANKS
- 2.11.1. Acceptable manufacturers for buffer tanks for hydronic heating and cooling systems: Niles Steel, Lochinvar, Amtrol, A.O. Smith, Wessels, or Taco.
- 2.11.2. Construct tanks in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code, and design and stamp tanks for 860 kPa (125 psi) operating pressure.
- 2.11.3. Construct tanks of carbon steel. Provide an internal baffle for 2-port tanks. Prime exterior surfaces and paint with red oxide paint.
- 2.11.4. Include with tank: screwed, flanged, or grooved system connections at the same elevation; temperature gauge port; pressure relief valve; drain valve connection; and air vent connection.
- 2.11.5. Provide tanks complete with ring base and lifting rings. Provide tanks that are self supporting.
- 2.11.6. Provide tank with capacity and dimensions as follows:
- .1 Chilled Water System BT-01: _____ L (_____ US gal) volume, _____ mm (_____ in.) tall, _____ mm (_____ in.) diameter.
 - .2 Heating Water System BT-02: _____ L (_____ US gal) volume, _____ mm (_____ in.) tall, _____ mm (_____ in.) diameter.
3. Execution
- 3.1. INSTALLATION
- 3.1.1. For pipe 65 mm (2-1/2 in.) and larger, use flanges, and for smaller pipe, use unions at all valves and equipment.
- 3.1.2. Flare connections may be used on soft copper tubing where one end of the flare connection is an integral part of the equipment or valve.
- 3.1.3. Provide pipe coatings in accordance with the requirements of this section, where carbon steel piping or stainless steel piping is installed exterior to the building.
- 3.1.4. Provide automatic air vents at all high points on piping mains for hot and chilled water systems. Where venting a horizontal pipe, grade pipe up in direction of flow with vent at high point. Provide gate valve at the float inlet. Pipe outlets to drain using copper pipe. Drain pipe shall be run such that its route is visible.
- 3.1.5. Provide manual air vents on all hot water heating units where air may be trapped. Use screw-driver operated vents of chrome plated brass. Vents shall be accessible without removing cover of heating unit.
- 3.1.6. Provide air separators and air and dirt separators where shown on the Drawings.

- 3.1.7. Arrange all runs of piping to prevent interference and to achieve a satisfactory and professional installation of neat appearance. Run all piping parallel to walls. All valves, controls, equipment, expansion compensators, flexible connections and, as far as possible, all piping shall be easily accessible for inspection, maintenance and operation.
- 3.1.8. Pitch all lines 25 mm in 12 m (1 in. in 40 ft.-0 in.) unless shown otherwise.
- 3.1.9. Install drain valves at all low points for draining and locate where easily accessible. In order to achieve this, install remote from system where necessary, clearly marked. Typical marking similar to the following:
 - .1 Heating system
 - .2 Danger, authorized personnel only
- 3.1.10. Carefully ream threaded joints and join with compound on the male thread only. Re-tighten flanged connections after the installation has been brought up to its service. Following testing, apply insulation. Take care not to overstress the material during construction.
- 3.1.11. Pipe welding operations shall be performed by welders Provincial Certification for the class of piping to be welded. Ensure the internal opening of pipes and fittings are not restricted by superfluous material.
- 3.1.12. When welding or cutting with a torch, take precautions to prevent fire by maintaining fully charged 4.5 kg (10 lbs.) carbon dioxide extinguisher immediately adjacent to the operation. Protect wooden structure with fire retardant blankets.
- 3.1.13. Arrange piping to permit ease of equipment removal. Provide flanges or unions on all pipe connections to each piece of equipment.
- 3.1.14. Connect all multi-row water coils in counter flow.
- 3.1.15. Drains from packaged air handling unit drain pans shall be of same size as connection on unit. Provide traps on all drains and deep seal traps on both sides of the fan and coil sections.
- 3.1.16. Connect bases of all pumps with packed glands to drain with 12 mm (1/2 in.) OD copper tubing.
- 3.1.17. Provide on the discharge line of each spray pump, a 12 mm (1/2 in.) valved bleed-off. Connect to discharge line above sump water level and run to drain.
- 3.1.18. Provide strainers upstream of each pump suction, steam control valve and steam trap not preceded by a control valve, and where shown.
- 3.1.19. Provide butterfly valves where shown; these are permitted in lieu of gate valves in sizes 65 mm (2-1/2 in.) and larger.
- 3.1.20. Install all valves in Equipment Rooms in accessible locations from the floor. Where valves are not accessible from the floor, equip with chain operators at the discretion of the Engineer's Representative.
- 3.1.21. Provide gate, globe and check valves in all piping systems as shown and as required for satisfactory operation and control of equipment. Provide shut-off valves wherever piping is connected to all equipment. Provide one flow balancing valve and one shut-off valve on water coils.
- 3.1.22. Provide for the expansion and contraction of all pipes. Install with sufficient flexibility to prevent end-thrust and movements caused by thermal expansion or Contraction causing detrimental distortion or damage of connection equipment. Provide offsets between mains and equipment of sufficient length to safely absorb the expansion of the main.
- 3.1.23. Install all control devices, valves and any other appurtenances as directed by the controls and/or BAS trades.
- 3.1.24. Make connections between copper and steel with brass or bronze fittings.

- 3.1.25. Ball valves may be used in low temperature and/or pressure systems only in lieu of gate valves in 50 mm (2 in.) and smaller. Provide union downstream of ball valves for servicing if ball valve is not a three piece design.
- 3.1.26. For grooved piping, ensure ends are clean and free from indentations, projections, and roll marks in the area from the pipe end to the groove for proper gasket sealing. Ensure all couplings meet the manufacturer's standards for visual inspection. Verify the gasket style and elastomeric material (grade) as suitable for the intended service as specified. Install in accordance with manufacturer's latest written recommendations. Have a manufacturer's factory trained representative periodically visit the site and review the installation for best practices. Correct any identified deficiencies. For Grooved Product that has been examined and has not met the visual inspection criteria for proper installation, correct and have the manufacturer re-examine prior to the completion of the Work. Install flow balancing valves in sections of straight pipe as recommended by the manufacturer, but in no case with less than 10 pipe diameters upstream of the valve.
- 3.1.27. Install flow balancing valves in the following locations:
- .1 At each heating, chilled or condenser water riser, or main floor branch
 - .2 Each heating water and cooling water coils including unit heaters, fan coils and force flow heaters
 - .3 Each heat exchanger
 - .4 Each wall fin, radiant ceiling or similar heating device
 - .5 Each heat pump
 - .6 Each differential pressure bypass control valve line
 - .7 Each main building or secondary heating or cooling circuit
 - .8 And where shown
- 3.1.28. Provide bird screen on all vents terminating horizontally, with a gooseneck or other configurations where a vent stack cover is not provided.
- 3.1.29. Buffer tanks:
- .1 Place tanks on 100 mm high housekeeping pads.
 - .2 Provide drain valve, automatic air eliminator, and pressure relief valve for buffer tanks and pipe to nearest floor drain.
 - .3 Provide a manual isolation valve on each buffer tank system connection.

END OF SECTION

23 21 23.00 Centrifugal Pumps

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. WARRANTY

1.2.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.2. GENERAL

2.2.1. Single or double suction pumps, as shown, from:

- .1 Armstrong
- .2 Xylem Bell & Gossett
- .3 Taco
- .4 Grundfos-Paco
- .5 Patterson Pump Company
- .6 Wilo

2.2.2. Pumps shown as operating in parallel must be selected for stable performance under single pump operation. Submit Shop Drawings showing both single and parallel pump operation.

2.2.3. Pump volute shall be sized for a maximum of 17 fps velocity. When a pump cannot meet this requirement the manufacturer shall clearly indicate this on the Shop Drawing and include a written explanation as to why the particular pump has been selected.

2.2.4. Impeller shall be enclosed type. Complete impeller and shaft assembly shall be statically and dynamically balanced.

2.2.5. For fixed speed pumps impeller shall not exceed 85 percent of casing cut water point. For variable speed pumps the duty point shall be selected similar to a fixed speed pump and the impeller shall be maximized to operate 5% greater than the rated motor horsepower at pump run out.

2.2.6. Pump inlet and outlet shall be flanged for 860 kPa (125 psi) ANSI flanges or for 1720 kPa (250 psi) ANSI flanges to meet the system requirements. Inlet and outlet flanges shall be equal in size.

2.2.7. Motor shall be in conformance with Section 20 05 13.00 - ELECTRIC MOTORS.

2.2.8. Select motors to be non-overloading over the entire pump curve.

2.2.9. Provide pumps in accordance with the Pump Schedule.

2.2.10. Where Vertical In-Line pumps are scheduled or specified as the basis of design, base mounted pumps shall not be permitted as a substitute.

2.3. BASE MOUNTED PUMPS

- 2.3.1. Each base mounted pump shall have a heavy cast iron or steel base for common support of the pump and direct connected motor.
- .1 Pump and motor shall be connected through a flexible coupling supplied with the pump. For variable speed applications provide a suitable coupling.
 - .2 A coupling guard shall be provided to OSHA standards.
 - .3 Pump casing shall be cast iron, impeller shall be bronze, shaft shall be stainless steel or steel with bronze sleeves.
 - .4 Bearings shall be ball type, mounted inboard and outboard in supporting mandrel.
 - .5 Bearings shall be grease or oil lubricated type. Permanently lubricated bearings are not acceptable.
- 2.3.2. For base mounted pumps a stuffing box with packing shall be provided for condenser water pumps.
- 2.3.3. Casing shall be fitted with properly anchored impeller wear rings for all base mounted pumps.

2.4. VERTICAL IN-LINE PUMPS

- 2.4.1. Pumps shall be vertical P base motor driven units with split type rigid spacer coupling for pumps 7.5 kW (10 hp) and over to be easily removed on site to reveal a space between the pump and motor sufficient to allow servicing of seal without disturbing pump or motor.
- .1 Casing shall be cast iron, impeller shall be bronze and shaft shall be stainless steel.
 - .2 Mechanical seal shall be outside balanced.
 - .3 For double volute pumps less than 345 kPa (50 psi) operating pressure, inside unbalanced mechanical seals are acceptable. For operating pressures 345 kPa (50 psi) and higher, a balanced mechanical seal shall be provided.
- 2.4.2. Seal flushing connection complete with filter and sight flow indicator to suit system working conditions shall be provided on all pumps 7.5 kW (10 hp) and over. Filter shall be sized to suit the flow rate required for the seal and shall be oversized by three times for glycol systems.
- .1 As an alternative to the above provide a cyclone sediment separator and sight flow indicator where differential pressures exceed 207 kPa (30 psi).
- 2.4.3. Internal mechanical seal shall be John Crane Silicon Carbide or equal.
- 2.4.4. External mechanical seal shall be stainless steel multi-spring outside balanced type with Viton secondary seal, carbon rotating face and silicon carbide stationary seat.
- .1 Provide a 316 stainless steel gland plate.
 - .2 Provide a factory installed flushline with manual vent.
- 2.4.5. For heating systems with operating temperatures greater than 82.2 deg. C. (180 deg. F.) and for condenser water systems use Silicon Carbide seals.
- 2.4.6. Provide strainer guide vanes on vertical suction piping section of all vertical in-line pumps, where specifically shown. Refer to Section 23 21 13.23 - PIPES, VALVES AND FITTINGS for detailed Specification.

3. Execution

3.1. INSTALLATION

- 3.1.1. Grout base-mounted pumps to vibration isolation base after shimming and aligning in accordance with manufacturer's written instructions. Alignment shall be provided by a certified millwright once at start-up and once at operating temperature. Grout void under steel or cast iron base full of concrete. Base shall be large enough to support base elbow at pump suction for single suction pumps and both suction and discharge elbow on double suction pumps.
- 3.1.2. Increases and reducers on pump suction and discharge shall be eccentric fittings and shall be of a gradual increase or reduction to prevent unnecessary turbulence or noise.
- 3.1.3. Provide vibration isolation and flexible connections for all pumps in accordance with Section 20 05 48.00 - VIBRATION AND NOISE CONTROL.
- 3.1.4. Filters shall be changed by this Division after the system is flushed and on a regular basis until handed over to the Owner or their representatives.

END OF SECTION

23 22 53.00 Pressure Relief Valves

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. WARRANTY

1.2.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. All pressure relief valves shall be code rated for the service and shall be approved under Canadian Interprovincial Boiler Inspection Regulations.

2.1.2. Pressure relief valves shall be Spirax Sarco or approved equal.

3. Execution

3.1. INSTALLATION

3.1.1. Hot water pressure relief valves shall operate at 207 kPa (30 psi) unless shown otherwise. Where higher pressure relief settings are required, relief valve shall operate at 70 kPa (10 psi) less than the maximum rated pressure of the lowest rated system component (tank, boiler, heat exchanger, etc.) or 1034 kPa (150 psi) whichever is less.

END OF SECTION

23 23 01.00 Refrigerant Piping

1. General
 - 1.1. WORK INCLUDED
 - 1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
 - 1.1.2. Provide low Global Warming Potential (GWP) refrigerant complying with the performance requirements stated within Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
 - 1.2. SUBMITTALS
 - 1.2.1. Submit Product data sheets for all Products required, except for pipe and fittings.
 - 1.2.2. Submit a schematic piping diagram for each refrigerant piping system indicating pipe sizes, slopes, valves, traps, and piping specialties sealed by a Professional Engineer in the Province of the installation.
 - 1.2.3. Submit confirmation of registration of the Project with the Authority Having Jurisdiction.
 - 1.3. REGULATORY COMPLIANCE AND QUALITY ASSURANCE
 - 1.3.1. The installing Contractor shall be certified and shall register all Projects in accordance with the requirements of the Authority Having Jurisdiction.
 - 1.3.3. All components of a refrigeration piping system shall have a Canadian Registration Number or CSA certification acceptable to Authority Having Jurisdiction.
 - 1.3.4. All systems shall display appropriate Ozone Depletion Prevention (ODP) tags prior to commissioning. Manufacturer shall not commission any system not displaying proper ODP tags.
 - 1.4. SPECIAL CONSIDERATIONS FOR VARIABLE REFRIGERANT FLOW (VRF) PIPING SYSTEMS
 - 1.4.1. VRF refrigeration piping systems shall be installed as per the balance of this Specification with the following considerations and/or exceptions:
 - 1.4.2. Refrigerant Contractors shall be certified by the VRF Equipment Supplier. Proof of training certification shall be made available upon request.
 - 1.4.3. There shall be minimal use of refrigeration specialties (filter driers, accumulators, receivers, check valves, etc.) in the VRF pipe system. Install in accordance with VRF manufacturer's recommendations.
 - 1.4.4. Pressure relief valves shall be 4482 kPa (650 PSI) rated and installed in pairs (two valves per circuit).
 - 1.4.5. Y style piping joints and headers shall be provided by the manufacturer to ensure proper refrigerant balance and flow for optimum system capacity and performance.
 - 1.4.6. T style joints, field fabricated joints, or Y joints that are not provided by the manufacturer shall not be permitted.
 - 1.4.7. Approved flaring block, and approved torque wrenches, both available from VRF manufacturer, shall be used for all flare connections.

- 1.4.8. Pipe clamps shall fasten around the piping insulation. Pipe clamps that compress the copper directly shall be installed a minimum of 900 mm (36 in) away from joints, and shall be loosely tightened to allow for copper expansion.
- 1.4.9. Provide VRF manufacturer with actual pipe lengths installed for calculation of refrigerant charge. Supply and charge VRF system with required quantity of refrigerant prior to VRF manufacturer commissioning. Refrigerant charging shall be done in the liquid state.
- 1.5. WARRANTY
- 1.5.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
- 2. Products
- 2.1. PIPE, FITTINGS AND JOINTS
- 2.1.1. Provide hard drawn, air conditioning / refrigerant grade ASTM B280 “Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service” copper piping for runs longer than 3 m (10 ft.); for shorter runs air conditioning / refrigerant grade ASTM B280 soft annealed copper piping is permissible provided the requirements of Part 3 are met..
 - .1 Braze all joints except as noted.
 - .2 Joints 22 mm (7/8 in) and smaller may be flared.
 - .3 Fittings shall be cast copper alloy for flared copper tube, or wrought copper and bronze solder-joint pressure fittings.
 - .4 Joints and fittings for brazed joint shall be wrought-copper or forged-brass sweat fittings.
 - .5 Cast sweat-type joints and fittings shall not be permitted for brazed joints.
 - .6 Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of equipment.
- 2.2. BRAZING FILLER METAL
- 2.2.1. Filler metal shall be type BAg-5 with AWS Type 3 flux except as noted.
- 2.2.2. Copper to copper joint filler metal shall be BCuP-5 or BCuP-6.
- 2.2.3. Brazing rods for all joints shall be 15 % Lucas Milhaupt “sil-Fos”.
- 2.3. VALVES
- 2.3.1. Valves shall be designed, manufactured, and tested specifically for refrigerant service. Valve bodies shall be of brass, bronze, steel, or ductile iron construction. Valves 25 mm (1 in) and smaller shall have brazed or socket welded connections. Valves larger than 25 mm (1 in) shall have butt welded end connections. Threaded end connections shall not be used, except in pilot pressure or gauge lines where maintenance disassembly is required and welded flanges cannot be used. Internal parts shall be removable for inspection or replacement without applying heat or breaking pipe connections. Valve stems exposed to the atmosphere shall be stainless steel or corrosion resistant metal plated carbon steel. Direction of flow shall be legibly and permanently indicated on the valve body. Purge, charge and receiver valves shall be of manufacturer’s standard configuration.
- 2.3.2. Refrigerant access valves and hose connections shall be in accordance with AHRI 720.

- 2.3.3. Isolation valves shall be installed where shown on the schematics. Isolation valves shall be bi-flow self-seating with operating pressures up to 4482 kPa (650 PSI). Valves shall be complete with brass Schrader connections located on the valve body only.
- 2.3.4. Check Valves shall be Mueller Industries Inc. "Checkmaster" straight through type for valves 6.4 mm to 16 mm (1/4 in to 5/8 in) diameter, globe type for valves 22 mm (7/8 in) diameter and larger, each complete with extended tubing for brazing connections, and as follows:
- .1 Straight through type check valves are to be complete with a machined brass gasketed body, phosphor bronze spring, and neoprene seat.
 - .2 Globe type check valves are to be complete with a cast bronze body, forged brass cap, phosphor bronze spring, PTFE seat disc, and neoprene O-ring seal.
- 2.3.5. Liquid Solenoid Valves
- .1 Ball type valves as specified above, each in accordance with AHRI 760 and be suitable for continuous duty with applied voltages 15 % under and 5 % over nominal rated voltage at maximum and minimum encountered pressure and temperature service conditions, direct-acting or pilot-operating type, moisture-proof, ULC approved, totally encapsulated or encapsulated and metal jacketed as required. Valves shall have an operating pressure differential suitable for the refrigerant used.
- 2.3.6. Expansion Valves
- .1 Valve shall be the diaphragm and spring-loaded type with external equalizers, and bulb and capillary tubing. Valve shall be equipped with an external superheat adjustment along with a seal cap. Internal equalizers may be utilized where flowing refrigerant pressure drop between outlet of the valve and inlet to the evaporator coil is negligible and pressure drop across the evaporator is less than the pressure difference corresponding to 1 Deg. C. (2 Deg. F.) of saturated suction temperature at evaporator conditions. Pilot-operated valves shall have a characterized plug to provide required modulating control.
 - .2 Electronic expansion valves shall be brass body, needle valve with floating needle and machined seat, stepper motor drive.
- 2.3.7. Safety Relief Valves
- .1 Suction lines shall be rated at 2413 kPa (350 PSI) and liquid at 4482 kPa (650 PSI) or liquid and discharge lines at 4482 kPa (650 PSI) respectively.
 - .2 Purpose built Y-fitting shall be Superior Products model 3155W.
- 2.3.8. Evaporator Pressure Regulators, Direct-Acting
- .1 Valve shall include a diaphragm/spring assembly, external pressure adjustment with seal cap, and pressure gauge port. Valve shall maintain a constant inlet pressure by balancing inlet pressure on diaphragm against an adjustable spring load. Pressure drop at system design load shall not exceed the pressure difference corresponding to a 1 Deg. C. (2 Deg. F.) change in saturated refrigerant temperature at evaporator operating suction temperature. Spring shall be selected for indicated maximum allowable suction pressure range.
- 2.4. PIPING ACCESSORIES
- 2.4.1. Filter Driers
- .1 Sizes 15 mm (5/8 in) and larger shall be the full flow, replaceable core type. Sizes 15 mm (1/2 in) and smaller shall be the sealed type. Cores shall be of suitable desiccant that will not plug, cake, dust, channel, or break down, and shall remove water, acid, and foreign material from the refrigerant. Filter driers shall be constructed so that none of

the desiccant will pass into the refrigerant lines. Minimum bursting pressure shall be 10.3 MPa (1500 PSI).

2.4.2. Discharge Line Oil Separator

- .1 Discharge line oil separator shall be provided in the discharge line from each compressor. Oil return line shall be connected to the compressor as recommended by the compressor manufacturer.

2.4.3. Accumulator

- .1 Accumulators shall be provided in the suction line to protect the compressor from liquid refrigerant damage. Accumulator shall be cUL listed under the required operating pressures and must be installed as close to the compressor as possible.

2.4.4. Refrigerant Moisture and Liquid Indicators

- .1 Indicators shall be single or double port, ULC listed. Body shall be copper or brass with flared or soldered ends. Sight glass shall have color coded paper moisture indicator with removable element cartridge and plastic cap. Maximum working pressure shall be 3447 kPa (500 PSIG). Maximum working temperature shall be 93.3 Deg. C. (200 Deg. F.).

2.4.5. Pressure and Vacuum Gauges

- .1 Gauges shall conform to ASME B40.100 and shall be provided with throttling type needle valve or a pulsation dampener and shut-off valve. Gauge shall be a minimum of 85 mm (3-1/2 in) in diameter with a range from 0 kPa (0 PSIG) to approximately 1.5 times the maximum system working pressure. Each gauge range shall be selected so that at normal operating pressure, the needle is within the middle-third of the range.

2.4.6. Insulation

- .1 Liquid, suction and hot gas lines shall be individually insulated in accordance with Section 20 07 00.00 – INSULATION.

3. Execution

3.1. GENERAL

- 3.1.1. Consider the piping shown on the Drawings as diagrammatic, indicating the general runs and connections only, and parts may not be shown in the true position. Be responsible for the proper erection of the systems of piping in every respect suitable for the work intended.
- 3.1.2. Install all piping in a professional manner and in accordance with the best practices of the trade. Piping shall be pitched 13 mm (1/2 in) for every 3000 mm (10 ft) of length in the direction of flow to ensure adequate oil drainage. Open ends of refrigerant lines or equipment shall be properly capped or plugged during installation to keep moisture, dirt, or other foreign material out of the system. Piping shall remain capped until installation. Equipment piping shall be in accordance with the equipment manufacturer's recommendations and as shown.
- 3.1.3. Pipe supports shall be a maximum of 1800 mm (6 ft.) apart. Pipe clamps shall fasten around the piping.
- 3.1.4. Piping supports and guides using steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

- 3.1.5. Anchors shall be provided wherever necessary or indicated to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline. Where pipe and conduit penetrations of vapor barrier sealed surfaces occur, these items shall be anchored immediately adjacent to each penetrated surface, to provide essentially zero movement within penetration seal.
- 3.1.6. Install in accordance with CSA B52 and ASME B31.5 Mechanical Refrigeration Code.
- 3.1.7. Safety pressure relief valves shall be installed in the piping as per CSA B52. All pressure relief valves and brazed joints shall be suitably sized.
- 3.1.8. Install two pressure relief valves per refrigeration circuit using a purpose built "Y" fitting complete with integral ball valves.
- 3.1.9. Install on the liquid and suction line or liquid and discharge line as per Drawing details. Pressure relief valves shall be individually isolated to allow for maintenance and replacement.
- 3.1.10. Nitrogen purging / sweeping shall be used when brazing and welding to minimize oxidization.
- 3.1.11. Isolation valves shall be installed where shown on the schematics or as required.
- 3.1.12. Prevent the release of refrigerants into the atmosphere during installation and testing.
- 3.1.13. Pipe shall be cut accurately to measurements established at the jobsite, and worked into place without springing or forcing, completely clearing all windows, doors, and other openings. Pipe or tubing shall be cut square reamed to remove burrs, and shall permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers.
- 3.1.14. Install pipe, valves, and fittings to facilitate easy maintenance. Do not locate valves, couplings, or flanged/union connections directly above electrical panels, motor starters or MCCs.
- 3.1.15. Where soft annealed copper piping is permissible above, install it straight and free of dips that may trap refrigerant.
- 3.1.16. A liquid line filter dryer shall be installed in each refrigerant circuit located such that all liquid refrigerant passes through a filter dryer. Dryers shall be sized in accordance with the manufacturer's recommendations for the system in which it is installed.
- 3.1.17. A moisture indicating sight glass shall be installed in all refrigerant circuits down stream of all filter dryers and where indicated. Site glasses shall be full line size.
- 3.1.18. Arrange for review and acceptance of all refrigerant pipe joints by the Authority Having Jurisdiction prior to concealing the joints.

END OF SECTION

23 25 13.00 Heating System Chemical Treatment

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Shop Drawings: Submit Shop Drawings of all components of the system in accordance with SECTION 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS. Include all wiring diagrams.

1.2.2. Manufacturer's Data: Submit details of all testing equipment to be provided.

1.3. QUALITY ASSURANCE

1.3.1. Qualifications of Manufacturers: Work under this section shall be limited to the following companies:

- .1 Solenis
- .2 GE Water and Process Technologies
- .3 Anco Chemicals Water Treatment Inc.
- .4 Norkem Inc.
- .5 Klenzoid

1.4. WARRANTY

1.4.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.2. CLOSED RECIRCULATING LOOP FOR HEATING SYSTEM

2.2.1. For each heating system provide an adequately sized pot feeder for the entire system but not less than a 7.6 L (2 gallon) pot feeder. Pot feeder shall have a maximum working pressure of 300 psi at 200 deg F. Tank shell shall be 10 gauge steel, tank heads shall be 9 gauge steel, and cap shall be cast iron with Buna N seal ring, equal to Solenis PN 9233-03-2 or Neptune DBF-2HP. Pot feeder assembly shall be complete with valved inlet and outlet, screen, drain and pot feeder.

2.2.2. For each heating system provide an adequately sized pot feeder for the entire system but not less than a 19 L (5 gallon) pot feeder. Pot feeder shall have a maximum working pressure of 300 psi at 200 deg F. Tank shell and heads shall be 11 gauge steel, and cap shall be cast iron with Buna N seal ring, equal to Solenis PN 9233-04-0, or Neptune DBF-5HP. Pot feeder assembly shall be complete with valved inlet and outlet, screen, drain and pot feeder.

- 2.2.3. Provide two (2) corrosion test coupons, one copper equal to Drew PN 7721-01-3 and one steel equal to Solenis PN-7722-01-1. Corrosion coupons to be installed in 19 mm (3/4 in.) tee fittings on the upstream side of the pot feeder.
- 2.2.4. Corrosion and scale inhibitor for closed loop heating systems shall be equal to GE W&P Technologies CORRSHIELD MD4102 or Solenis CSW 311.
- 2.2.5. Provide an adequate quantity of chemical treatment for 6 months of operation after Substantial Completion of the Contract.
- 2.2.6. Provide bypass filter as specified in Section 23 25 14.00 - PIPE SYSTEM FILTERS.

3. Execution

3.1. INSTALLATION

- 3.1.1. Pot feeder is to be installed in parallel with filter on supply and return line headers. Headers shall be in an accessible location, less than 1.5 m (5 ft.) above the floor.
- 3.1.2. The Water Treatment Supplier shall provide a service program for a period of 1 year from Substantial Completion of the Contract. Service visits shall be conducted on regular frequency suitable to meet system stability requirements. A report containing findings and recommendations shall be submitted to the Owner following each visit.
- 3.1.3. Provide two days service (7-1/2 hours per day) of manufacturer's representative to add chemicals to the systems until properly protected, adjust the equipment and the blow down rates. Representative shall also, during this time, instruct the Owner's representative in the correct use of the treatment, show the Owner the test results for the systems, how to test the systems, and how often.

END OF SECTION

23 25 14.00 Pipe System Filters

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. WARRANTY

1.2.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. For systems under 600 GPM, provide pipe system filter housings capable of receiving a single double open end (DOE) filter cartridge. Construct head of cast iron; construct shell of Type 304 or Type 316L stainless steel.

2.1.2. For systems over 600 GPM, provide pipe system filter housings capable of receiving multiple double open end (DOE) filter cartridges. Construct shell and heads of Type 316L stainless steel.

2.1.3. Provide shell and heads suitable for 1035 kPa (150 psi) working pressure and provide filter media suitable for 149 deg. C. (300 deg. F.) service temperature.

2.1.4. Provide bleached cotton filter media for selective removal of particles from 1 to 100 microns. Provide non-rupturing media and mount so that no by-pass of media can occur.

2.1.5. Size filters for 3 % of total system flow and apply within the mid-capacity of the filter operating flow rate.

3. Execution

3.1. INSTALLATION

3.1.1. Install pipe system filters in the following systems:

- .1 Perimeter heating systems
- .2 Constant temperature heating system
- .3 Chilled water system

3.1.2. Install pipe system filters across the pumps with valved inlet and outlet. Provide flow balancing outlet valve. Refer to Section 23 21 13.23 - PIPES, VALVES AND FITTINGS (EXCEPT PLUMBING). Provide flanges or unions for servicing. Provide valved drain on unit casing.

END OF SECTION

23 25 16.00 Chilled & Condenser Water Treatments

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Shop Drawings: Submit Shop Drawings of all components of the system in accordance with SECTION 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS. Include all wiring diagrams.

1.2.2. Manufacturer's Data: Submit details of all testing equipment to be provided.

1.3. QUALITY ASSURANCE

1.3.1. Qualifications of Manufacturers: Work under this section shall be limited to the following companies:

- .1 Solenis
- .2 GE Water and Process Technologies
- .3 Chem-Aqua.
- .4 Norkem Inc.
- .5 Klenzoid

1.4. WARRANTY

1.4.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.2. OPEN RECIRCULATING SYSTEM (CONDENSER WATER)

2.2.1. Pre-piped, pre-wired non-acid chemical feed system complete with pumps on common mounting frame with 6 mm (1/4 in.) mild steel base plate. Provide interlock to prevent chemical make-up when condenser water pumps are off. System shall be suitable for cooling tower system having maximum circulating water rate as shown on the Cooling Tower Schedule.

2.2.2. Feed pump shall be capable of delivering 0.007 L/s (6.6 USGPH) against 690 kPa (100 psi) complete with built-in relief valve. Feed pumps shall be suitable to draw directly from the chemical supply containers.

2.2.3. Provide pre-wired baked enamel 1.5189 mm thick (0.0598 in. - 16 ga) steel control panel for all controls, starters, and similar components in colour selected by Engineer's Representative requirements. Each item shall be provided with lamacoid label.

2.2.4. Meter on make-up water system to cooling towers shall operate inhibitor chemical feed pumps through automatic reset timers. Timers shall be adjustable from 1 to 30 minutes.

- 2.2.5. Manual condenser water bleed off to drain shall be 12 mm (1/2 in.) Hancock Model 4585 flow control valve or other approved manufacturer.
- 2.2.6. Provide and install 4 coupon PVC corrosion test rack, complete with flow meter. Corrosion test rack shall be equal to GE W&P Technologies model 2042205, 1" NPT w/ 4 coupon holders, 8 GPM valve, 4 transparent viewing sections, two mild steel coupons and two copper coupons. Also provide 2041977 Replacement Coupon Holder, 1" Black Iron w/ 6" Teflon™ Stem and Teflon nut & Screw.
- 2.2.7. Automatic blow-down shall be by a conductivity controller that controls the quantity of dissolved solids by opening the normally closed control valve. Valve may be either electric or pneumatic operated. If pneumatic is used, provide air from the nearest control air line.
- 2.2.8. Provide 50 mm (2 in.) water meter in make-up water line to cooling tower. Provide water meter with auxiliary contact for operating automatic chemical feed controls.
- 2.2.9. Injector shall be PVC construction and complete with shut off valve and double check valve. Chemicals are fed neat from their shipping containers and shall be injected into condenser water line down stream of the condensers. Chemicals shall be equal to:
- .1 Scale and Corrosion Inhibitor - Solenis Performax Millennium
 - .2 Alternating Biocide - Solenis Biosperse 250 and Biocide T
- 2.2.10. All piping, valves and fittings shall be PVC.
- 2.2.11. Provide sufficient quantity of algaecides and biocides for algae and slime control for six months following Substantial Completion of the Contract.
- 2.3. CLOSED RECIRCULATING SYSTEM (CHILLED WATER)
- 2.3.1. For each chilled water system provide an adequately sized pot feeder to inject nitrate borate solutions into the entire system but not less than a 7.6 L (2 gallon) pot feeder. Pot feeder shall have a maximum working pressure of 300 psi at 200 deg F. Tank shell shall be 10 gauge steel, tank heads shall be 9 gauge steel, and cap shall be cast iron with Buna N seal ring, equal to Solenis PN 9233-03-2 or GE W&P Technologies DBF-2. Pot feeder assembly shall be complete with valved inlet and outlet, screen, drain and pot feeder.
- 2.3.2. For each chilled water system provide an adequately sized pot feeder for the entire system but not less than a 19 L (5 gallon) pot feeder. Pot feeder shall have a maximum working pressure of 300 psi at 200 deg F. Tank shell and heads shall be 11 gauge steel, and cap shall be cast iron with Buna N seal ring, equal to Solenis PN 9233-04-0, or GE W&P Technologies DBF-5. Pot feeder assembly shall be complete with valved inlet and outlet, screen, drain and pot feeder.
- 2.3.3. Provide two (2) corrosion test coupons, one copper equal to Solenis PN 7721-01-3 and one steel equal to Solenis PN-7722-01-1. Corrosion coupons to be installed in 19 mm (3/4 in.) tee fittings on the upstream side of the pot feeder.
- 2.3.4. Spray coils on each system shall be provided with a chemical treatment system controlled from a make-up water meter to supply a sequestering agent to the spray water. Bleed-off shall be controlled from a conductivity controller. Provide a biocide/algaecide for control of slime in the tank.
- 2.3.5. Corrosion and scale inhibitor for closed loop heating systems shall be equal to GE W&P Technologies CORRSHIELD MD4102 or Solenis CSW 311.
- 2.3.6. Provide an adequate quantity of each type of chemical for complete oxygen removal, scale protection or other type of protection sufficient to treat the entire system or systems for six (6) months after Substantial Completion of the Contract.

- 2.3.7. Provide testing equipment as per SECTION 23 25 26.00 - CLEANING AND FILLING for all types of chemicals used in the systems. Equipment shall be mounted in a baked enamel steel storage cabinet with hinged door. Colour of cabinet shall be to the Engineer's Representative's requirements.
- 2.3.8. Provide bypass filter as specified in SECTION 23 25 14.00 - PIPE SYSTEM FILTERS.
- 3. Execution
 - 3.1. INSTALLATION
 - 3.1.1. Pot feeder is to be installed in parallel with filter on supply and return line headers. Headers shall be in an accessible location, less than 1.5m (5 ft) above the floor.
 - 3.1.2. The Water Treatment Supplier shall provide a service program for a period of 1 year from Substantial Completion of the Contract. Service visits shall be conducted on regular frequency suitable to meet system stability requirements. A report containing findings and recommendations shall be submitted to the Owner following each visit.
 - 3.1.3. Install system in accordance with reviewed Shop Drawings and manufacturer's installation instructions.
 - 3.1.4. Wall mount control panel, starters, and similar components where shown, unless otherwise directed. Controls shall be flush mounted. Provide manual-off-automatic switches for chemical feed pumps together with running and trip lights. Provide interlock with condenser water pumps to prevent chemical injection when condenser water pumps are off.
 - 3.1.5. Furnish isolating gate valve upstream of the bleed off valve.
 - 3.1.6. Furnish isolating gate valve upstream of the control valve.
 - 3.1.7. Furnish control valve, size of which shall be equal to the blow-down pipe size.
 - 3.1.8. Install isolating valves and valved by-pass around water meter. Provide interconnecting wiring between meter and chemical feed control system.
 - 3.1.9. Provide manufacturer's representative to add chemicals to the systems until properly protected, adjust the equipment and the cooling tower bleed-off. Representative shall also instruct the Owner's representative in the correct use of the treatment. Upon completion submit a letter stating that all systems have been correctly set-up, are operating as required for adequate protection, and the Owner has received adequate instruction for the ongoing maintenance of the systems.
 - 3.1.10. Provide all interconnecting wiring and piping to complete the system. All electrical connections as required are the responsibility of the Mechanical Contractor.

END OF SECTION

23 25 26.00 Cleaning and Filling

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Shop Drawings: Submit Shop Drawings of all chemicals used in the system in accordance with SECTION 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Water piping cleaning solution for closed loop systems shall be equal to GE W&P Technologies FERROQUEST FQ7103 or Solenis CSW 600. Refer to manufacturer's written instructions for chemical concentrations.

2.1.2. Provide inhibited ethylene glycol system solution that is 50% by volume of factory, pre-mixed solution. Acceptable Products: Dow Chemical Co. "Dowtherm SR-1", Interstate Chemical Co. "Intercool NFE", Chemfax Chem-Cool, or Recochem Inc. "Recotherm IG".

2.1.3. Provide inhibited propylene glycol system solution that is 50% by volume of factory, pre-mixed solution. Acceptable Products: Chemfax Chem-Frost propylene glycol.

2.1.4. Provide alcohol Anti-freeze solution that is 40% by volume of Anchem Sales "Ancool-100."

2.1.5. Glycol make-up packages shall be provided for glycol water make-up. Each glycol make up package shall be equal to Solenis Chemical E5800; PN 9243-01-5, Expanflex model GMP-2-50, GE W&P Technologies AGS-2045, or Armstrong GLA-STD-LP-1 for 1.8 gpm make-up at 50 psig with a 120 V (1/3 hp) motor and 50 gallon polyethylene storage tank complete with hinged cover. Unit shall be complete with cut-off and (audible and visual) alarm in case of high pressure or low solution level. The pumping assembly shall be mounted in a sturdy steel frame, complete with legs to keep it off the floor. The package shall include a motor, a pump, a magnetic starter, a pressure tank, a priming valve, a PRV, a shut-off valve and a pressure gauge

3. Execution

3.1. INSTALLATION

3.1.1. All systems shall have been hydrostatically tested prior to cleaning.

3.1.2. Thoroughly flush all systems with raw water to remove loose mill scale and debris. Remove and clean all strainers and flush low points before chemical cleaner is added.

- 3.1.3. Disconnect all coils and by-pass flow.
- 3.1.4. A temporary pump shall be installed in the system and shall be capable of pumping adequate discharge at adequate head.
- 3.1.5. A temporary heater shall be installed in the system and shall be capable of maintaining the circulating water temperature as required for chemical treatment.
- 3.1.6. Systems shall be filled with city water and approved chemical cleaner introduced by a small temporary chemical injector pump at the temporary circulating pump section. Cleaner shall be introduced to maintain concentrations as per the manufacturer's recommendations.
- 3.1.7. All systems shall be cleaned in accordance with manufacturer's written instructions and under the supervision of the Chemical Supplier's representative. Minimum cleaning procedures shall be to fill all water piping cleaning solution, circulate at 1.5 times specified system flow rate and maintain at highest possible temperature for 72 hours. During this period heavy blowdown of all low points shall be carried out every 6 hours. Strainers shall be cleaned as necessary to permit maximum flow possible and, in any event, at least every 6 hours. Drain the solution, all strainers, and flush entire system with clean water for a minimum of 24 hours. Repeat fill and flush procedure as often as required, adding inhibitor with each fill, to achieve acceptable contaminant levels. Systems shall then be refilled, ready for use. Temperature of system for cleaning shall be to suit Chemical Supplier's requirements.
- 3.1.8. Take samples of system from a series of representative drains as directed by the Engineer's Representative. If system is still dirty, repeat cleaning procedure specified above until acceptable. Acceptable samples shall indicate that alkalinity and pH have returned to potable water levels. Copies of all test reports shall be submitted by the Water Treatment Supplier to the Engineer's Representative for verification prior to final filling.
- 3.1.9. Add fluid and chemical treatment immediately after cleaning has been completed and accepted. Acceptable control parameters shall be as follows:
 - .1 Nitrite: 1000 - 1500 ppm
 - .2 pH: 8.5 – 10 or as required by equipment manufacturer
 - .3 Iron: Less than 2.0 ppm
 - .4 Copper: Less than 0.3 ppm
 - .5 Molybdate: 100 - 150 ppm
 - .6 Hardness (CACO3): Less than 50 ppm or as required by equipment manufacturer (soften water as required)
- 3.1.10. For glycol systems install glycol make-up system as per manufacturer's written instructions and in accordance with Section 23 77 13.00 - EXPANSION TANKS. Fill system with specified glycol product to achieve the required glycol concentration. Glycol systems shall be provided with a Freezing Point Glycol Test Kit equal to Solenis PN 7729-01-7.
- 3.1.11. For ground source closed loop heat pump systems after cleaning and draining, fill the system with alcohol or propylene glycol anti-freeze solution as specified or shown in equipment schedules.
- 3.1.12. For tenant Work the Base Building Contractor shall drain and fill the base building system. Arrange and pay for this Work.
- 3.1.13. The Mechanical Contractor shall supply the Engineer's Representative with certified documentation from the Water Treatment Supplier that the systems have been properly equipped, chemically cleaned and that they are maintaining sufficient levels of scale/corrosion inhibitor. The Contractor shall request such documentation from the Water Treatment Supplier within one week of presentation to the Engineer's Representative.
- 3.1.14. A label or tag identifying any chemical additives, their concentration, and their maintenance requirements shall be permanently and prominently displayed on the heat source.

END OF SECTION

23 26 13.00 Pipe Expansion Joints, Guides and Anchors

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.1.2. Select hangers, supports, anchors, guides and restraints to withstand all static and dynamic loading conditions which act upon the piping system and associated equipment. Design expansion and contraction solution to suit the temperature and spatial restraints of the location where the pipes are installed. Prepare detailed Shop Drawings showing all anchors, guides, and expansion compensation for all systems with the potential for thermal expansion/contraction and/or loads due to weight or thrust. Provide Shop Drawings bearing the signed seal of a Professional Engineer licensed to practice in the appropriate discipline and Place of the Work. Include in the Shop Drawings all details of construction, static and dynamic forces at points of attachment, etc. necessary for review and acceptance by the Project Structural Engineer's Representative. Make adjustments as necessary to satisfy the requirements of the Structural Division. Do not install any anchor points without reviewed Shop Drawings and, where installed prior to review, remove and replace to the satisfaction of the Engineer's Representative.

1.2. SYSTEM TEMPERATURES

1.2.1. Refer to schematics on Drawings for required operating pressures.

1.2.2. Base Shop Drawings required above on the following minimum and maximum temperatures.

System Type	Minimum Temperature	Maximum Temperature	Notes
Heating Water	4 C	115 C	Max temperature includes safety factor
Chilled Water	4 C	45 C	
Condenser Water	4 C	49 C	
Domestic Cold Water	4 C	45 C	
Domestic Hot Water / Recirculation	4 C	70 C	
Steam	4 C	198 C	
Condensate	4 C	100 C	

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

- 2.1.1. Expansion joints, guides and anchors: United Flexible, Flexonics, Hydroflex, or Victaulic, specifically designed for the system in which they are installed.
- 2.1.2. Victaulic Floor-Mounted Riser Anchor for Grooved Steel Piping: Engineered pipe anchor, sizes 50 mm (2 in.) through 300 mm (12 in.), standard weight carbon steel to ASTM A53 "Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless" with orange enamel coating with carbon steel brackets. Victaulic Original-Groove System grooved ends. Anchors suitable for system operating pressure to 3447 kPa (500 psi). Victaulic No. A10.
- 2.1.3. Victaulic AGS Heavy Riser Anchor: Engineered pipe anchor, sizes 350 mm (14 in.) through 600 mm (24 in.), standard weight carbon steel to ASTM A53 "Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless" with orange enamel coating with carbon steel brackets. Victaulic Advanced-Groove System (AGS) grooved ends. Anchors suitable for system operating pressure to 3447 kPa (500 psi). Victaulic No. WA20.
- 2.1.4. Victaulic Floor-Mounted Riser Anchor for Grooved Stainless Steel Piping: Engineered pipe anchor, sizes 50 mm (2 in.) through 300 mm (12 in.), schedule 40 stainless steel to ASTM A312 "Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes," type 304 with carbon steel brackets. Victaulic Original-Groove System grooved ends. Anchors suitable for system operating pressure to 3447 kPa (500 psi). Victaulic No. A10S.
- 2.1.5. Expansion compensation:
 - .1 Expansion compensation solution as presented per Part 1 requirements.
 - .2 Expansion joints for 75 mm (3 in.) diameter pipe and larger: packless bellows type with equalizing rings, stainless steel bellows, limit stops, internal telescoping sleeves and carbon steel schedule with bevelled welding ends, or flanged to suit installation.
 - .3 Expansion joints for 65 mm (2-1/2 in.) diameter pipe and smaller: packless bellows type with stainless steel bellows, anti-torque device, limit stops, guides and threaded pipe ends.
 - .4 Grooved expansion joints for 20 mm (3/4 in.) and larger sizes: expansion joint consisting of a series of grooved end nipples joined with flexible-type couplings. Joint movement and expansion capabilities determined by number of couplings / nipples used in the joint. Victaulic Style 155, 155P and W155 AGS.
 - .5 Furnish an inspection and data report, furnish with expansion compensation system.

3. Execution

3.1. INSTALLATION

- 3.1.1. Provide for the expansion and contraction of all pipes, and install with sufficient flexibility to prevent end thrust and movements caused by thermal expansion or contraction causing detrimental distortion or damage of connected equipment. Provide offsets between mains and equipment of sufficient length to safely absorb the expansion of the main.
- 3.1.2. During operation, the chilled water supply temperature will be 4 deg. C. (39 deg. F.). Precompress expansion joints in accordance with manufacturer's installation instructions based on the ambient installation temperature.
- 3.1.3. Guides shall be as shown and shall be located as follows:

- .1 Distance from expansion joint to first guide shall be maximum 4 pipe diameters
- .2 Distance from first to second guide shall be maximum 14 pipe diameters
- .3 Maximum spacing between additional guides:
 - .1 3.7 m for 65 mm (12 ft. for 2-1/2 in.) pipe
 - .2 7.3 m for 75 mm and 100 mm (24 ft. for 3 in. and 4 in.) pipe
 - .3 11 m for 125 mm and 150 mm (36 ft. for 5 in. and 6 in.) pipe
 - .4 14.6 m for 200 mm (48 ft. for 8 in.) pipe
 - .5 18.3 m for 250 mm (60 ft. for 10 in.) pipe
- 3.1.4. Anchors shall be as shown.
- 3.1.5. Ensure anchors, expansion compensation, and guides are located and installed in accordance with the Engineered Shop Drawings required by this specification section.
- 3.1.6. Expansion joint and anchor manufacturer to provide on-site inspection to ensure proper installation per design requirements and manufacturer's installation instructions.

END OF SECTION

23 26 16.00 Flexible Pipe Connectors

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. WARRANTY

1.2.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Pipe connectors, where shown, for water, shall be Hydroflex Hose, Flexonics or Vibro-Flo or corrugated metal with braided sheath.

2.1.2. Corrugated metal and sheath shall be of bronze or stainless steel with threaded ends for 50 mm (2 in.) pipe size and smaller and flanged ends for larger sizes.

2.1.3. Total length of connector shall vary from a minimum of 300 mm (12 in.) for 25 mm (1 in.) deflection, and up to 450 mm (18 in.) for 50 mm (2 in.) or greater deflection.

2.1.4. Minimum working pressure at 21.1 deg. C. (70 deg. F.) shall be 1200 kPa (175 psi) based on maximum working pressure not exceeding burst pressure.

3. Execution

3.1. NOT USED

END OF SECTION

23 31 13.00 Ductwork and Specialties

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Shop Drawings

- .1 Submit Shop Drawings of all catalogued components to be supplied. Include manufacturer's data sheets for certification, performance criteria, ratings, and physical dimensions and finishes.
- .2 Submit Shop Drawings of each supporting structural assembly required in the ductwork systems, designed by an engineer licensed to practice in the Place of the Work in the appropriate discipline. Same design engineer stamps each and every Shop Drawing.

1.2.2. Samples: Submit samples as required.

1.2.3. Submit marked up prints showing detailed locations of all devices mounted in or on ductwork, dimensioning their locations.

1.3. QUALIFICATIONS

1.3.1. Acceptable sheet metal trade specialists are limited to following:

- .1 Engie
- .2 Modern Niagara (DMC Mechanical Ltd.)
- .3 Smith & Long (Giffin Sheetmetal Ltd.)
- .4 J.C. Rogers
- .5 Black & MacDonald
- .6 Tam-Kal
- .7 David C. Little Contracting Inc.

1.4. WARRANTY

1.4.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Fabricate all ductwork unless specifically noted otherwise, of galvanized sheet steel with Z180 coating to A653/A653M.

2.1.2. Sealing compound: Minnesota Mining and Manufacturing or other approved manufacturer. Duct tape shall be Duro-Dyne or other approved manufacturer.

2.1.3. Flexible ducting:

- .1 Flexible fabric ducting shall be Flexmaster Fabriflex FAB-4. ULC listing S110.
 - .2 Flexible metal ducting shall be Flexmaster Triple-Lock Aluminum Flexible ducting T/L. ULC listing S110.
 - .3 Acoustic flexible metal ducting shall be Flexmaster Triple-Lock Acoustic Flexible ducting T/L-A-T/L consisting of perforated aluminum inner core, 38 mm (1-1/2 inch) insulation, and aluminum outer covering. ULC listing S110.
 - .4 Thermal flexible metal ducting shall be Flexmaster Triple-Lock Thermal Flexible T/L-M ducting ULC listing S110.
- 2.1.4. Access Ports shall be Lawson-Taylor or other approved manufacture of 32 mm (1-1/4 in.) dia. ports.
- 2.1.5. Flexible Connections:
- .1 Ventfabrics, Duro Dyne, or Dyne-Air.
 - .2 For fans less than 0.5 kPa (2 in. wg.) connections shall be minimum 680 gm/sq.m. (20 oz./sq.yd.) fire retardant polyvinyl-chloride polyester fabric equal to Vinyl-Flex.
 - .3 For fans in excess of 0.5 kPa (2 in. wg.) connections shall be minimum 1,080 gm/sq.m. (32 oz./sq.yd.) non-toxic neoprene coated fibreglass fabric equal to Neoprene N.T.
 - .4 For all flexible connections located outside the building (e.g. roof top units) flexible connections shall be fire retardant Hypalon coated fibreglass fabric and shall be a minimum 9915 gm/sq.m. (27 oz./sq.yd.) equal to Hypalon.
 - .5 For all systems where the temperature may exceed 112 deg. C. (235 deg. F.) silicone rubber coated fibreglass shall be used, and shall be equal to Silicone H1-T. Submit flexible connections for review before installation.
- 2.1.6. Dampers:
- .1 Dampers: For right angle branch duct take-off from vertical riser; Air vector Vectrol or other approved manufacturer.
 - .2 Construct fire dampers, smoke dampers and combination smoke and fire dampers of stainless steel where dampers are installed in aluminum or stainless steel ductwork.
 - .3 Fire Dampers: Underwriters' Laboratories Classified to ANSI/UL 555 Standard for Fire Dampers and CAN/ULC S112 Standard Method of Fire Test of Fire Damper Assemblies or ANSI/UL 555C Standard for Ceiling Dampers as applicable.
 - .1 Fire dampers shall be curtain type, rated as "Dynamic," and shall have the blades clear of the air stream. Fire dampers shall be Type B or Type C as required to suit system air velocity and pressure. Fire dampers in return and exhaust systems may be Type A with the blades in the air stream where permitted by the Engineer's Representative. Dampers shall be multi-sectional as required to suit size and UL/ULC Listing requirements. Where the specified curtain fire dampers are limited by the UL/ULC Listing for maximum size, they shall be substituted with multi-blade type complete with power actuation and/or fusible link as required to satisfy the fire rating of the partition. Where a fire damper is required to be installed behind a wall grille, Slimline type dampers may be used to provide a flush to wall grille installation.
 - .2 Fire-stop flaps or ceiling mounted fire dampers shall be as shown in the Underwriters' Laboratories Listing for the specific ceiling assembly used.
 - .3 Thermally insulated motorized control dampers: in accordance with the requirements contained within Section 23 09 00 – BUILDING AUTOMATION SYSTEM (BAS).

- .4 Combination balancing/fire damper: Combination balancing device and fire damper, in one Product, tested in accordance with ULC S112 "Standard Methods of Fire Test of Fire-Damper Assemblies", appropriate for use in fire separations of up to 2 hours.
- .5 Combination Smoke and Fire Dampers: Multi-blade type complete with operating shaft, stainless steel side seals and fire resistant insulating blade seals. Dampers shall bear label corresponding to fire rating shown on the Architectural Drawings and shall be of the same manufacturer as noted for fire dampers. Damper shall be opened/closed by electric damper actuator and fully closed on activation of electric temperature sensing device. Limit switches shall be provided to show position of damper blades. Leakage through dampers shall not exceed 40.6 L/s/ sq.m. (8 cfm/sq.ft.) of damper area at 1.0 kPa (4.0 in. wg.) of differential pressure when determined in accordance with CAN/ULC S112.1 "Leakage Rated Dampers for Use in Smoke Control Systems." Submit test data with Shop Drawings.
- .6 Smoke Dampers: Similar to dampers described above but without electric temperature sensing device.
- .7 Provide integral smoke detector as part of combination smoke and fire dampers, and smoke dampers required above. Provide integral smoke detector that is rated for zero flow.
- .8 Actuators For Combination Smoke and Fire Dampers and Smoke Dampers, Electronic:
 - .1 Actuator Type: Modulating.
 - .2 Control Signal: Compatible with fire alarm system and BAS.
 - .3 Power: Where a 120 V circuit is provided by the Electrical Contractor, provide a 120:24 V transformer, where required based on the actuator in question.
 - .4 Operating Time: Maximum 75 seconds throughout the full rotation.
 - .5 Angle of Rotation: Adjustable between 0° to 90°.
 - .6 Stall protection: Mechanical or electronic.
 - .7 Provide actuators with electronic overload protection or digital rotation sensing circuitry to prevent actuator damage throughout the entire rotation.
 - .8 Failsafe: Spring return. Spring return to normal position within 10 seconds.
 - .9 Manual Override: Crank type.
 - .10 Position Indicator: Reversible for clockwise or counter-clockwise rotation; set the 0 degrees mark to the failsafe position.
 - .11 Torque: To damper manufacturer's requirements to provide complete compression of seals between frame and blades and for smooth control.
 - .12 Provide 2 SPDT auxiliary switches to prove open-closed.
 - .13 Provide electric temperature sensing device with damper actuators for all combination smoke and fire dampers. Temperature sensing device shall be ULC listed and suitable for UL 555S "Smoke Dampers" smoke and fire damper application.
 - .14 Provide UL 555S "Smoke Dampers" listed damper actuators for all dampers used in smoke control. All actuators shall be factory installed on dampers.
 - .15 Listed to UL 2043 "Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces."
- .9 Positive Seal Shut-off Dampers:
 - .1 Isolation type, positive seal, bubble tight damper at a differential pressure of 2.5 kPa (10 in. wg.). Damper shall be constructed with 1.9837 mm (0.0781 in - 14 USS gauge) thick, Type 304 stainless steel dish shaped disc with a knife-edge

- that seals against a T-304 stainless steel frame. The frame shall have a closed-cell neoprene rubber gasket that creates a gasket-to-knife edge seal. The damper shall have a $\frac{1}{4}$ turn worm-gear actuator with handwheel. The actuator shall have an aluminum base and cover. The rated torque shall be 225 Joules (2,000 in. lbs.) with a gear ratio of 30:1. The actuator shall be fully lubricated and self-locking.
- .2 The damper shall be all weld design, all pressure retaining weld joints and seams shall be continuously welded. Weld joints and seams requiring only intermittent welds by design shall not be continuously welded interior weld joints, where possible, shall be continuously welded to provide a smooth interior design, as a minimum, all welds shall be wire brushed and/or buffed to remove heat discoloration, burrs and sharp edges. All welding procedures, welders, and welder operators shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX. All production welds shall be visually inspected in accordance with standard procedure incorporating the work acceptance criteria in Section 5 and 6 of ANSI/ANWS D9.1-1990 Specification of Welding of Sheet Metal.
- .10 Fabricate manual duct dampers as shown on Standard Details from galvanized steel 1.26 mm thick (0.048 in - 18 GSG gauge) or heavier. Dampers for ducts up to 300 mm (12 in.) deep shall be one blade carried on a 9 mm (3/8 in.) square steel rod mounted inside the duct. Dampers for ducts of greater depth than 300 mm (12 in.) shall be multi-blade, opposed-acting type, and shall have blades mounted in 38 mm (1-1/2 in.) steel channel frame, and interconnected for operation from one locking type hand quadrant. Dampers for right angle take-off of branch from vertical riser shall have operator extended to an accessible location. For externally insulated ducts, mount quadrant on a bracket, designed to clear the insulation. All dampers shall have indicator to show position of damper blade.
- .11 Fabricate splitter dampers as shown on Standard Details from at least the same thickness of galvanized steel as the duct in which it is installed, down to a minimum of 0.95 mm thick (0.0374 in - 20 GSG gauge). Fabricate of double thickness so that the entering edge presents a round nose to the air flow, and mount securely on hinges at the air leaving edge. Length of splitter shall be at least 1-1/2 times the width of the smaller branch duct, but in no case less than 300 mm (12 in.) long. Attach splitter hinge near the air entering edge with support passing through a clamp on the side of the duct, located where it is most accessible for external adjustment and locking of the damper.
- .12 Counterbalanced backdraft dampers shall be multi-blade louvre type, constructed of extruded aluminum in extruded aluminum frames with adjustable coated counterbalance weights. Blades shall be joined with a tie bar and have rust-proof shafts rotating in synthetic bearings.
- .13 Motorized dampers for Control Operation: In accordance with applicable requirements control systems (pneumatic) or central energy management systems section.
- 2.1.7. Interior Duct Protective Coating: Chlorinated rubber base paint or Eisenheiss Black.
- 2.1.8. Hardware and Accessories:
- .1 Spin-in connections shall be specifically built for that purpose. Dampers shall be a minimum 1 gauge heavier than the ductwork in which it is installed and shall have a full length shaft pivoted at two diametrically opposed points. An indicator shall be attached to the shaft to indicate the damper position.
- .2 Hardware for balancing or splitter dampers shall be rattle-free and leak resistant. Bearing rods shall be sized to suit the damper size. Neoprene seals shall be used to minimize leaks. Hardware shall be Dyn-Air or equal.

- .3 Provide single thickness turning vanes built to and supported at intervals dictated by SMACNA HVAC Duct Construction Standards Metal and Flexible. Provide rails securely set in the elbow so that they cannot loosen.
- 2.1.9. Provide following duct penetrations with barred duct inserts to restrict passage for minimum and maximum security applications:
 - .1 Barred ductwork insert shall be 5 mm (3/16 in.) welded steel on all four sides with 19 mm (3/4 in.) solid round security bars on 150 mm (6 in.) centres with 65 mm x 5 mm (2-1/2 in. x 3/8 in.) security bars on sizes exceeding 300 mm (12 in.). Angle frame shall be 5 mm (3/16 in.) steel angle (one welded to unit and one shipped loose for field welding). Install per manufacturer's current installation instructions.
- 2.2. FABRICATION
- 2.2.1. Fabricate ductwork in accordance with applicable duct construction requirements of SMACNA.
- 3. Execution
- 3.1. INSTALLATION
- 3.1.1. Make all laps in the direction of air flow. Use no sheet metal screws in the duct where it is possible to use rivets and bolts. Hammer down all edges and slips so as to leave smooth finished surface inside the ducts.
- 3.1.2. Brace and stiffen all ducts, and make tight so that they will not breathe, rattle, vibrate or sag. Cross-break all rectangular ducts with heights or widths of 300 mm (12 in.) or larger.
- 3.1.3. Where rectangular ducts are shown, round ducts may be substituted at the Contractor's option, provided there is sufficient room. Conversion from rectangular to round duct, sizing shall be as shown on charts in ASHRAE.
- 3.1.4. Hang all ductwork securely and in a rigid manner. Provide hangers in accordance with SMACNA Standard "HVAC Duct Construction Standards Metal and Flexible."
- 3.1.5. Where pre-engineered support systems are provided, provide systems that have been evaluated and certified by SMACNA as well as a 3rd party evaluation service. Ensure application of pre-engineered support systems comply with the limitations noted in the SMACNA and 3rd party certification documents for the specific product in question (e.g. maximum duct width, single tier trapeze only, etc.). Install pre-engineered support systems in strict conformance to the manufacturer's written installation instructions and the conditions of the SMACNA and 3rd party evaluation documents.
- 3.1.6. Support all vertical ducts at each floor, on all sides, with angle riveted to the ducts.
- 3.1.7. The following low pressure, medium pressure and high pressure duct construction is based on an ASHRAE method of construction, and gives a minimum standard of construction. Alternative ASHRAE or SMACNA duct construction is acceptable, provided it meets the minimum standards as outlined by these Specifications. Submit proposed alternatives for review prior to fabrication.
- 3.1.8. Low pressure ductwork 0.5 kPa (2 in. wg) static pressure and less as follows:
 - .1 Rectangular/round duct location:
 - .1 Ductwork serving fans with an external static pressure of 0.5 kPa (2 in. wg) or less.
 - .2 Downstream of terminal heating and cooling devices.

- .2 Seal ducts to Seal Class C in accordance with SMACNA "HVAC Duct Construction Standards Metal and Flexible" and "HVAC Air Duct Leakage Test Manual."
 - .3 SMACNA leakage class:
 - .1 Rectangular ductwork: 16
 - .2 Round ductwork: 8
 - .4 Refer to tables for low pressure rectangular duct construction and round duct construction below for further duct construction requirements.
- 3.1.9. Medium pressure ductwork greater than 0.5 kPa (2 in. wg) and less than 1.5 kPa (6 in. wg) static pressure as follows:
- .1 Rectangular/round duct location:
 - .1 Ductwork serving fans with an external static pressure greater than 0.5 kPa (2 in. wg) and less than 1.5 kPa (6 in. wg).
 - .2 Smoke exhaust systems.
 - .3 Life safety pressurization systems.
 - .4 Refer to Section 23 31 16.29 – SPECIAL DUCTWORK for additional requirements.
 - .2 Seal ducts 1 kPa (4 in. wg) and greater static pressure to Seal Class A and 0.75 kPa (3 in. wg) static pressure to Seal Class B in accordance with SMACNA "HVAC Duct Construction Standards Metal and Flexible" and "HVAC Air Duct Leakage Test Manual."
 - .3 SMACNA leakage class:
 - .1 Rectangular ductwork:
 - .1 1 kPa (4 in. wg) and greater static pressure: 4
 - .2 0.75 kPa (3 in. wg) static pressure: 8
 - .2 Round ductwork:
 - .1 1 kPa (4 in. wg) and greater static pressure: 2
 - .2 0.75 kPa (3 in. wg) static pressure: 4
 - .4 Refer to tables for medium pressure rectangular duct construction and round duct construction below for further duct construction requirements.
- 3.1.10. High pressure ductwork 1.5 kPa (6 in. wg) static pressure and greater as follows:
- .1 Rectangular/round duct location:
 - .1 Ductwork serving fans with an external static pressure of 1.5 kPa (6 in. wg) and greater.
 - .2 Laboratory exhaust systems.
 - .3 Dust collector systems.
 - .4 Welding exhaust systems.
 - .5 Refer to Section 23 31 16.29 – SPECIAL DUCTWORK for additional requirements.
 - .2 Seal ducts to Seal Class A in accordance with SMACNA "HVAC Duct Construction Standards Metal and Flexible" and "HVAC Air Duct Leakage Test Manual."
 - .3 SMACNA leakage class:
 - .1 Rectangular ductwork: 4
 - .2 Round ductwork: 2

- .4 Refer to tables for high pressure rectangular duct construction and round duct construction below for further duct construction requirements.

3.1.11. Comply with the tables below in conjunction with the clauses above.

TABLE 1: LOW PRESSURE RECTANGULAR DUCT CONSTRUCTION

MAX. DUCT DIMENSION	SHEET METAL US GAUGE	TRANSVERSE JOINT CONNECTION AND BRACING
Up to 300 mm (12 in.)	26	Flat drive or flat 'S' no bracing
325 mm to 425 mm (13 in. to 18 in.)	24	Flat drive or flat 'S' no bracing
475 mm to 750 mm (19 in. to 30 in.)	24	25 mm (1 in.) standing 'T' bracing 25 mm x 25 mm x 3 mm (1 in. x 1 in. x 1/8 in.) at maximum 1500 mm (60 in.) centres.
775 mm to 1050 mm (31 in. to 42 in.)	22	25 mm (1 in.) standing 'T' bracing 25 mm x 25 mm x 3 mm (1 in. x 1 in. x 1/8 in.) at maximum 1500 mm (60 in.) centres.
1075 mm to 1200 mm (43 in. to 48 in.)	22	38 mm (1-1/2 in.) standing 'T'; bracing 38 mm x 38 mm x 3 mm (1-1/2 in. x 1-1/2 in. x 1/8 in.) at maximum 1500 mm (60 in.) centres.
1225 mm to 1350 mm (49 in. to 54 in.)	22	38 mm (1-1/2 in.) standing 'T'; bracing 38 mm x 38 mm x 3 mm (1-1/2 in. x 1-1/2 in. x 1/8 in.) at maximum 1200 mm (48 in.) centres.
1375 mm to 1500 mm (55 in. to 60 in.)	20	38 mm (1-1/2 in.) standing 'T'; bracing 38 mm x 38 mm x 3 mm (1-1/2 in. x 1-1/2 in. x 1/8 in.) at maximum 1200 mm (48 in.) centres.
1525 mm to 2100 mm (61 in. to 84 in.)	20	38 mm (1-1/2 in.) standing 'T'; bracing 38 mm x 38 mm x 3 mm (1-1/2 in. x 1-1/2 in. x 1/8 in.) at maximum 1200 mm (48 in.) centres.
2125 mm to 2400 mm (85 in. to 96 in.)	18	50 mm (2 in.) standing 'T' bracing 38 mm x 38 mm x 5 mm (1-1/2 in. x 1-1/2 in. x 3/16 in.) at maximum 600 mm (24 in.) centres.
2425 mm to 3000 mm (97 in. to 120 in.)	18	50 mm (2 in.) standing 'T' bracing 50 mm x 50 mm x 6 mm (2 in. x 2 in. x 1/4 in.) at maximum 600 mm (24 in.) centres.
3025 mm and over (121 in. and over)	18	As above with addition of tie rods at 300 mm (120 in.) centres for joint bracing.
.1 Bracing spacing shown is maximum spacing between two bracings or between bracing and joint. .2 Locate bracings mid-way between joints. .3 Make longitudinal joints Pittsburgh lock seam at edge of duct, and grooved seam on face of duct.		

TABLE 2: MEDIUM PRESSURE RECTANGULAR DUCT CONSTRUCTION

MAX. DUCT DIMENSION	SHEET METAL US GAUGE	TRANSVERSE JOINT CONNECTION & BRACING
Up to 300 mm (12 in.)	24	25 mm (1 in.) standing seam, 16 mm (5/8 in.) welded flange 25 mm (1 in.) pocket lock, no bracing.
325 mm to 425 mm (13 in. to 18 in.)	24	25 mm (1 in.) standing seam, 22 mm (7/8 in.) welded flange, 25 mm (1 in.) pocket lock, bracing 25 mm x 25 mm x 16 gauge (1 in. x 1 in. x 16 UG gauge) at 1200 mm (48 in.) centres.
475 mm to 600 mm (19 in. to 24 in.)	22	32 mm (1-1/4 in.) standing seam, 35 mm (1-3/8 in.) welded flange, 30 mm (1-1/8 in.) pocket lock, bracing 25 mm x 25 mm x 3 mm (1 in. x 1 in. x 1/8 in.) at maximum 120 mm (48 in.) centres.
625 mm to 900 mm (25 in. to 36 in.)	22	38 mm (1-1/2 in.) standing seam, 38 mm (1/2 in.) pocket lock, bracing 25 mm x 25 mm x 3 mm (1 in. x 1 in. x 1/8 in.) at maximum 120 mm (48 in.) centres.
925 mm to 1200 mm (37 in. to 48 in.)	22	50 mm (2 in.) standing seam or 50 mm (2 in.) flanged joint, bracing 38 mm x 38 mm x 3 mm (1-1/2 in. x 1-1/2 in. x 1/8 in.) at maximum 750 mm (30 in.) centres.
1125 mm to 1500 mm (49 in. to 60 in.)	20	38 mm (1-1/2 in.) standing seam or 38 mm (1-1/2 in.) flanged joint with tie rod in centre, bracing 50 mm x 50 mm x 3 mm (2 in. x 2 in. x 1/8 in.) at maximum 600 mm (24 in.) centres.
1525 mm to 1800 mm (61 in. to 72 in.)	20	38 mm (1-1/2 in.) standing seam or 38 mm (1-1/2 in.) flanged joint with tie rod in centre, bracing 50 mm x 50 mm x 3 mm (2 in. x 2 in. x 1/8 in.) at maximum 600 mm (24 in.) centres.
1825 mm to 2100 mm (73 in. to 84 in.)	18	50 mm (2 in.) standing seam or 38 mm (1-1/2 in.) flanged joint with tie rod in centre, bracing 65 mm x 65 mm x 5 mm (2-1/2 in. x 2-1/2 in. x 3/16 in.) at maximum 600 mm (24 in.) centres.
2425 mm and over (96 in. and over)	18	50 mm (2 in.) standing seam or 38 mm (1-1/2 in.) flanged joint with tie rod in centre, bracing 65 mm x 65 mm x 5 mm (2-1/2 in. x 2-1/2 in. x 3/16 in.) at maximum 600 mm (24 in.) centres.
.1 Bracing spacing shown above is maximum spacing between two bracings or between bracing and joint. Locate bracing mid-way between joints. .2 Make longitudinal joints Pittsburgh lock seam at edge of duct, and grooved seam on face of duct.		

TABLE 3: HIGH PRESSURE RECTANGULAR DUCT CONSTRUCTION

MAX. DUCT DIMENSION	SHEET METAL US GAUGE	CONSTRUCTION
Up to 300 mm (12 in.)	22	Flanged angle gasketed joint or butt welded joint with 32 mm x 32 mm x 3 mm (1-1/4 in. x 1-1/4 in. x 1/8 in.) angle.
325 mm to 450 mm (13 in. to 18 in.)	22	Flanged angle gasketed joint or butt welded joint with flanged angle 32 mm x 32 mm x 3 mm (1-1/4 in. x 1-1/4 in. x 1/8 in.) and reinforcing angle 25 mm x 25 mm x 16 US gauge (1 in. x 1 in. x 16 US gauge) at maximum 1200 mm (48 in.) centres.
475 mm to 600 mm	22	Flanged angle gasketed joint or butt welded joint with flanged angle 32 mm x 32 mm x 3 mm (1-1/4 in. x 1-1/4 in. x 1/8 in.) and reinforcing angle 25 mm x 25 mm x 3 mm (1 in. x 1 in. x 1/8 in.) at maximum 1200 mm (48 in.) centres.
625 mm to 900 mm (25 in. to 36 in.)	22	Flanged angle gasketed joint or butt welded joint with flanged angle 32 mm x 32 mm x 3 mm (1-1/4 in. x 1-1/4 in. x 1/8 in.) and reinforcing angle 32 mm x 32 mm x 3 mm (1-1/4 in. x 1-1/4 in. x 1/8 in.) at maximum 800 mm (32 in.) centres.
925 mm to 1200 mm (37 in. to 48 in.)	22	Flanged angle gasketed joint or butt welded joint with flanged angle 38 mm x 38 mm x 3 mm (1-1/2 in. x 1-1/2 in. x 1/8 in.) and reinforcing angle 65 mm x 65 mm x 3 mm (2 in. x 2 in. x 1/8 in.) at maximum 750 mm (30 in.) centres.
1225 mm to 1500 mm (49 in. to 60 in.)	20	Flanged angle gasketed joint or butt welded joint with flanged angle 50 mm x 50 mm x 5 mm (2 in. x 2 in. x 3/16 in.) and reinforcing angle 50 mm x 50 mm x 3 mm (2 in. x 2 in. x 3/16 in.) at maximum 600 mm (24 in.) centres.
Over 1500 mm (60 in.) and all sizes between fan and round duct	20	Flanged angle gasketed joint or butt welded joint with flanged angle 50 mm x 50 mm x 5 mm (2 in. x 2 in. x 3/16 in.) and reinforcing angle 50 mm x 50 mm x 3 mm (2 in. x 2 in. x 3/16 in.) at maximum 600 mm (24 in.) centres.

TABLE 4: ROUND DUCT CONSTRUCTION

1. Round ducts up to 750 mm (30 in.) diameter factory fabricated, helically wound galvanized iron strips with spiral lock seam.			
DIAMETER	STRIP METAL US GAUGE	STRIP JOINT	GIRTH JOINT
Up to 200 mm (8 in.)	26	100 mm (4 in.)	50 mm (2 in.) long slip
225 mm to 550 mm (9 in. to 22 in.)	24	100 mm (4 in.)	50 mm (2 in.) long slip
575 mm to 750 mm (23 in. to 30 in.)	22	150 mm (6 in.)	100 mm (4 in.) long slip

Join with galvanized iron coupling sleeves or conduit fittings of welded construction.

Construct larger ductwork as follows with longitudinal lock or butt welded seams:

DIAMETER	SHEET METAL US GAUGE	REINFORCING	GIRTH JOINT
775 mm to 900 mm (31 in. to 36 in.)	20	None	100 mm (4 in.) long slip
925 mm to 1500 mm (37 in. to 60 in.)	18	32 mm x 32 mm x 3 mm (1-1/4 in. x 1-1/4 in. x 1/8 in.) angle on max 1800 mm (72 in.) centres	32 mm x 32 mm x 3 mm (1-1/4 in. x 1-1/4 in. x 1/8 in. angle flanged.

- 3.1.12. Seal all joints of all ducts. Brush joints with the compound before and again after assembly. Seal any leaks causing noise.
- 3.1.13. Seal the bottom and side joints of outside air ducts or plenums water-tight.
- 3.1.14. Flexible duct shall be connected to sheet metal duct and diffusers using duct sealer, minimum of two screws separated by 180 degrees and metal draw bands. Duct tape is not acceptable.
- 3.1.15. Flexible ductwork may be used under the following conditions:
- .1 Where shown on Drawings to allow easy location of diffusers.
 - .2 Except where indicated otherwise in clauses below, minimum length of flexible duct used to connect diffusers and interior troffers: 2,400 mm (84 in.).
 - .3 Except where indicated otherwise in clauses below, maximum length of flexible duct: 3,000 mm (120 in.).
 - .4 Do not pass flexible ductwork through floors or fire walls.
 - .5 Install flexible ductwork as a single section of duct (no joints). In the event that building construction requires connection between lengths of flexible duct, use a rigid section of duct as the joint. Secure flexible duct to the rigid section using ties and sealant.
 - .6 Support flexible duct lengths greater than 2,400 mm (84 in.) at the midpoint with strap hangers.
 - .7 Within residential suites, flexible ductwork may be used under the following conditions:

- .1 Exhaust ductwork connected to wall box using a maximum of 914 mm (36 in.) of flexible ductwork. Flex duct not permitted on outside air ductwork.
- 3.1.16. Where ductwork passes through a wall or floor, other than when a fire damper is required, pack around the duct using a fire resistant material to ensure a sound and airtight joint.
- 3.1.17. If changes of size of ducts are necessary because of building construction, maintain the same circular equivalent for the new size. Ratio of the longest side of the duct to the least shall not exceed 4 to 1 unless specifically authorized by the Engineer's Representative.
- 3.1.18. Select the gauge of metal and method of construction for the new size. Notify the Engineer's Representative of any change before such changes are incorporated into the Work.
- 3.1.19. If changes of location of duct are required because of building construction, review with the Engineer's Representative before the locations indicated are changed in any way.
- 3.1.20. Make changes of direction of horizontal ducts with elbows having an inside radius not less than 3/4 the width of the duct. Make change of direction from horizontal to vertical duct with elbows having an inside radius equal to the depth of the duct. Where this is not possible due to the building construction, use turning vanes.
- 3.1.21. Provide access ports at convenient locations in all main ducts and main branch take-offs with airtight covers and extension sleeves through insulation to allow air meter readings. Access ports shall be approved by the Engineer's Representative and the testing company before installation.
- 3.1.22. Provide flexible connections at each air handling unit (where not provided internally) and fan duct connections before and after any required transitions on the fan inlet and outlet respectively (i.e. on the largest duct perimeter and not directly installed on the fan inlet and outlet to reduce noise and air turbulence).
- 3.1.23. Install manual duct dampers as shown on Standard Details. Ensure dampers for right angle take-off of branch from vertical riser have operator extended to an accessible location. Adjust quadrants to clear duct insulation.
- 3.1.24. Provide splitter dampers as shown on Standard Details.
- 3.1.25. Incorporate counterbalanced backdraft dampers where shown. Adjust counterweights to the minimum pressure required to relieve the system pressure. Incorporate gravity backdraft dampers where shown.
- 3.1.26. Install motorized dampers where directed.
- 3.1.27. Install fire dampers where shown and at all penetrations through all fire rated assemblies. Provide firestop flap type fire dampers where fire dampers are shown in grilles or diffusers at ceiling level. Provide the appropriate fire damper model to suit the installation condition and provide all necessary flanges, frames, fittings, and accessories to ensure a flush installation. Obtain local authorities' approvals for all damper locations and keep one set of marked-up prints on site. Approvals shall be obtained before installation of fire dampers.
- 3.1.28. Where a fire damper is required to be installed behind a wall mounted grille, provide damper, angles, and retaining devices as required to provide a smooth, flat to wall installation.
- 3.1.29. Where fire dampers for ducts shown on Drawings require a change of type and/or powered actuation due to dimension limitations to satisfy the cUL Classification requirements, provide transitions as required to adjust duct dimensions while maintaining the equivalent circular duct diameter to avoid exceeding any specific listed maximum dimension. Where transitions are not possible or dimensions cannot be adjusted to avoid powered actuation, provide power from the closest available emergency power source as required. Review all conditions with the Engineer's Representative in advance of fabrication.

- 3.1.30. Install combination smoke and fire dampers and smoke dampers where shown. Ensure operators are accessible for maintenance. Coordinate installation of required fire alarm connections with Electrical Contractor and provide wiring connections to BAS where required by damper sequence of operations. Coordinate connections to damper actuators in accordance with sequence of operations and damper locations.
- 3.1.31. Receive automatic dampers from separate Section on site, and set in place under the supervision of the control manufacturer.
- 3.1.32. Provide access panels at all fire dampers, gravity dampers, motorized dampers, coils, heaters, humidifiers, fan bearings or similar equipment requiring occasional maintenance or inspection. Panels shall be 600 mm x 450 mm (24 in. x 18 in.) or full width of duct if less than 450 mm (18 in.) wide. Panels shall be of double wall construction and shall be internally insulated on insulated ducts. Frame shall be of structural angle with welded corners, gasketed to receive the panel. Panel shall be held in place with 4 window sash locks.
- 3.1.33. Paint visible internal surface behind each grille or register flat black.
- 3.1.34. Where duct is acoustically lined, duct dimensions shown are net, inside of lining, free area dimensions.
- 3.1.35. Ductwork installed underground shall be round spiral sheet metal constructed in accordance with high pressure duct standards. Joints shall be sealed with high pressure duct sealant and taped. Duct shall be completely covered with a minimum of two coats of bitumastic coatings.
.1 Slope underground duct and provide drainage in accordance with the Building Code.
- 3.1.36. Intake and exhaust ductwork for indoor cooling towers shall be constructed the same as ductwork but the bottom section of the intake duct shall have extra reinforcing to support a mass of 100 kg (weight of 250 lbs) without deflecting. Provide a supporting steel angle frame to support the plenum from the floor.
- 3.1.37. Provide internal acoustic duct lining in accordance with Section 20 05 48.00 – VIBRATION AND NOISE CONTROL.
- 3.1.38. Air wells shall be 1.95 mm thick (0.0767 in - 14 GSG gauge) galvanized steel construction with all joints welded. Clean all welds so that no water traps occur. Touch-up all welds with zinc rich primer. Suitably brace the entire assembly with steel angle to prevent flexing and drumming. Coat the entire surface exposed to the outside air with 2 coats of rustproofing finish. Submit sample of rustproofing for review. Provide a structural supporting frame to support the entire unit plus an additional live loading of 4.2 kg/sq.m. (100 lbs/sq.ft.).
- 3.1.39. Spin-in connections shall only be used downstream of variable volume boxes.
- 3.1.40. Ductwork shall be run parallel to the closest wall. Coordinate with piping and structural elements.
- 3.1.41. All exposed open ends of ductwork located less than 2000 mm (79 in) above the finished floor that do not have a diffuser, grille or register shall have a protective screen mounted in a suitable frame to connect the screen securely to the duct, wall and floor as applicable. The screen shall be installed and painted matte black and shall not be capable of passage of anything larger than a 15 mm (1/2 in.) sphere through the openings.
- 3.1.42. Supply air ductwork to variable volume boxes shall be rigid duct of size shown in schedules. If the length exceeds 3000 mm (10 ft.) or if there are 2-45 deg. elbows or 1-90 deg. elbow or more increase the supply air ductwork to the variable volume box one size. If the length exceeds 6000 mm (20 ft.) increase the duct by two sizes. Under no conditions shall the supply ductwork exceed 9000 mm (30 ft.) or have more than 3-90 deg. elbows or the equivalent. Transition to variable volume box inlet sizes a minimum of 4 duct diameters upstream of the terminal unit.

- 3.1.43. Where acceptable to Engineer's Representative, and where fans shut down upon detection of fire, static fire dampers may be used in lieu of dynamic fire dampers.

END OF SECTION

23 34 63.00 Roof Mounted Fans

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. RELATED WORK SPECIFIED ELSEWHERE

1.2.1. Electrical hard wire supply and primary connections to electrical components - under Electrical Division.

1.2.2. Supply and installation of built-up wood curb and flashings - under Section 06100 and 07600.

1.3. SUBMITTALS

1.3.1. Shop Drawings:

- .1 Submit Shop Drawings of all roof mounted fans with catalogued components to be supplied. Include manufacturer's data sheets for all fans at specified airflow, performance criteria, ratings, and physical dimensions and finishes. Provide fan curves for each fan at the specified operation point, with the flow, static pressure and horsepower clearly plotted. Provide outlet velocity and both inlet and outlet sound power readings for the eight octave bands.

1.3.2. Manufacturer's Data:

- .1 Conform to AMCA Standards 205 "Energy Efficiency Classification for Fans," 211 "Certified Ratings Program - Product Rating Manual for Fan Air Performance," and 311 "Certified Ratings Program - Product Rating Manual for Fan Sound Performance". Test fans in accordance with ANSI/AMCA Standard 210 "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating" and AMCA Standard 300 "Reverberant Room Method for Sound Testing of Fans" in an AMCA accredited laboratory and provide bearing the AMCA seal for air and sound performance.
- .2 Conform to AMCA 99 "Standards Handbook" for Classification for Spark Resistant Construction.

1.4. WARRANTY

1.4.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Except as otherwise indicated, provide roof mounted fans by Cook, FlaktWoods, Greenheck, PennBarry or Twin City.

2.1.2. For all fans, comply with UL/cUL 705 "Power Ventilators."

- .1 For all fans used in machinery room ventilation systems where A2L class refrigerants are used, provide fans complete with electric motors outside the air stream and non-ferrous or spark resistant fan rotating elements.

- 2.1.3. For all fans used for smoke control, provide fans that are UL/cUL listed and tested for operation at 260 Deg. C. (500 Deg. F.) for a minimum of four hours, and 520 Deg. C. (1000 Deg. F.) for a minimum of fifteen minutes.
- 2.1.4. Provide low silhouette fans of bolted and welded construction utilizing corrosion resistant fasteners. Enclose the fan with a galvanized steel hood with the entire assembly primed with a zinc rich primer or, an aluminum hood, treated to prevent corrosion. Bolt the hood to the fan housing and make removable to allow unobstructed access to the motor and power assembly. Provide aluminum base with continuously welded curb cap corners for maximum leak protection.
- 2.1.5. Provide dome type fans of bolted and welded construction utilizing corrosion resistant fasteners. Provide motor cover, shroud, curb cap, and lower wind band constructed of heavy gauge aluminum and treated to reduce corrosion. Provide aluminum base with continuously welded curb cap corners for maximum leak protection. Provide shroud with an integral rolled bead for added strength.
- 2.1.6. Provide wheel that is non-overloading centrifugal backward inclined, constructed of aluminum. Provide wheel inlet that overlaps an aerodynamic aluminum inlet cone or venturi to provide maximum performance and efficiency. Provide assembled wheel that is electronically balanced both statically and dynamically to balance grade G6.3 per ANSI S2.19 "Mechanical Vibration - Balance Quality Requirements Of Rigid Rotors - Part 1: Determination Of Possible Unbalance, Including Marine Applications."
- 2.1.7. Mount the motor, bearings and drives on a steel power assembly, isolated from the unit structure with rubber vibration isolators. Enclose these components in a weather-tight compartment, separated from the exhaust airstream.
- 2.1.8. Provide units complete with a galvanized bird screen treated to prevent corrosion.
- 2.1.9. Provide bearings that are heavy duty, grease lubricated, anti-friction ball or spherical roller, self-aligning, pillow block type and selected for a minimum L50 life in excess of 200,000 hours at maximum load.
- 2.1.10. Size blower shaft for a critical speed of at least 125 % of the maximum RPM.
- 2.1.11. Provide belts that are oil and heat resistant, non-static type. Provide drives that are precision machined cast iron type, keyed and securely attached to the wheel and motor shafts. Size drives for 150 % of the installed motor horsepower. Factory set the variable pitch motor drive to the specified fan RPM.
- 2.1.12. Coat all steel fan components with an electrostatically applied, baked polyester powder coating or other equivalent protective coating.
- 2.1.13. Provide motors in accordance with the requirements of Section 20 05 13.00 - ELECTRIC MOTORS. See Fan Schedule for hp (wattage) ratings.
- 2.1.14. Provide motor operated dampers under a separate Section as shown on Drawings and specified in Section 23 09 00.00 - BUILDING AUTOMATION SYSTEM (BAS). Where motor operated dampers are not shown, provide gravity dampers at the fan by this Section.
- 2.1.15. Mount unit on a prefabricated roof curb to match the fan size. Provide flat curb for flat roofs and pitched curb to suit slope of roof for pitched roofs. Acoustically line all exhaust curbs, except for kitchen and laboratories. Provide unit that is nominally 610 mm (24 in.) high.
- 2.1.16. Provide vibration isolation as specified in Section 20 05 48.00 - VIBRATION AND NOISE CONTROL.
- 2.1.17. Provide roof mounted fans in accordance with the Fan Schedule.

3. Execution

3.1. INSTALLATION

- 3.1.1. Install fans in locations shown on Drawings.
- 3.1.2. Align shafts, belt drive and motor, adjust belt tension, ensure all set screws are tight and check motor rotation before start-up.
- 3.1.3. Protect motors and fans during construction.

END OF SECTION

23 37 13.00 Diffusers, Grilles and Registers

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. RELATED WORK SPECIFIED ELSEWHERE

1.2.1. Continuous air slot in ceiling - under Division 9 - Finishes.

1.2.2. Door grilles - under Architectural Division - Grilles.

1.3. SUBMITTALS

1.3.1. Shop Drawings: Submit detailed Shop Drawings of all components furnished under this Section. Manufacturer to indicate ceiling installation type for each type of diffuser specified.

1.3.2. Manufacturer's Data: Submit test results of type " " diffuser models to be used on the Project, including air pattern and noise levels for air quantities from 10 % to 110 % of the required maximum air flow.

1.3.3. Sample of exposed duct detail. See mechanical standard details on the Drawings.

1.4. WARRANTY

1.4.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Acceptable manufacturers:

- .1 Price
- .2 Nailor
- .3 Krueger equal to the units specified
- .4 Titus equal to the units specified

2.1.2. Select diffusers to provide uniform air coverage without overlap. Base selection on air velocity of 0.127 to 0.254 m/s (25 to 50 fpm) up to a height of 1800 mm (6 ft.) above the floor.

2.1.3. Noise generated by diffusers: room sound pressure level not to exceed noise criteria 32 with a 10 dB room attenuation, the sound power level referenced to 10⁻¹² power watts.

2.1.4. Volume and air pattern devices: Do not provide dampers in the diffuser neck unless specifically indicated in the description or on the Schedule. Where dampers or air pattern devices are specified, include hardware to allow full adjustment from the face of the diffuser or air pattern device.

2.1.5. In gypsum board or plaster ceiling applications, provide matching mounting frame. Coordinate colour with the architect.

- 2.1.6. T-bar ceilings: coordinate diffuser compatibility with T-bar ceiling specified by the architectural division. Match the colour of ceiling tile in lay-in ceilings. Size to suit ceiling grid as required, imperial or metric.
- 2.1.7. Test Requirements: ASHRAE Standard 70, including air pattern and noise levels for air quantities from 10% to 110% of the required maximum air flow. Sound power tests measured in accordance with ASHRAE Standard 70 and NC ratings determined using a 10 dB room attenuation factor.
- 2.2. SQUARE SUPPLY DIFFUSERS
 - 2.2.1. Type P: Steel square plaque diffuser 600 mm x 600 mm (24 in. x 24 in.) face size consisting of a precision formed back cone of one piece seamless construction, a round inlet collar of sufficient length for connecting rigid or flexible duct as shown, a removable inner plaque assembly no more than 6.4 mm (1/4 in.) below the ceiling plane to assure proper air distribution performance.
 - .1 Price SPD
 - .2 Nailor UNI
 - 2.2.2. Type P1: As specified above but with 300 mm x 300 mm (12 in. x 12 in.) face size in a 600 mm x 600 mm (24 in x 24 in) panel for installation in ceiling specified by the architect.
 - .1 Price SPD
 - .2 Nailor UNI
 - 2.2.3. Type P2: As specified above except of aluminum construction for installation in areas of high humidity such as shower rooms, etc.
 - .1 Price ASPD
 - .2 Nailor AUNI
- 2.3. LINEAR SUPPLY AND RETURN DIFFUSERS
 - 2.3.1. Type S: linear supply diffusers of the sizes, configurations and mounting types required.
 - .1 Plenum Construction:
 - .1 Zinc coated steel
 - .2 6 mm (1/4 in.) internal insulation
 - .3 Sloped shoulders for enhanced spread (internal baffles are not acceptable)
 - .4 Mounting style suitable for ceiling type (drywall or T-Bar)
 - .5 Round side inlet of size indicated on the Drawings
 - .2 Diffuser Construction:
 - .1 Extruded aluminum boarder with mitred ends
 - .2 "Ice tong" style pattern controllers for 180 deg. pattern adjustment and black finish
 - .3 Concealed frame for drywall installation, T-Bar style for T-Bar ceilings
 - .4 Continuous installation to match Drawings and architectural look
 - .3 S1 Type: One slot, 19 mm (3/4 in.) slot
 - .4 S2 Type: Two slots, 19 mm (3/4 in.) slot
 - .5 S3 Type: Three slots, 19 mm (3/4 in.) slot

- .6 Return Sections: Parts of continuous diffusers that do not have a supply air boot shown are returns. They are indicated with an R on the Drawings. Refer to air terminal schedule on drawings for slot width, number of slots and overall length.
 - .1 In continuous installations, include the air pattern controller for supply boot flexibility.
 - .2 In non-continuous installation, provide a sight baffle in lieu of the pattern controllers.
- .7 Manufacturer:
 - .1 Price SDS/SDA
 - .2 Nailor Series 5000/5300
- 2.4. SILL, SIDEWALL AND FLOOR GRILLES
- 2.4.1. Type G: Heavy duty linear floor grille type with 3 mm x 19 mm (1/8 in. x 3/4 in.) extruded heavy duty aluminum bars on 6 mm (1/4 in.) centers for zero deflection. Install removable core in heavy duty floor frame. Set frame high enough to suit architectural floor covering.
 - .1 Price LBMH-15A.
- 2.5. WALL AND DUCT GRILLES
- 2.5.1. Type B: standard double deflection type with adjustable horizontal face bars and vertical rear bars.
 - .1 Construction: Steel double deflection with two sets of adjustable deflection blades, front blades parallel to the long dimension, spaced 19 mm (3/4 in.) on centre spacing.
 - .2 Finish: aluminum powder coat finish
 - .3 Damper: Opposed blade, of the same material as the grille, operable from the face.
 - .4 Manufacturer:
 - .1 Price 520(D)
 - .2 Nailor 5100 Series
- 2.5.2. Type B1: Same as above except of Aluminum construction for high humidity areas such as shower rooms.
 - .1 Manufacturer:
 - .1 Price 620(D)
 - .2 Nailor 5100 Series
- 2.5.3. Type B2: Same as above except of stainless-steel construction.
 - .1 Manufacturer:
 - .1 Price 720(D)
 - .2 Nailor 5100 Series
- 2.6. RETURN, EXHAUST AND TRANSFER GRILLES
- 2.6.1. Type E: Egg crate type of size shown on the Drawings.
 - .1 Construction:
 - .1 Aluminum egg crate core, 13 mm x 13 mm x 13 mm (1/2 in. x 1/2 in. x 1/2 in.) and extruded aluminum border.
 - .2 Finish: B12 white powder coat finish

- .3 Assembly suitable for T-Bar ceiling installation or wall installation as shown on the Drawings.
 - .2 Manufacturer:
 - .1 Price Series 80
 - .2 Nailor 5100 Series
- 2.6.2. Type K: Standard return grilles with horizontal fixed bars set at approximately 45 deg. for wall returns and set straight for ceiling return.
 - .1 Construction: Steel single deflection return grille with blades oriented parallel to the long dimension, spaced at 19 mm (3/4 in.) on centre.
 - .2 Finish: white powder coat finish
 - .3 Damper: Opposed blade, of the same material as the grille, operable from the face.
 - .4 Manufacturer:
 - .1 Price 530(D)
 - .2 Nailor 6100 Series
- 2.6.3. Type K1: Same as above except of aluminum construction.
 - .1 Manufacturer:
 - .1 Price 630(D)
 - .2 Nailor 6100 Series
- 2.6.4. Type K2: Same as above except of stainless-steel construction.
 - .1 Manufacturer:
 - .1 Price 730(D)
 - .2 Nailor 6100 Series
- 2.6.5. Type D: Heavy duty gym return grilles
 - .1 Construction:
 - .1 Heavy 14-gauge steel construction, horizontal fixed bars set parallel to the long dimension with 0 deg. deflection.
 - .2 Damper: Black key operated damper mounted behind grille operable from the face.
 - .3 Border: Heavy gauge flat steel border with concealed fasteners.
 - .4 Finish: White powder coat.
 - .2 Manufacturer:
 - .1 Price Series 90
 - .2 Nailor 6145H-HD
- 2.6.6. Type J: Transfer Grilles - Steel construction, standard single deflection fixed blade type, 45 deg. deflection, blades horizontal orientation, surface mount border with countersunk screw holes and oval head screws. Match finish to wall.
 - .1 Price model 535
 - .2 Nailor 6155H/V
- 2.6.7. Door transfer grilles: Finely spaced blades for an attractive sight proof appearance and designed for applications in doors or partitions with sections as thin as 35 mm (1-3/8 in.) with flat border and countersunk holes.
 - .1 Manufacturer:

- .1 Price ATG1
- .2 Nailor 51DGD

3. Execution

3.1. INSTALLATION

- 3.1.1. Refer to the Architectural Drawings for actual locations of diffusers, grilles and registers and install to suit these Drawings. The Mechanical Drawings show intent and number of diffusers, grilles and registers required.
- 3.1.2. Provide transfer grilles in all finished spaces where air is transferred through a ceiling or partition.
- 3.1.3. For exposed ductwork installations, oversize connections to grilles and in-turn flanges to meet the flange of the grilles and the duct. Out-turned or exposed flanges with screw mounting are not acceptable.
- 3.1.4. For special mounting of diffusers, grilles and registers, refer to Architectural Drawings.
- 3.1.5. Where diffusers, grilles or registers are installed in drywall or inaccessible ceilings, provide means of adjusting flow pattern, flow balancing and flow equalizing from the face of the diffuser.
- 3.1.6. Install mounting frame tied into plaster and gypsum board ceilings to allow lay in type diffusers to rest on the frame.
- 3.1.7. Lay diffusers on inverted T-bars spaced on ... mm (... in.) centers in T-bar ceilings.
- 3.1.8. Be responsible for mounting concealed flange linear diffusers in heated environment and following manufacturer's instructions.
- 3.1.9. Caulk around edges of linear diffusers in installations with imperfect walls.

END OF SECTION

23 41 16.00 Disposable Filters

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. WARRANTY

1.2.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Filters shall be American Air Filter, Camfil Farr, Cambridge, Purafil, or Airguard

2.1.2. Pre-filter shall be constructed of galvanized steel frame, 3.0607 mm thick (0.1205 in - 11 gauge) galvanized wire grid and 50 mm (2 in.) thick disposable media. Filter shall have an Underwriters' Class 2 rating. Static pressure drop for a clean filter shall not exceed 0.042 kPa (0.17 in. wg.) for 944 L/s (2000 cfm) passing through a 600 mm x 600 mm (24 in. x 24 in.) filter.

2.1.3. Alternate Pre-filter efficiency filters shall be constructed with water resistant cell walls and non-woven cotton fabric media. Filters shall have any Underwriters' Class 2 rating. Filters shall be nominally 600 mm x 600 mm x 100 mm (24 in. x 24 in. x 4 in.) deep. Media shall have Minimum Efficiency Reporting Value of MERV 7. Media shall be supported on a wire mesh. Static pressure drop for filter for a nominal 944 L/s (2000 cfm) passing through a 600 mm x 600 mm (24 in. x 24 in.) filters shall be 0.06 kPa (0.25 in.wg.) initial and 0.25 kPa (1.0 in.wg.) final.

2.1.4. Final filters shall be supported pleated type constructed of water resistant, fireproof cell walls and spun glass media. Filters shall have an Underwriters' Class 2 rating. Filters shall be nominally 600 mm x 600 mm x 300 mm (24 in. x 24 in. x 12 in.) deep. Media shall have a Minimum Efficiency Reporting Value of MERV11, MERV 13, MERV14, or MERV15. Media efficiencies shall be as shown on Schedules. Static pressure drops for filter for a nominal 944 L/s (2000 cfm) passing through a 600 mm x 600 mm (24 in. x 24 in.) filter shall be as follows:

MEDIA	INITIAL	FINAL
MERV 11	0.10 kPa (0.39 in.wg.)	0.37 kPa (1.5 in.wg.)
MERV 13	0.14 kPa (0.56 in.wg.)	0.37 kPa (1.5 in.wg.)
MERV 14	0.14 kPa (0.58 in.wg.)	0.37 kPa (1.5 in.wg.)

2.1.5. Final filters shall extended surface bag filters with metal frame and spun glass bag filter media. Filters shall have any Underwriters' class 2 rating. Filters shall be nominally 600 mm x 600 mm x 900 mm (24 in. x 24 in. x 36 in.) deep with a gross media area of 104 ft². Media shall have a Minimum Efficiency Reporting Value of MERV12, MERV14, or MERV15. Media efficiencies shall be as shown on Schedules. Static pressure drops for filters for a nominal 944 L/s (2000 cfm) passing through a 600 mm x 600 mm (24 in. x 24 in.) filter shall be as follows:

MEDIA	INITIAL	FINAL

MERV 12	0.07 kPa (0.27 in.wg.)	0.25 kPa (1.0 in.wg.)
MERV 14	0.07 kPa (0.29 in.wg.)	0.25 kPa (1.0 in.wg.)
MERV 15	0.08 kPa (0.31 in.wg.)	0.25 kPa (1.0 in.wg.)

- 2.1.6. All bag filters shall be complete with a supporting frame to prevent assembly bag collapse under low-air flow or no-air flow conditions.
- 2.1.7. Each filter bank shall be complete with retainer and frames for assembly into a panel and complete with all miscellaneous fittings and gaskets to ensure a complete assembly.
- 2.1.8. Operate units with pre-filters during finishing time. Provide one complete set of new prefilters and final filters on date of acceptance of the building. Ensure all filters are installed before testing and balancing.
- 2.1.9. Prefilters shall be in conformance with the Prefilter Schedule.
- 2.1.10. Final filters shall be in conformance with the Final Filter Schedule.

3. Execution

3.1. INSTALLATION

- 3.1.1. Install blank-off panels between filter banks and plenums to ensure no air by-pass occurs.

END OF SECTION

23 57 19.13 Heat Exchangers - Plate Type

1. General
 - 1.1. WORK INCLUDED
 - 1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
 - 1.2. WARRANTY
 - 1.2.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
2. Products
 - 2.1. MATERIALS
 - 2.1.1. Plate type heat exchangers shall be Xylem, Alfa-Laval, Armstrong, Tranter, APV, Taco, GEA or AIC Inc. with fluids and performance in accordance with the Heat Exchanger Schedule.
 - 2.1.2. Provide AHRI 400 certification for all fluids.
 - 2.1.3. Construction shall consist of a carbon steel frame with one stationary cover and one moveable cover. The heat transfer plates and the moveable cover shall be suspended from an upper carrying bar and guided by a lower guiding bar, which are attached to the stationary frame plate and shall be easy to move after disconnection of the tightening bolts. The design shall permit ready access to the plate pack for inspection and cleaning and it shall permit removal of individual plates. Tightening bolts shall be galvanized carbon steel.
 - 2.1.4. The frame parts shall be sandblasted and painted with a primer and a finishing paint.
 - 2.1.5. The material for the heat transfer plates shall be stainless steel for all HVAC and potable water applications and titanium for units serving pool water.
 - 2.1.6. For potable water and pool applications, provide double wall heat exchanger with two plates pressed together to create two fluid leak paths to atmosphere. Provide 0.35 mm plate thickness for each plate and 0.7 mm total thickness of two plates pressed together.
 - 2.1.7. Gaskets shall be Nitrile or EPDM and suitable for the given fluids, pressures and temperatures.
 - 2.1.8. The design, construction, inspection and testing shall comply with the applicable Provincial pressure vessel regulations. Submit certificates to the Engineer's Representative.
 - 2.1.9. Provide CRN number and all required registration documentation for heat exchangers.
 - 2.1.11. During manufacturing all tests and inspection required by applicable regulations and codes shall be performed to assure that material, workmanship, finish dimensions and markings are in accordance with the Specifications. The heat exchanger shall be subject to hydrostatic testing.
 - 2.1.12. Provide two relief valves set at working pressure for each exchanger installed on headers to protect the plates. The pressure rating of the heat exchanger shall be greater than the working pressure noted in the Heat Exchanger Schedule assuming the one side is under pressure and the other side is empty of fluid. If nothing is noted, the rating shall be not less than 150 PSI. All units shall be tested to ASME standards and not less than 1.3 times the design pressure.

- 2.1.13. For units where both sides are part of a closed loop system, the heat exchangers shall be selected with a 0.0001 BTU/ft2hr.deg fouling factor for the unit (0.00005 BTU/ft2hr.deg.F. applied to each side) based on the capacities given in the Schedules.
 - 2.1.14. For units where one or both sides are part of an open loop system, the heat exchangers shall be selected with a 0.00025 BTU/ft2hr.deg fouling factor for the unit (0.000125 BTU/ft2hr.deg on each of the open side(s)) based on the capacities given in the Schedules. Examples of 'open systems' are open condenser water loops, domestic water and all pool applications.
-
- 3. Execution
 - 3.1. INSTALLATION
 - 3.1.1. Provide isolation valves and unions or flanges on all connections to the heat exchanger in locations to permit the disassembly without disrupting the system piping.
 - 3.1.2. Ensure both sides of the heat exchanger are isolated when either side of the exchanger is drained in order to protect unit against an excessive pressure differential from damaging the unit.
 - 3.1.3. The Contractor shall provide a lamacoid on each heat exchanger that reads as follows:
"WARNING: ISOLATE BOTH SIDES OF THE HEAT EXCHANGER WHEN DRAINING
EITHER SIDE OF THE UNIT"

END OF SECTION

23 72 19.00 Energy Recovery Ventilators

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Shop Drawings:

- .1 Submit Shop Drawings of all energy recovery ventilators with catalogued components to be supplied. Include manufacturer's data sheets for: performance criteria, ratings, and physical dimensions and finishes.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Commercial Energy Recovery Ventilators (ERV):

- .1 Provide belt driven, indoor type, horizontal and/or bottom return/discharge ERV as shown.
- .2 Manufacturer: Mitsubishi Lossnay, Loren Cook, Engineered Air, Venmar, Aldes, Greenheck, or Ruskin
- .3 Unit:
 - .1 Of bolted construction utilizing corrosion resistant fasteners.
 - .2 Walls and roof: bolted to a 16 ga. galvanized steel base with lifting lugs.
 - .3 Provided with all internal surfaces covered with 25 mm (1 in.) thick, 3 lb. density foil faced insulation. Fasten insulation with adhesive and weld pins.
 - .4 Energy recovery wheel mounted in a slide track for easy inspection and cleaning. Provide separate blower and motor for supply and exhaust airstream for independent system balancing.
 - .5 Blower and motor assemblies mounted on rubber vibration isolators.
 - .6 Provide 50 mm (2 in.) thick, 30 % efficient pleated filters for supply and exhaust airstreams.
 - .7 Provide removable side panels for easy access to motors, blowers, filters and energy recovery wheel.
 - .8 Provide unit with an engraved aluminum nameplate and ship unit in International Safe Transit Association (ISTA) certified transit tested packaging.
- .4 Provide units with:
 - .1 Energy Wheel: A total energy recovery wheel constructed of fluted synthetic fiber-based media impregnated with a non-migrating water selective 4 angstrom

- molecular sieve desiccant. Wheels with the desiccant applied in a secondary operation will not be accepted. Energy transfer ratings AHRI certified in accordance AHRI Standard 1060 "Performance Ratings of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment."
- .2 Electric Re-Heat Coil: Provide coils of the capacity shown on the Drawings. Provide all controls integral to the unit.
 - .3 Filters: Standard size 50 mm (2 in.) thick, 30 % efficient pleated filters in both supply and exhaust air streams.
 - .4 Fan Wheel: DWDI centrifugal forward curved type, constructed of painted steel. Wheel balanced in accordance with AMCA Standard 204 "Balance Quality and Vibration Levels for Fans."
 - .5 Motor: High efficiency heavy duty type with permanently lubricated sealed ball bearings and furnished at the specified voltage, phase and enclosure suitable for variable frequency drives where indicated.
 - .6 Controls and Electrical: All internal electrical components pre-wired for single point power connection. Internal control panel cUL listed with hinged access door and interlocking CSA Type 3R fused disconnect switch. Provide each motor complete with variable frequency drive. Provide a 24 V circuit to allow remote on/off control of ERV by Building Automation System and control each variable frequency drive via a 0-20 mA connection by the BAS. Provide short circuit protection on primary and secondary of control power transformer.
 - .7 Bearings: Permanently lubricated, sealed ball type selected for a minimum L50 life in excess of 200,000 hours at maximum catalogued operating speed.
 - .8 Belts and Drives: Provide oil and heat resistant, non-static type belts. Provide precision machined cast iron type drives, keyed and securely attached to the wheel and motor shafts. Size drives for 150% of the installed motor horsepower. Set the variable pitch motor drive to the specified fan RPM at the factory.
- .5 Provide unit complete with the following control options:
- .1 Filter Sensor – Monitors fan compartment pressure change, which actuates a filter sensor warning light on the unit controller.
 - .2 Rotation Sensor – Monitors wheel rotation. When wheel stops, sends a 24 V signal to the BAS.
 - .3 Economizer Mode – Stops wheel during periods when outdoor air conditions are close to indoor air conditions such that sensible and latent heat transfer no longer occurs.
 - .4 Remote enthalpy sensor.
 - .5 Preheat Frost Control – Provide outside air temperature sensor. When outside air is below a preset air temperature, energize a two stage electric coil to preheat intake air. Refer to schedule for electric heater kW rating.
 - .6 Motorized dampers for unit isolation on the outside air and return air.
 - .7 Backdraft damper on exhaust air discharge.

3. Execution

3.1. INSTALLATION

3.1.1. General:

- .1 Install all ventilators with vibration isolation hangers with flexible connections on both inlet and outlet.
 - .2 Provide full size access panels.
- 3.1.2. Residential Suite Heat Recovery Units:
 - .1 Install room ventilators where shown.
- 3.1.3. Commercial Energy Recovery Ventilators (ERV):
 - .1 Install as per manufacturer's written recommendations.
 - .2 Co-ordinate controls with Section 23 09 00.00 – BUILDING AUTOMATION SYSTEM (BAS).

END OF SECTION

23 74 13.13 Small Packaged (Modular) Roof Mounted Air Conditioning Units

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.1.2. Provide low Global Warming Potential (GWP) refrigerant complying with the performance requirements stated within Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings in accordance with Section 20 05 03.00 - SHOP DRAWINGS. Ensure Shop Drawings include unit Short Circuit Current Rating (SCCR).

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Packaged roof top units shall be Aaon, Daikin, Carrier, Lennox, or JCI York.

2.1.2. Units shall be specifically designed for outdoor rooftop application and include a weatherproof cabinet. Cooling capacity, heating capacity and fan performance shall be ARI certified. Complete unit shall be ETL- Canada listed.

2.1.3. Provide units that are safety certified to CAN/CSA-C22.2 No. 60335-2-40 "Safety of household and similar electrical appliances - Part 2 - 40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers" for units utilizing A2L class refrigerants.

2.1.4. Unit shall bear a minimum Short Circuit Current Rating (SCCR) listed by a Nationally Recognized Testing Lab, acceptable to the local Authority Having Jurisdiction, and shall be **10,000 A**. Lower SCCR listed units implying the use of current limiting fuses ahead of them in the field, in lieu of an actual appropriate SCCR rating, are not acceptable.

2.1.5. The unit shall undergo a complete factory run test prior to shipment. The factory test shall include final balancing of the supply and return fan assemblies, a refrigeration circuit run test, a unit control system operations checkout, test and adjustment of the gas furnace, a unit refrigerant leak test and a final unit inspection.

2.1.6. Each unit shall be complete with all components required for a complete and operational system, including but not limited to the following:

- .1 ECM variable speed supply air fan section with centrifugal fans.
- .2 Air cooled refrigeration section
- .3 Economizer fan and damper section
- .4 Roof top enclosure

- .5 Remote space 7 Day Programmable Heating/cooling thermostat with Tenant Override capability
 - .6 Filter section
 - .7 Roof mounting frame and curb
 - .8 Back up heating coil.
 - .9 Enthalpy wheel heat recovery section
- 2.1.7. Provide weatherproof rooftop enclosure for all above components, complete with an outside air inlet. Factory install piping and wiring of all components, complete with all safety and operating controls, and make ready for field connection of power and thermostat wiring to terminal strip, and gas piping to gas inlet.
- 2.1.8. Each unit shall have the capacity shown in the Roof Top Unit Schedules with 35 deg. C. (95 deg. F.) ambient air entering the condenser.
- 2.1.9. Unit shall be capable of delivering 1415.8 L/s (3000cfm) at 12.8 deg. C. (55 deg. F.) db. and 12.8 deg. C. (55 deg. F.) wb with 35 deg. C. (83.1 deg. F.) ambient air entering the condenser when in cooling mode and of delivering 1415.8 L/s (3000 cfm) at 21.1 deg. C. (70 deg. F.) with 6.7 deg. C. (44 deg. F.) entering when in heating mode.
- 2.2. CASING
- 2.2.1. Exterior panels shall be double-wall construction. Insulation shall be a minimum of 1" thick with an R-value of 4.0, and shall be neoprene coated glass fiber. All floor panels shall have a solid galvanized steel inner liner on the air stream side of the unit to protect insulation during service and maintenance.
- 2.2.2. The frame and unit base shall be heavy gauge galvanized steel. Unit base shall overhang the roof curb for water runoff and shall have a formed recess that seats on the roof curb gasketing to provide a positive weather tight seal
- 2.2.3. Service doors shall be provided for the fan section, filter section, control panel section, and heating vestibule in order to provide user access to unit components. All service access doors shall be mounted on multiple, stainless steel hinges and shall be secured by a latch system. Removable service panels secured by multiple mechanical fasteners are not acceptable.
- 2.2.4. Stainless steel drain pans shall be sloped in two directions and comply with ASHRAE Standard 62.1. The drain pan shall extend beyond the leaving side of the coil.
- 2.3. FAN SECTION
- 2.3.1. Supply air fan shall be centrifugal with capacity to deliver the air quantity shown as outlined in the Roof Top Unit Schedule. Reinforce casings to prevent drumming.
- 2.3.2. Fan assemblies shall be statically and dynamically balanced for quiet operation. Provide slide out rails for servicing and maintenance of the fan. All fan assemblies shall employ solid steel fan shafts. Bearings shall be sized to provide an L-50 life of 250,000 hours.
- 2.3.3. The fan assembly shall have adjustable pitched sheaves on the motor. Bushings shall be used on all sheaves to allow for easy removal of the pulleys from the fan and motor shaft. Fixed bore pulleys fastened to the shaft by setscrews will not be allowed. The drives shall be selected with a 1.2 service factor.
- 2.3.4. Variable air volume systems, or units serving single zones shall be provided with variable speed drives to reduce airflow at cooling loads below 50% per ASHRAE 90.1.

- 2.3.5. The fan motor shall be a totally enclosed EC motor that is speed controlled by the rooftop unit controller. Acceptable alternate is a premium efficiency open drip proof motor suitable for use with a variable speed drive. Motor safeties shall include thermal overload protection and phase failure protection. Provide variable speed drive integral with the unit.
- 2.4. FILTER SECTION
- 1.1.1. Filter section shall be complete with Farr D/C or other approved manufacturer of 50 mm (2 in.) thick pre-filter consisting of throw away media in permanent frames. Media shall have an efficiency of (2 inch Merv 13-85%) (4 inch Merv 14-95%).
- 2.5. ECONOMIZER
- 2.5.1. Unit shall be provided with an outdoor air economizer section. The economizer shall include outdoor, return, and exhaust air dampers. The outdoor air hood shall be factory installed and constructed from galvanized steel finished with the same durable paint finish as the main unit.
- 2.5.2. The economizer operation shall be fully integral to the mechanical cooling and allow up to 100% of mechanical cooling if needed to maintain the cooling discharge air temperature. The outside and return air dampers shall be sized to handle 100% of the supply air volume. The dampers shall be opposed blade design. Damper blades shall be gasketed with side seals to provide an air leakage rate of 4 cfm / square foot of damper area at 1" differential pressure per ASHRAE 90.1 Energy Standard.
- 2.5.3. A barometric exhaust damper shall be provided to exhaust air out of the back of the unit. A bird screen shall prevent infiltration of rain and foreign materials. Exhaust damper blades shall be lined with vinyl gasketing on contact edges. If powered economiser is to be provided, delete barometric
- 2.5.4. Powered economizer shall provide free cooling using up to 100% outside air at all outside temperatures below 23.9 deg. C. (75 deg. F.) and minimum of approximately 10% outside air shall be provided above this temperature. Outside air damper shall close when unit is shut down. Include powered economiser option depending on return air path conditions Exhaust fans shall be direct drive, axial type. Blades shall be constructed with fabricated steel and shall be securely attached to fan shafts. All exhaust fan assemblies shall be statically and dynamically balanced. Motors shall be permanently lubricated, heavy-duty type, carefully matched to the fan load. Ground and polished steel fan shafts shall be mounted in permanently lubricated and sealed ball bearings. Bearings shall be selected for a minimum (L10) life in excess of 100,000 hours at maximum cataloged operating speeds.
- 2.5.5. Control of the dampers shall be by a factory installed direct coupled actuator. Damper actuator shall be of the modulating, spring return type. A comparative enthalpy control shall be provided to sense and compare enthalpy in both the outdoor and return air streams to determine if outdoor air is suitable for "free" cooling. If outdoor air is suitable for "free" cooling, the outdoor air dampers shall modulate in response to the unit's temperature control system.
- 2.6. REFRIGERATION AND CONDENSING SECTIONS
- 2.6.1. Coils shall have seamless copper tubes, mechanically bonded to aluminum plate-type fins. The fins shall have full drawn collars to completely cover the tubes.
- 2.6.2. Air cooled refrigeration section shall provide stable operation down to 12.8 deg. C. (55 deg. F.) Only include where required, otherwise economiser will be sufficient outside air temperature.
- 2.6.3. Optional low ambient cooling to 0 degrees F shall be provided. Include only if required, otherwise delete.

- 2.6.4. Condenser fans shall be direct drive, axial type designed for low tip speed and vertical air discharge. These fans are standard arrangement. Choose this option or paragraph below to upgrade to EC. Condenser fan rpm shall be 1140 rpm maximum. Fan blades shall be constructed of steel and riveted to a steel center hub. Condenser fan motors shall be heavy-duty, inherently protected, three-phase, non-reversing type with permanently lubricated ball bearing and integral rain shield.
- 2.6.5. Fan motors shall be ECM type. The rooftop controller shall proportionally control the speed. This is an option on only a few available units. Confirm requirement for Project. of the condenser fan motors to maintain the head pressure of the refrigerant circuit within acceptable limits. Mechanical cooling shall be provided to 0 deg. F. Motor safeties shall include thermal overload protection and phase failure protection.
- 2.6.6. The condenser fan shall be dynamically designed for low noise generation with low tip speeds. Fan blade shall be of a composite material. The maximum sound power level shall be xx/xx/xx/xx for the 2nd/3rd/4th/5th power bands respectively. Choose the composite/profile fan for Projects that required reduced sound power levels at the condenser.
- 2.6.7. All units of 6.5 ton capacity and above shall have minimum two independent refrigeration circuits.
- 2.6.8. Each circuit shall have fan cycling on at least one condenser fan to maintain positive head pressure. An ambient thermostat shall prevent the refrigeration system from operating below 20 deg. F.
- 2.6.9. Each unit shall have multiple, heavy-duty scroll compressors. Each compressor shall be complete with gauge ports, crankcase heater, sight-glass, anti-slug protection, motor overload protection and a time delay to prevent short cycling and simultaneous starting of compressors following a power failure. Compressors shall be isolated with resilient rubber isolators to decrease noise transmission.
- 2.6.10. Variable Speed Compressors Confirm availability of this option. This is an upgrade for additional energy savings.
- .1 The unit shall have multiple scroll compressors. One of the compressors shall be inverter driven and the unit controller must control the speed of the compressor to maintain the discharge air temperature.
- 2.6.11. Each circuit shall be complete with isolation ball valves on the suction and discharge sides of the compressor, a low pressure control, filter-drier, liquid moisture indicator/sight-glass, thermostatic expansion valve, and a manual reset high pressure safety switch. The thermal expansion valve shall be capable of modulation from 100% to 25% of its rated capacity. Sight-glasses shall be accessible for viewing without disrupting unit operation.
- 2.6.12. The refrigeration circuit shall have both low and high pressure safety switches. Temperature sensors shall be provided for measuring suction and discharge temperature of the refrigerant.
- 2.6.13. Refrigerant circuit shall have a bypass valve between the suction and discharge refrigerant lines for compressor startup under low head pressure conditions. When there is a call for mechanical cooling the bypass valve shall open to equalizing the suction and discharge pressures. When pressures are equalized the bypass valve shall close and the compressor shall be allowed to start.
- 2.6.14. Each circuit shall be dehydrated and factory charged with Refrigerant and oil.

2.7. HEATING SECTION

- 2.7.1. Natural gas fired heating section shall provide indirect heating through an aluminized steel or stainless steel heat exchanger if the return air is greater than 30% of the outside air volume; or Type 409 stainless steel heat exchanger if the return air is less than 30% of the outside air volume. Provide electric ignition with remote flame sensor. Unit shall be suitable for 1.74 kPa (7 in.wg.) gas pressure. The natural gas section shall be capable of modulating at a 10:1 staging ratio.
- 2.7.2. Electric heating coils shall be of the open resistance element type of 80% nickel and 20% chromium. Elements shall be uniformly distributed over the cross sectional area of the unit with vertical support brackets to prevent coil element sag. Coil elements shall be insulated from metal by ceramic bushings. Provide expanded steel baffle on coil inlet for uniform airflow. Electric coils shall be provided with built-in primary automatic and secondary manual reset thermal protection devices and static pressure type airflow switch to prevent energization when airflow is inadequate. Delete electric heat if not required.
- 2.7.3. Provide electric coils with variable control achieved by a duct mounted thermostat and SCR controller. Provide control panel with a unit mounted circuit breaker size for interrupting capacity as to meet CSA requirements.
- 2.7.4. Control panels shall be integral to the heating coil (remote mounted). Control panels shall be of CSA construction with magnetic circuit fusing for each 48 amp circuit to meet CSA requirements, SCR controller and 120 volt fused control power transformer sized as required. All control and safety devices shall be factory wired as to meet CSA requirements. Thermostat provided under Section 23 09 00.00 – BUILDING AUTOMATION SYSTEM (BAS).

2.8. HEAT RECOVERY SECTION

- 2.8.1. The rooftop unit shall be provided with an AHRI certified rotary wheel air-to-air heat exchanger in a cassette frame complete with seals, drive motor and drive belt. The energy recovery wheel shall be an integral part of the rooftop unit with unitary construction and shall not require field assembly.
- 2.8.2. Energy wheel performance shall be AHRI Standard 1060 Certified and bear the AHRI Certified Product Seal. The energy recovery media shall have a minimum of 70% effectiveness at nominal unit airflow. The energy recovery section shall be UL/ULC Recognized component for electrical and fire safety.
- 2.8.3. The wheel shall be coated with silica gel desiccant, permanently bonded without the use of binders or adhesives. Coated wheels shall be washable with detergent or alkaline coil cleaner and water. The silica gel shall not dissolve or deliquesce in the presence of water or high humidity.
- 2.8.4. The rooftop unit shall be designed with a track so the entire energy recovery wheel cassette can slide out from the rooftop unit to facilitate cleaning.
- 2.8.5. Fresh air to the wheel shall be filtered by 50 mm (2 in) MERV 7 filters.
- 2.8.6. The substrate shall be made of a lightweight polymer and shall not degrade or require additional coatings for application in coastal environments. The wheel polymer layers shall be wound continuously with one flat and one structured layer in an ideal parallel plate geometry providing laminar flow and minimum pressure drop. The polymer layers shall be captured in a stainless steel wheel frame or aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix.
- 2.8.7. Energy recovery wheels greater than 480 mm (19 in.) in diameter shall be provided with removable wheel segments.

- 2.8.8. Wheel frame shall be a welded hub, spoke and rim assembly of stainless, plated, and or coated steel and shall be self-supporting without the wheel segments in place. Wheel rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.
- 2.8.9. Wheel segments shall be removable without the use of tools to facilitate maintenance and cleaning.
- 2.8.10. Wheel bearings shall provide an L-10 life of 400,000 hours.
- 2.8.11. The exhaust air fan shall be a direct drive plenum fan coupled to an ECM motor or a VFD driven motor Exhaust air fan may not be available on all unit sizes. Confirm with manufacturer. The unit controller shall control the exhaust fan to maintain building pressure.
- 2.8.12. The control of the energy recovery wheel shall be an integral part of the rooftop unit's main controller. The DDC controller shall have visibility of the outdoor air temperature, leaving wheel temperature, return air temperature, and exhaust air temperature.
- 2.8.13. The rooftop unit DDC controller shall provide frost prevention for the energy recovery wheel. Select method of wheel control and frost control The DDC controller will start and stop the energy wheel to prevent the wheel from reaching a frost condition.
- 2.8.14. Variable speed control shall be accomplished by the use of an A/C inverter. The control system shall modulate the rotational speed of the wheel based on supply air temperature. Rotational speed shall be automatically reduced to prevent frosting. Supply air temperature shall be manually adjusted via unit mounted potentiometer. The control system shall include four linearized thermistor sensors:
 - .1 Proportional temperature controller mounted in the supply air stream,
 - .2 Differential summer/winter change over sensors mounted in the outdoor and return air streams,
 - .3 Frost prevention sensor located in the exhaust air stream.
- 2.8.15. Drive belts of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.
- 2.9. SPACE HUMIDITY CONTROL/ HOT GAS REHEAT
 - 2.9.1. The hot gas reheat humidity control option shall be factory installed and shall provide greater dehumidification of the occupied space by two modes of dehumidification operations in addition to its normal design cooling mode:
 - .1 Subcooling mode further sub cools the hot liquid refrigerant leaving the condenser coil when both temperature and humidity in the space are not satisfied.
 - .2 Hot gas reheat mode shall mix a portion of the hot gas from the discharge of the compressor with the hot liquid refrigerant leaving the condenser coil to create a two-phase heat transfer in the system, resulting in a neutral leaving air temperature when only humidity in the space is not satisfied.
 - .3 Includes head pressure controller on refrigeration circuit.
 - 2.9.2. The hot gas reheat coil shall be {single stage.} {fully modulating with control of the leaving air temperature accurate to +/- 2°}. The modulating hot gas reheat systems shall allow for independent control of the cooling coil leaving air temperature and the reheat coil leaving air temperature. The cooling and reheat leaving air temperature set points shall be adjustable through the unit controller.
 - 2.9.3. Hot gas coil shall be sized to allow for full condensing across the operation range of the unit. High temperature liquid shall be piped downstream of the unit's condenser coils into the liquid line.

- 2.9.4. The refrigeration circuit shall not require receivers. The hot gas coil shall be used for refrigerant storage when the unit is not operation in a dehumidification or reheat mode.
- 2.10. ELECTRICAL
- 2.10.1. Each unit shall be wired and tested at the factory before shipment. Wiring shall comply with all applicable UL and CSA standards. All wiring shall be number coded per the electrical wiring diagrams. All electrical components shall be labeled according to the electrical diagram and be CSA recognized where applicable.
- 2.10.2. Unit shall be suitable for 575/3/60 or 208/3/60 power supply as scheduled. Select a suitable voltage.
- 2.10.3. Unit shall have a single point power terminal block for main power connection. A terminal board shall be provided for low voltage control wiring. Branch short circuit protection, 120 volt control circuit transformer and fuse, system switches, and a high temperature sensor shall also be provided with the unit.
- 2.10.4. Provide mechanical screw-type lugs designed for copper conductors and sized to handle 125% of total heater load in the control panel for terminating power wiring. Provide a complete wiring diagram permanently attached to the inside of the control panel cover.
- 2.10.5. Each compressor and condenser fan motor shall be furnished with contactors and inherent thermal overload protection. Supply fan motors shall have contactors and external overload protection. Knockouts shall be provided in the bottom of the main control panels for field wiring entrance.
- 2.10.6. A GFI receptacle shall be unit mounted. The receptacle shall be powered by a factory installed and wired 120 V, 20 amp power supply. The power supply shall be wired to the line side of the unit's main disconnect, so the receptacle is powered when the main unit disconnect is off. This option shall include a GFI receptacle, transformer, and a branch circuit disconnect.
- 2.10.7. Provide harmonic filter for Electronically Commutated Motors (ECM) or for Unit, in accordance with the requirements of Section 20 35 26.00 – HARMONIC FILTERS.
- 2.11. ROOF CURB
- 2.11.1. Provide a roof mounting frame for each unit. In addition, furnish a supplementary frame to compensate for the sloping roof This is a costly option. Only include when necessary. This supplementary frame shall mate with the unit frame and be of the same thickness.
- 2.11.2. Roof curb shall be prefabricated 14-gauge galvanized steel, mounting curb for field assembly on the roof decking. The roof curb shall be a full perimeter type with complete perimeter support of the air handling section and condensing section. The curb shall be a minimum of 610 mm (24 in.) high. Gasket shall be provided for field mounting between the unit base and roof curb.
- 2.12. REFRIGERANT LEAK DETECTION SYSTEM
- 2.12.1. The system must provide all the functionalities necessary to comply with current ASHRAE 15 "Safety Standard for Refrigeration Systems" guidelines and CSA B52 "Mechanical Refrigeration Code" requirements to limit the releasable refrigerant charge consisting of the following:
- .1 Non-adjustable, refrigerant leak detector(s) located within the refrigerant coil section of the unit.
 - .2 Self-diagnostic capabilities.

- 2.12.2. Upon detection of leaked refrigerant or failure of any leak detector, the system shall de-energize electric resistance heat within the unit and/or downstream ductwork, energize air circulating fans, and isolate all possible paths of refrigerant.
- 2.13. CONTROLS
- 2.13.1. Each unit shall be equipped with a microprocessor based direct digital control (DDC) system. The unit control system shall include all required temperature and pressure sensors, input/output boards, main microprocessor and operator interface. The unit control system shall perform all unit control functions including scheduling, unit diagnostics and safeties.
- 2.13.2. The stand-alone microprocessor controllers shall not be dependent on communications with any on-site or remote PC or master control panel for proper unit operation. The microprocessor shall maintain existing set points and operate stand-alone if the unit loses either direct connect or network communications. The microprocessor memory shall be protected from voltage fluctuations as well as any extended power failures. All factory and user set schedules and control points shall be maintained in non-volatile memory. No settings shall be lost, even during extended power shutdowns.
- 2.13.3. The microprocessor control system shall permit starting and stopping of the unit locally or remotely. The control system shall be capable of providing a remote alarm indication. The unit control system shall provide for outside air damper actuation, emergency shutdown, remote heat enable/disable, remote cool enable/disable, heat indication, cool indication, and fan operation.
- 2.13.4. All digital inputs and outputs shall be protected against damage from transients or incorrect voltages. All field wiring shall be terminated at a separate, clearly marked terminal strip.
- 2.13.5. The microprocessor controller shall have a built-in adjustable time schedule. There shall be one start/stop per day and a separate holiday schedule. The controller shall accept up to sixteen holidays each with up to a 5-day duration. Each unit shall also have the ability to accept a time schedule via BAS network communications.
- 2.13.6. The unit is to be programmed with a night setback or setup function, with a signal provided from a space sensor. Sensor options shall include a zone sensor with tenant override switch plus heating and cooling set point adjustment.
- 2.13.7. Provide a seven day programmable heating/cooling thermostat with integral selection switch for each unit. Provide a key-locked tamper-proof cover for each thermostat. Delete clause for thermostat if the RTU will be connected to a BAS.
- 2.13.8. At the main micro-processor controller provide a unit keypad/display character format shall be 4 lines x 20 characters. All control settings shall be password protected against unauthorized changes. For ease of service, the display format shall be English language readout. Coded formats with look-up tables will not be accepted. The user interaction with the display shall provide the following information as a minimum:
- .1 Return air temperature
 - .2 Discharge air temperature
 - .3 Outdoor air temperature
 - .4 Space air temp
 - .5 Outdoor enthalpy, high/low
 - .6 Dirty filter indication
 - .7 Airflow verification
 - .8 Cooling status
 - .9 Control temperature (Changeover)

- .10 VAV box output status
 - .11 Cooling status/capacity
 - .12 Unit status
 - .13 All time schedules
 - .14 Active alarms w/time and date
 - .15 Previous alarms with time and date
 - .1 Optimal start
 - .2 System operating hours
 - .3 Fan
 - .4 Exhaust fan
 - .5 Cooling
 - .6 Individual compressor
 - .7 Heating
 - .8 Economizer
 - .9 Tenant override
- 2.13.9. For variable air volume systems, the DDC controller shall include a discharge air temperature reset program for part load operating conditions. The discharge air temperature shall be controlled between a minimum and a maximum discharge air temperature (DAT) based on one of the following inputs:
- .1 Airflow
 - .2 Outside air temperature
 - .3 Space Temperature
 - .4 Return air temperature
 - .5 External signal of 1-5 VDC
 - .6 External signal of 0-20 mA
 - .7 Network signal
- 2.13.10. On constant volume applications, the DDC controller shall include a supply air fan speed reset sequence. The speed of the supply fan shall be modulated from high speed to low speed based on:
- .1 Status of Compressor staging
- 2.13.11. The unit control system shall have the ability to communicate to an independent Building Management System through a direct (BACnet Ethernet) (BACnet MSTP) (LonTalk) communication connection. The independent BMS system shall have access to "read only" variables and "read & write" variables. Communications shall not require field mounting of any additional sensors or devices at the unit.
- 2.14. SEQUENCE OF OPERATION
- 2.14.1. The unit shall be controlled on a time of day. The unit shall accept the programmed room temperature setpoint based on time of day, and current room temperature.
- 2.14.2. The supply air fan shall remain operational when the space is in occupied mode.
- 2.14.3. On a call for cooling, the RTU controller shall modulate both the supply air fan and the D/X cooling stages in sequence to maintain the current space temperature setpoint based on the current space conditions. When the cooling demand is less than 50%, the controller shall reduce the fan speed accordingly.

- 2.14.4. On a call for heating, the RTU shall operate the fan at 50% (programmable) speed and modulate the gas burner to maintain the current space temperature setpoint based on the current space conditions.
- 2.14.5. When the RTU is in un-occupied mode, the fan shall cycle with the D/X cooling stages and the gas burner as required to maintain the space unoccupied setpoint.

3. Execution

3.1. INSTALLATION

- 3.1.1. Provide all control wiring from thermostat and thermostat sub-base.
- 3.1.2. Supply and install wiring of the airflow switch for the electrical coil.
- 3.1.3. Provide access to all components of the refrigerant leak detection system for testing and replacement.
- 3.1.4. Gas fired roof top unit shall not be installed closer than 2 m (6 ft.) to the edge of the roof.
- 3.1.5. BAS connection to the unit provided under Section 23 09 00.00 – BUILDING AUTOMATION SYSTEM (BAS).
- 3.1.6. Start up and test all unit functions and ensure proper operation. Factory technician to provide copy of start-up log to Owner and to demonstrate operation and maintenance to Owner.

END OF SECTION

23 77 13.00 Expansion Tanks

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Shop Drawings: Submit Shop Drawings of the tank support frames for structural review, and tank drawings, including details and catalogue cuts of any standard components being incorporated into the system.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.2. Replaceable bladder type expansion tanks shall be pre-charged replaceable bladder type equal to Calefactio Explanflex Type 'AL', Xylem Series 'B', Armstrong Type 'L', or Amtrol Extrol Series 'L' stamped 800 kPa (125 psi) operating pressure.

- .1 Tanks shall be constructed in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code.
- .2 Tanks shall be all steel construction and replaceable bladder shall be heavy duty butyl rubber compound.
- .3 Tank shall include 38 mm (1-1/2 in.) threaded bottom inlet, built in air pressure gauge, air inlet connection to facilitate adjusting of pre-charge air pressure to meet actual system conditions, and 19 mm (3/4 in.) drain connection.
- .4 Tanks shall be complete with ring base, and lifting rings.
- .5 Tanks shall have capacities as indicated in the Expansion Tank Schedule.
- .6 Tanks shall have capacities as indicated on the Drawings.

2.1.3. Diaphragm type expansion tanks shall be pre-charged diaphragm type equal to Calefactio Explanflex Type 'OT', Xylem Series 'D' or Armstrong Type 'AX' stamped 800 kPa (125 psi) operating pressure.

- .1 Tanks shall be constructed in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code.
- .2 Tanks shall be all steel construction with integral heavy duty butyl rubber diaphragm.
- .3 Tanks shall be complete with lifting rings, NPT system connection, built in air pressure gauge, and air inlet connection to facilitate adjusting pre-charge pressure to meet actual system conditions.
- .4 Tanks shall be complete with saddles.
- .5 Tanks shall have capacities as indicated in the Expansion Tank Schedule.

- .6 Tanks shall have capacities as indicated on the Drawings.
- 2.1.4. Domestic water expansion tanks:
 - .1 Capacity as indicated in the Expansion Tank Schedule.
 - .2 Lead free.
 - .3 Fixed or replaceable bladder type, or diaphragm type.
 - .4 Steel tank in-line or stand type as indicated and as per the Drawings or Schedules.
 - .5 Certified to NSF/ANSI Standard 61 "Drinking Water System Components – Health Effects."
 - .6 Factory pressurized (adjustable) with permanent separation of air and water.
 - .7 Suitable for a maximum working pressure of 1034 kPa (150 psi) at 116 deg. C (240 deg. F).
 - .8 Constructed and stamped in accordance with the ASME Code Section VIII for Unfired Pressure Vessels.
 - .9 Complete with a red oxide primer finish and the following:
 - .1 A NPT stainless steel system connection sized as shown on Drawings.
 - .2 A Schrader air charging valve.
 - .3 A heavy-duty butyl rubber bladder.
 - .4 A polypropylene liner.
 - .5 A built in air pressure gauge.
 - .6 Where replaceable bladder type expansion tank is provided, a tapping for installation of a drain valve.
 - .10 Manufacturer:
 - .1 Calefactio, Armstrong, Xylem.
- 2.1.5. Water Pressure Reducing Valve: Watts, or Cash Acme, equal to Watts UB5, screwed with low lead bronze body for operating pressures up to 2070 kPa (300 psi) at 71 deg. C. (160 deg. F.).
- 2.1.6. Upstream from pressure reducing valve, provide backflow prevention in accordance with Section 22 11 13.00 - PIPES, VALVES, AND FITTINGS (PLUMBING SYSTEMS).
- 2.1.7. Downstream from pressure reducing valve, provide a pressure relief valve. All components of valves in contact with water shall be non-ferrous. Set pressure reducing valve and pressure relief valve in accordance with the system fill pressure and maximum system pressure in the Expansion Tank Schedule, respectively.
- 2.1.8. Expansion tanks used for Glycol systems shall not have a cold water make-up connection.
- 3. Execution
 - 3.1. INSTALLATION
 - 3.1.1. Expansion tanks shall be self-supporting and shall be placed on 100 mm housekeeping pads.
 - 3.1.2. Provide 19 mm (3/4 in.) drain line complete with valve to nearest floor drain for replaceable bladder type expansion tanks.
 - 3.1.3. Pipe pressure relief valve to nearest floor or hub drain for water systems and to glycol make-up package for glycol systems.
 - 3.1.4. Hang expansion tanks from roof structure on angle iron frame. Support tank below each saddle. Refer to Drawings for additional details.

- 3.1.5. Support expansion tank on angle iron frame welded to base plate anchored to floor with self drilling anchor bolts cross brace with angle irons.

END OF SECTION

23 81 23.00 Computer Room Air Conditioning Units

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.1.2. Provide low Global Warming Potential (GWP) refrigerant complying with the performance requirements stated within Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. ALTERNATIVE PRICE

1.2.1. Refer to Bidding Documents for Alternative Price to substitute Schneider, Stulz, or Data Aire equipment in lieu of Base Bid Vertiv equipment specified. Alternative may be acceptable to the Owner provided all design criteria, noise control and space requirements comply or exceed requirements of Base Bid Products.

1.3. SUBMITTALS

1.3.1. Submit Shop Drawings in accordance with Section 20 05 03.00 - SHOP DRAWINGS. Ensure Shop Drawings include unit Short Circuit Current Rating (SCCR).

1.4. WARRANTY

1.4.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Computer room units shall be Vertiv self-contained factory assembled unit with down discharge air flow pattern. The units shall be completely pre-piped, pre-wired and ready for final connections and manufactured in accordance with UL listings and CSA Standards.

2.1.2. Provide units that are safety certified to CAN/CSA-C22.2 No. 60335-2-40 "Safety of household and similar electrical appliances - Part 2 - 40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers" for units utilizing A2L class refrigerants.

2.2. FLOOR MOUNTED UNITS

2.2.1. Fabricate frame for units from 3.416 mm thick (0.1345 in - 10 MSG gauge) sheet steel, and coat with a heavy corrosion inhibiting finish. Fabricate internal panels of a 1.26 mm thick (0.048 in - 18 GSG gauge) galvanized steel, coat and seal against corrosion.

2.2.2. Fabricate casings from 1.26 mm thick (0.048 in - 18 GSG gauge) steel, and coat with baked enameled finish inside and out. Colour of outer surface selected by Engineer's Representative. Supporting framework shall be suitable for mounting on raised floor.

- 2.2.3. Insulate exterior panels with minimum 25 mm (1 in.) thick glass fibre insulation. Equip panels with fasteners and make removable for access to the equipment. Arrange panels to provide access to the electrical control panel and control valve compartment without interrupting the air flow.
- 2.2.4. Furnish semi hermetic type compressor with internal spring isolation and sound muffling, complete with current overload cutout, internal motor winding thermostat, high and low pressure cutouts, and timer to prevent compressor short cycling. For dual compressors, provide a sequencing switch to alternate the lead compressor. Provide each unit with independent dual refrigeration circuits. Each circuit shall include a hot glass muffler, liquid line filter dryer, refrigerant sight glass with moisture indicator, adjustable externally equalized expansion valve, and liquid line solenoid valve.
- 2.2.5. The control system shall include four step cylinder unloaders activated by solenoid valves.
- 2.2.6. Cooling coil shall be suitable for the total cooling capacity shown. Coils shall be tested for 2070 kPa (300 psig). Drain pan and drain pipe shall be installed below coils. Each refrigerant circuit shall have a separate expansion valve. For water or glycol cooled systems, install a separate valve on each circuit.
- 2.2.7. Two way or three way modulating mixing valves shall control water flow. Valve shall have an adjustable potentiometer and shall be set to open 1/3 upon call for dehumidification. Valve shall close when unit is shut down. units shall have two way valve and units three way valves.
- 2.2.8. Refrigerant circuits shall be controlled by thermal expansion. Service valves shall be installed on all discharge, suction and liquid lines.
- 2.2.9. Provide centrifugal double inlet forward curve fans, statically and dynamically balanced. Drive the fans by 1750 rpm fan motor mounted on an adjustable slide base. Provide two-belt, variable speed drive package, sized for 200 % of the fan motor horsepower.
- 2.2.10. Thermostat shall control the cooling capacity of the unit to maintain the required setpoint. Humidistat shall control the humidifier to maintain the required humidity.
- 2.2.11. Filter shall be disposable 60 % average efficiency as measured on the NBS atmospheric duct spot method.
- 2.2.12. Heaters shall be sized to suit the cooling capacity of the unit.
- .1 Heaters shall be electric.
 - .2 Heaters shall be suitable for 34.5 kPa (5 psig) steam entering the coil.
 - .3 Heaters shall be suitable for hot water entering at 82.2 deg. C. (180 deg. F.) and leaving at 71.7 deg. C. (160 deg. F.).
- 2.2.13. The humidifier shall be of the infra-red type consisting of high intensity quartz lamps mounted above and out of the water supply. The evaporator pan shall be stainless steel and arranged to be serviceable for cleaning without disconnecting water supply lines, drain lines, or electrical connections. The complete humidifier section shall include liquid level control, emergency overflow and shall be prepped ready for final connections. The humidification system shall use bypass air to prevent over humidification of the computer room.
- 2.2.14. The humidifier shall be provided with an automatic flush control system. The flush control system shall be field adjustable to change the cycle time in accordance with local water conditions.
- 2.2.15. Provide suitably sized and valved domestic cold water from nearest source to humidifier.
- 2.2.16. Humidifier shall be replaceable steam type with ammeter, water filter, water solenoid valve, pressure regulator, timer controlled flush cycle, drain valve, steam generator cylinder, and steam probe.

- 2.2.17. Provide suitably sized and valved domestic cold water from nearest source to humidifier.
- 2.2.18. Water cooled condenser shall be shell and tube type with water regulating valves for water entering at deg. C. deg. F.) and leaving at deg. C. (deg. F.).
- 2.2.19. Glycol cooled, condenser shall be shell and tube type with matching glycol dry cooler mounted on the roof. Dry cooler shall be complete with heavy gauge baked enameled steel casing, statically and dynamically balanced fans and cooling coils sized to match the air conditioning units capacity.
- 2.2.20. Air cooled refrigerant condenser unit shall be roof mounted with heavy gauge, baked enameled finish, with statically and dynamically balanced fans and cooling coils sized to match the air conditioning units capacity.
- 2.2.21. All components shall be suitable for volt, 3 phase, 60 cycle. Power supply units shall be complete with control transformers.
- 2.2.22. The unit shall be mounted on a floor support stand of the same height as the floor. The stand shall be supplied with the unit. Coordinate installation with the Floor Supplier.
- 2.2.23. The unit shall be mounted on a floor support stand supplied and installed by the floor manufacturer. Coordinate size and loading of the floor stand.
- 2.2.24. The main power panel shall include complete branch circuit protection for every electrical component so that any one component can be isolated from the main power supply and be completely protected from primary single phasing and over-current. Supply and factory install all fuses. Access to main power panel shall be from the front of the unit without interrupting the operation of the unit.
- 2.2.25. Provide refrigerant leak detection system as follows:
- .1 The system must provide all the functionalities necessary to comply with current ASHRAE 15 "Safety Standard for Refrigeration Systems" guidelines and CSA B52 "Mechanical Refrigeration Code" requirements consisting of the following:
 - .1 Non-adjustable, refrigerant leak detector(s) located within the refrigerant coil section of the unit.
 - .2 Self-diagnostic capabilities.
 - .2 Upon detection of leaked refrigerant or failure of any leak detector, the system shall de-energize electric resistance heat within the unit and/or downstream ductwork, energize air circulating fans, and isolate all possible paths of refrigerant.
- 2.2.26. Unit shall bear a minimum Short Circuit Current Rating (SCCR) listed by a Nationally Recognized Testing Lab, acceptable to the local Authority Having Jurisdiction, and shall be **10,000 A** Lower SCCR listed units implying the use of current limiting fuses ahead of them in the field, in lieu of an actual appropriate SCCR rating, are not acceptable.
- 2.2.27. Provide 100% solid state electronic control system, complete with start button, stop button, and monitor panel.
- 2.2.28. The monitor panel shall have the following visual indicators for cooling, dehumidification, heating stage, change filters, humidification and low water flow.
- 2.2.29. The solid state temperature and humidity control module shall have an adjustable setpoint for room conditions. The temperature and humidity controls shall have a Push to test calibration check button, and built-in visual indicators to indicate the mode of operation of the control. All controls and control sensors shall be easily accessible plug-in modules.
- 2.2.30. Unit mounted controls shall be on/off switch, test button for indicator lights, power on, humidification, humidifier failure, air flow, filter replacement, high temperature and cooling failure. In addition a water detector and alarm shall be provided in the base of the unit.

- 2.2.31. Provide additional contacts for remote alarms for power failure, power on, running condition (air flow), humidity high/low, temperature high/low and water detector. All contacts shall be normally closed, and open to alarm.
- 2.2.32. Provide additional terminal for fire shut-down of unit.
- 2.2.33. The unit shall be provided with water detection sensors mounted under the raised floor to sense the presence of water.
- 2.2.34. Provide and install a non-locking disconnect switch with each unit.
- 2.2.35. Unit shall be as shown in the Schedules.
- 2.2.36. Unit shall be model capable of the following performances.
- 2.3. SMALL FLOOR MOUNTED UNITS (5 TONS OR SMALLER)
- 2.3.1. Computer Room air conditioning unit shall be equal to the Vertiv "Challenger 3000" factory assembled unit described hereafter. It shall be specifically designed for service from the front of the unit. The system shall be designed for draw through air arrangement to ensure even air distribution to the entire face area of the coil.
- 2.3.2. Each system shall be capable of handling 1320 L/s at 0.075 kPa (2,800 cfm at 0.3 in.) of water external static pressure with down discharge air flow pattern. It shall have a total cooling capacity of W/hr (btu/hr) sensible cooling capacity of W/hr (btu/hr), based on the entering air condition of 22.2 deg. C. (72 deg. F.) dry bulb, and 15.6 deg. C. (60 deg. F.) wet bulb. The humidifier shall have a capacity of kg/hr (lbs.hr). Reheat shall have a capacity of W/hr (btu/hr). The main fan motor shall be 1120 W (1.5 hp).
- 2.3.3. The frame shall be constructed of heliarc welded tubular and formed steel. All frame and internal fill components shall be coated using an auto deposition process to protect against corrosion. The exterior panels shall be powder coated with standard colour paint. The panels shall be insulated with a minimum 25.4 mm (1 in.), 0.68 kg (1-1/2 lbs) density fibre insulation. Front and side panels shall have captive, ¼ turn fasteners. The cabinet shall be designed so that all components are serviceable and removable from the front of the unit.
- 2.3.4. The fan shall be the centrifugal type, double width, double inlet. The shaft shall be heavy duty steel with self-aligning ball bearings with minimum life span of 100,000 hours. The fan motor shall operate at 1750 rpm and mounted on an adjustable base. The drive package shall be sized for 200% of the fan motor horsepower, and equipped with an adjustable motor pulley. The fan/motor assembly shall be mounted on vibration isolators. The fan shall be located to draw air over the coil to ensure even air distribution and maximum coil performance.
- 2.3.5. The filter shall be 50 mm (2 in.) thick and rated not less than 120% efficiency base on ASHRAE 52.2 "Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size".
- 2.3.6. For units utilizing A2L class refrigerants, provide refrigerant leak detection system as follows:
- .1 The system must provide all the functionalities necessary to comply with current ASHRAE 15 "Safety Standard for Refrigeration Systems" guidelines and CSA B52 "Mechanical Refrigeration Code" requirements consisting of the following:
 - .1 Non-adjustable, refrigerant leak detector(s) located within the refrigerant coil section of the unit.
 - .2 Self-diagnostic capabilities.
 - .2 Upon detection of leaked refrigerant or failure of any leak detector, the system shall de-energize electric resistance heat within the unit and/or downstream ductwork, energize air circulating fans, and isolate all possible paths of refrigerant.

- 2.3.7. The control system shall be microprocessor based. The system shall be provided with two 11 mm (0.43 in.) high, seven segment LED numerical display to allow observation of room temperature and humidity and each settable function.
- .1 Monitoring
 - .1 Normal Operating Modes (Heating, Cooling, Humidification, Dehumidification) shall be indicated by coloured LED's on the unit-mounted display panel.
 - .2 Control Parameters
 - .1 Temperature setpoint 18 to 29 deg. C. (65 to 85 deg. F.)
 - .2 Temperature sensitivity 1 to 3 deg. C. (1 to 5 deg. F.)
 - .3 Humidity setpoint 20-80% Rh
 - .4 Humidity sensitivity 1 to 10% Rh
 - .5 Humidifier flush rate
 - .6 Unit controls
 - .3 Compressor Short-Cycle Control
 - .1 The control system shall prevent compressor short-cycling by a 3 minute timer from compressor stop to the next start.
 - .4 Common Alarm or Remote On/off
 - .1 A common alarm relay shall be provided to interface alarms with a remote alarm device. This same relay may be used as a remote on/off control contact, instead of the common alarm function.
 - .5 Alarms
 - .1 The control system shall monitor unit operation and activate an audible and visual alarm in the event of the following factory preset alarm conditions:
 - .1 High temperature
 - .2 Low temperature
 - .3 High humidity
 - .4 Low humidity
 - .5 High head pressure
 - .6 Change filter
 - .7 Loss of air
 - .8 Local alarm
 - .6 Communications
 - .1 The microprocessor shall be compatible with all Vertiv remote monitoring and control devices.
- 2.3.8. Humidifier shall be replaceable steam type with ammeter, water filter, water solenoid valve, pressure regulator, timer controlled flush cycle, drain valve, steam generator cylinder, and steam probe.
- 2.3.9. Provide suitably sized and valved domestic cold water from nearest source to humidifier.
- 2.3.10. The low-watt density, stainless steel, finned-tubular electric reheat coils shall be capable of maintaining room dry bulb conditions when the system is calling for dehumidification. The reheat section shall include UL approved safety switches to protect the system from overheating. The capacity of the reheat coils shall be ... W/hr (56,200 btu/hr) with input power of 15 kW, controlled in 2 stages.

- 2.3.11. Construct floorstand of a heliarc welded tubular steel frame coated using an autodeposition process to protect against corrosion. Provide floorstand with adjustable legs and vibration isolation pads, mounted 300 mm (12 in.) above floor.
- 2.3.12. Mount a non-automatic molded case circuit breaker in the high voltage section of the electrical panel and with the switch accessible with the door in a closed position.
- 2.3.13. The evaporator coil shall have 0.62 sq.m. (6.67 sq.ft.) face area, 4 rows deep. It shall be configured as a frame and be constructed of copper tubes and aluminum fins and have a maximum face velocity of 123.4 m/s (405 ft/m) at 1320 L/s (2800 cfm). The coil shall be provided with a stainless steel drain pan.
- 2.3.14. The refrigeration system shall consist of a high efficiency scroll compressor, hot gas bypass, pressure safety switches, externally equalized expansion valve, filter dryer, and a refrigerant sight glass and moisture indicator.
- 2.3.15. A liquid line solenoid valve shall be provided for pump down control.
- 2.3.16. A crankcase heater shall be provided for additional system protection from refrigerant migration during off cycles.
- 2.3.17. The Vertiv manufactured air cooled condenser shall be the low profile, slow speed, direct-drive, propeller-fan type. The condenser shall be constructed of aluminum and contain a copper tube, aluminum fin coil with an integral electric control panel. The system shall be designed for 35 deg. C. (95 deg. F.) ambient.
- 2.3.18. The winter control system for the air cooled condenser shall be Vertiv Fan Speed Control (FCS). The variable speed motor shall turn on at 10% of the supply voltage and modulate in response to head pressure to a full speed of 1050 rpm. It shall be designed with ball bearings, permanent lubrication, and internal overload protection.
- 2.3.19. The control system shall be complete with transducers, thermostats and electrical control circuits, factory pre-wired and tested in an integral control panel. The transducer shall automatically sense the head pressure of the compressor and control the variable speed fan on the air cooled condenser to properly maintain the head pressure. The fan speed control system shall provide positive start-up and operation in ambient temperature as low as -28.9 deg. C. (-20 deg. F.). Included with the fan speed control system shall be a solid state winter start kit as an integral feature of the electronic control panel.
- 2.3.20. These units shall operate on 575/3/60.
- 2.4. CEILING MOUNTED UNITS
 - 2.4.1. Unit shall be a ceiling mounted packaged environmental unit for spot-cooling. Configuration to be horizontal for ceiling mounting and sized to fit the 600 mm x 1200 mm (24 in. x 48 in.) opening of a standard T-bar ceiling. Capacity and electrical power requirements shall be as called for in the Schedule.
 - 2.4.2. Service access to be through hinged filter and grille frame at the bottom of the unit. Fan shall be direct drive and dynamically balanced. Filters shall be disposable, 25 mm (1 in.) thick, 500 mm x 500 mm (20 in. x 20 in.) and shall be accessible through a hinged return air grille. Cabinet shall be zinc coated steel, with primer coat and baked enamel finish and internally insulated with 12 mm (1/2 in.) glass fibre insulation. Vibration isolators shall be an integral part of the cabinet.
 - 2.4.3. Refrigeration system is to be completely pre-piped using Type L copper and shall include expansion valve with external equalizer, filter-dehydrator, and access fittings on the suction and liquid line. The hermetic compressor shall be provided with vibration mounting springs, line break internal protection system, forced feed lubrication and internal pressure relief valve. The evaporator coil shall have multiple circuits with seamless copper tubes and mechanically bonded aluminum fins.

- 2.4.4. Prewire electrical components including all contactors, relay control transformers, and capacitors, and mount within the hermetic cooling section. Provide terminal blocks for both control and power connections. Install Liqui-Tect sensing device at the evaporator drain pan to stop unit from operating prior to an overflow condition.
- 2.4.5. Provide 100% solid state control system employing no moving parts. Supply temperature and humidity control and stop-run switch for wall mounting.
- 2.4.6. The unit shall include reheat elements and humidifier. Removal of the humidifier for periodic cleaning and replacement shall not require any special tools, or rewiring.
- 2.4.7. The electrical controls shall be prewired. Electrical components include all required solenoid valves, contactors and safeties. Controls include solid-state humidity, temperature and stop/run switches.
- 2.4.8. Water cooled condenser shall be for counter-flow performance. The condenser shall be built into the hermetic refrigeration module complete with an adjustable water regulating valve.
- 2.4.9. Provide condensate pump.
- 2.4.10. Provide a remote mounted thermostat, located where shown and/or directed. Thermostat shall be fully adjustable for both temperature and humidity and shall be complete with on/off switch for unit.

3. Execution

3.1. INSTALLATION

- 3.1.1. Connect chilled water, domestic water, and drain piping complete with isolating valves.
- 3.1.2. Mount water detection sensors and wire to computer room units.
- 3.1.3. Provide suitably sized and valved domestic cold water from nearest source to humidifier.
- 3.1.4. Provide piping from condensate pump to nearest suitable drain.
- 3.1.5. Furnish a non-locking disconnect switch with each unit. Provide all power and control wiring required for the unit from this point.
- 3.1.6. Adjust fan drives to obtain specified air flow with allowed pressure drop for dirty filters.
- 3.1.7. Provide factory trained and authorized personnel for field start-up. Submit start up report.
- 3.1.8. Mount unit on floor stand.
- 3.1.9. Connect refrigerant system, purge and charge as required.
- 3.1.10. Provide access to all components of the refrigerant leak detection system for testing and replacement.
- 3.1.11. Field check operations of all controls on the units.

END OF SECTION

23 81 26.00 Unitary Air Conditioning Units

1. General
 - 1.1. WORK INCLUDED
 - 1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
 - 1.1.2. Provide low Global Warming Potential (GWP) refrigerant complying with the performance requirements stated within Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
 - 1.2. SUBMITTALS
 - 1.2.1. Submit Shop Drawings in accordance with Section 20 05 03.00 - SHOP DRAWINGS. Ensure Shop Drawings include unit Short Circuit Current Rating (SCCR).
 - 1.3. WARRANTY
 - 1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
2. Products
 - 2.1. MATERIALS
 - 2.1.1. Provide unitary Air Conditioning Units (UACU) from the following companies, equal to Mitsubishi "Mr. Slim".
 - .1 Mitsubishi
 - .2 Daikin
 - .3 Carrier
 - .4 LG
 - 2.1.2. Provide units that are safety certified to CAN/CSA-C22.2 No. 60335-2-40 "Safety of household and similar electrical appliances - Part 2 - 40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers" for units utilizing A2L class refrigerants.
 - 2.1.3. Provide split system type UACU with minimum two speed indoor evaporator section and remote outdoor compressor/condensing unit.
 - 2.1.4. Model arrangements shall be as shown, and specified in the Schedules.
 - 2.1.5. The pipe system and components shall conform to Section 23 23 01.00 - REFRIGERANT PIPING.
 - 2.1.6. The combination of the evaporator and condensing sections shall be provided with the capacities designated in Schedules.
 - 2.1.7. Provide unit capable of cooling mode operation in ambient temperatures down to minus 34.4 deg. C. (30 deg. F.).
 - 2.1.8. Provide unit with room thermostat. Dampers for right angle branch duct take-off from vertical riser shall be Air Vector, Vectrol, or other approved manufacturer.
 - 2.1.9. Provide unit with filter.

- 2.1.10. For units utilizing A2L class refrigerants, provide refrigerant leak detection system as follows:
- .1 The system must provide all the functionalities necessary to comply with current ASHRAE 15 "Safety Standard for Refrigeration Systems" guidelines and CSA B52 "Mechanical Refrigeration Code" requirements consisting of the following:
 - .1 Safety shut off valve(s) certified in accordance with CSA C22.2 No. 60335-2-40 or No. 60335-2-89 "Household and similar electrical appliances - Safety - Part 2-89: Particular requirements for commercial refrigerating appliances and ice-makers with an incorporated or remote refrigerant unit or motor-compressor."
 - .2 Non-adjustable, refrigerant leak detector(s) located within each indoor evaporator unit.
 - .3 Self-diagnostic capabilities.
 - .2 Upon detection of leaked refrigerant or failure of any safety shut off valve or leak detector, the system shall de-energize electric resistance heat within the system, activate the release mitigation controls, energize air circulating fans, and isolate all possible paths of refrigerant.
 - .3 Upon loss of power to any portion of the refrigerant release mitigation controls, the safety shut off valve(s) shall close.
- 2.1.11. Provide BACnet interface to the BAS system for monitoring and alarm purposes. At a minimum provide the following information to the BAS.
- .1 Room temperature and set point
 - .2 System Start / Stop
 - .3 Alarm conditions.
 - .4 Refrigerant leak detection system alarm
- 2.1.12. Unit shall bear a minimum Short Circuit Current Rating (SCCR) listed by a Nationally Recognized Testing Lab, acceptable to the local Authority Having Jurisdiction, and shall be **10,000 A** Lower SCCR listed units implying the use of current limiting fuses ahead of them in the field, in lieu of an actual appropriate SCCR rating, are not acceptable.

3. Execution

3.1. INSTALLATION

- 3.1.1. Install complete refrigeration and controls in accordance with the manufacturer's recommendations.
- 3.1.2. Provide access to all components of the refrigerant leak detection system and release mitigation control system for testing and replacement.
- 3.1.3. Provide interconnecting wiring between components of refrigerant release mitigation controls.
- 3.1.4. Roof mounted condensers shall be complete with feet and secured to 750 mm x 750 mm (30 in. x 30 in.) precast concrete paving slabs.

END OF SECTION

23 81 29.00 Variable Refrigerant Flow (VRF) Systems

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.1.2. Provide low Global Warming Potential (GWP) refrigerant complying with the performance requirements stated within Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings in accordance with Section 20 05 03.00 - SHOP DRAWINGS. Ensure Shop Drawings include unit Short Circuit Current Rating (SCCR).

1.2.2. Provide full system schematics complete with refrigerant pipe sizing, length of piping between components, wiring and control details.

- .1 Have Professional Engineer registered in the place of the Project stamp and sign the submittal.
- .2 Identify maximum refrigerant capacity including maximum trim charge.
- .3 Identify refrigerant pipe length take offs for each portion of the schematic and the maximum allowable length for the given portion.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. The units shall be listed by Electrical Laboratories (ETL) and bear the cETL label.

2.1.2. Provide units that are safety certified to CAN/CSA-C22.2 No. 60335-2-40 "Safety of household and similar electrical appliances - Part 2 - 40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers" for units utilizing A2L class refrigerants.

2.1.3. All wiring shall be in accordance with the Electric Code.

2.1.4. All units shall meet or exceed the 2010 Federal minimum efficiency requirements and the ASHRAE 90.1 efficiency requirements for VRF systems.

2.1.5. Efficiency shall be published in accordance with the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 1230.

2.1.6. Provide systems from:

- .1 Daikin
- .2 LG
- .3 Panasonic
- .4 Mitsubishi

- 2.1.7. The variable capacity air conditioning system shall consist of multiple indoor evaporator units, refrigerant joints and headers, a 2 or 3 pipe refrigeration distribution system using microprocessor control, and outdoor unit. The outdoor unit shall be a direct expansion (DX), air-cooled heat pump, multi-zone air-conditioning system with variable speed driven compressors using refrigerant.
- 2.1.8. The pipe system and components shall conform to Section 23 23 01.00 - REFRIGERANT PIPING.
- 2.1.9. The system shall be installed by the Manufacturer's Factory Trained Contractor. Provide proof of training and certification upon request.

2.2. INDOOR EVAPORATOR UNITS

- 2.2.1. Microprocessor control shall be used to control superheat to satisfy a room temperature set point. The unit shall be equipped with a programmed drying mechanism that dehumidifies while inhibiting changes in room temperature when used with matching remote control.
- 2.2.2. Indoor units shall be designed for refrigerant, completely factory assembled and tested. Internal unit components shall be factory wired and piped and complete with electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, self-diagnostics, auto-re-start function, 3-minutes fused time delay and test run switch.
- 2.2.3. All unit refrigerant pipes shall be charged with dehydrated air or nitrogen prior to shipment from the factory.
- 2.2.4. Coils shall be of the direct expansion (DX) type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
- 2.2.5. Ducted indoor units shall be designed for ceiling concealed installation and shall be supplied with a horizontal discharge air connection, return air plenum and inlet air connection. Cabinet shall be constructed with sound absorbing fibre free insulation.
- 2.2.6. Ductless indoor units shall be designed for exposed installation and shall be white. Discharge air direction shall be controllable.
- 2.2.7. Standard filter shall be mold resistant, washable.
- 2.2.8. The fan shall be a direct-drive fan, with a statically and dynamically balanced impeller, with high/low or variable speed fan operation.

2.3. OUTDOOR CONDENSING UNITS

- 2.3.1. The outdoor condensing unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit and the condensing unit shall consist of variable speed scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filter, shut-off valves, oil separators, service ports and refrigerant regulator.
- 2.3.2. The outdoor unit shall be completely weatherproof and corrosion resistant, constructed from rust-proofed mild steel panels coated with a baked enamel finish.
- 2.3.3. The system shall automatically restart after a power failure, which shall not cause the programming or any settings to be lost.
- 2.3.4. The following safety devices shall be included on the condensing unit;
 - .1 high pressure switch,
 - .2 control circuit fuses,
 - .3 crankcase heaters,

- .4 fusible plug,
 - .5 high pressure switch,
 - .6 overload relay,
 - .7 inverter overload protector,
 - .8 thermal protectors for compressor and fan motors,
 - .9 over current protection for the inverter and
 - .10 anti-recycling timers.
- 2.3.5. To ensure the liquid refrigerant does not flash when supplying to the various fan coil units, the circuit shall be provided with a sub-cooling feature.
- 2.3.6. The condensing unit fan shall have multiple or variable speed operation.
- 2.3.7. The fan motor shall have permanently lubricated bearings.
- 2.3.8. The fan motor shall be provided with a fan guard to prevent contact with moving parts.
- 2.3.9. The condensing unit coil shall be manufactured from seamless rifled bore copper tubes mechanically expanded into waffle louver aluminum fins to form a mechanical bond.
- 2.3.10. The fins shall be corrosion resistant.
- 2.3.11. The inverter scroll compressors shall be variable speed controlled capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit.
- 2.3.12. The inverter driven compressor in each condensing unit shall be of highly efficient reluctance DC (digitally commutating), hermetically sealed scroll type. Compressor shall be internally isolated.
- 2.3.13. Compressor capacity shall modulate automatically to maintain a constant suction pressure while varying the refrigerant volume for the needs of the cooling or heating loads.
- 2.3.14. Compressors shall have a low torque start.
- 2.3.15. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector. Oil separators shall be standard with the equipment together with an intelligent oil management system. Oil recovery cycle shall be automatic.
- 2.4. REFRIGERANT LEAK DETECTION SYSTEM
- 2.4.1. The system must provide all the functionalities necessary to comply with current ASHRAE 15 "Safety Standard for Refrigeration Systems" guidelines and CSA B52 "Mechanical Refrigeration Code" requirements consisting of the following:
- .1 Safety shut off valve(s) certified in accordance with CSA C22.2 No. 60335-2-40 or No. 60335-2-89 "Household and similar electrical appliances - Safety - Part 2-89: Particular requirements for commercial refrigerating appliances and ice-makers with an incorporated or remote refrigerant unit or motor-compressor."
 - .2 Non-adjustable, refrigerant leak detector(s) located within each indoor evaporator unit.
 - .3 Self-diagnostic capabilities.
- 2.4.2. Upon detection of leaked refrigerant or failure of any safety shut off valve or leak detector, the system shall de-energize electric resistance heat within the system, activate the release mitigation controls, energize air circulating fans, and isolate all possible paths of refrigerant.
- 2.4.3. Upon loss of power to any portion of the refrigerant release mitigation controls the safety shut off valve(s) shall close.

2.5. CONTROLS

- 2.5.1. Indoor evaporator units shall be supplied with individual zone controllers.
- 2.5.2. Units shall bear a minimum Short Circuit Current Rating (SCCR) listed by a Nationally Recognized Testing Lab, acceptable to the local Authority Having Jurisdiction, and shall be **10,000 A** Lower SCCR listed units implying the use of current limiting fuses ahead of them in the field, in lieu of an actual appropriate SCCR rating, are not acceptable.
- 2.5.3. Each controller shall have:
 - .1 A maximum wiring length of 50 meters (164 ft).
 - .2 A self-diagnosis function that continuously monitors the system for malfunctions.
 - .3 Immediate display of fault location and condition.
 - .4 A thermostat sensor
 - .5 Ability to monitor room temperature and preset temperature by microcomputer and select cool/heat operation mode automatically (Heat Recovery Units only).
 - .6 A 48 hour clock / calendar backup.
 - .7 A built-in schedule timer.
- 2.5.4. Provide BACnet interface to the BAS system for monitoring and alarm purposes. At a minimum provide the following information to the BAS.
 - .1 Room temperature and set point
 - .2 Compressor status
 - .3 System Start / Stop
 - .4 Remote reset
 - .5 Alarm conditions.
 - .6 Refrigerant leak detection system alarm

3. Execution

3.1. INSTALLATION

- 3.1.1. Refrigeration pipe system shall be in accordance with Section 23 23 01.00 - REFRIGERANT PIPING.
- 3.1.2. Install complete refrigeration system, controls, and control wiring in accordance with the manufacturer's recommendations. Zone controllers shall be wired by installing Contractor.
- 3.1.3. Provide access to all components of the refrigerant leak detection system and release mitigation control system for testing and replacement.
- 3.1.4. Provide interconnecting wiring between components of refrigerant release mitigation controls.
- 3.1.5. Outdoor condensing units shall be secured on a stand or concrete pavers as per manufacturer's requirements. Install units on a flat surface level within 3 mm (1/8 in). Condensing units shall be installed above the snow line. Provide manufacturer supplied condensing unit frames as required.
- 3.1.6. Provide certified wiring schematics to the Electrical Division for associated equipment and controls.
- 3.1.7. Insulate all refrigeration pipe in accordance with Section 20 07 00.00 - INSULATION.
- 3.1.8. Provide an authorized technician to commission the installation and provide training for the operators.

3.2. COMMISSIONING

- 3.2.1. Supplier to provide commissioning (Cx) and warranty the system including validation of pipe length, size, and trim charge. Provide copy of Cx report and confirmation of final trim charge within acceptable design range for maximum refrigerant concentrations.
- 3.2.2. Provide supplier's Cx report within the O&M manual. Ensure that VRF trim charge is included in report.

END OF SECTION

23 82 16.00 Coils

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.1.2. Provide low Global Warming Potential (GWP) refrigerant complying with the performance requirements stated within Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. WARRANTY

1.2.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Coils: Daikin, Heatcraft, Engineered Air, Aerofin, JCI York or Greenheck, LJ Wing.

2.1.2. All coils shall have certified AHRI capacities.

2.1.3. All coils shall be of copper tube, aluminum fin construction with minimum 1.26 mm thick (0.048 in - 18 GSG gauge) galvanized sheet steel casing and galvanized steel angles for heating coils and 1.56 mm thick (0.0625 in - 16 USG gauge) Type 304L stainless steel casing and stainless steel angles for cooling coils. Header shall be copper tube or cast iron.

- .1 Coils for mounting in ductwork shall have holes in frame for bolting to flanged ductwork.
- .2 Cooling coils shall have fins spaced not closer than 3.175 mm OC (8 to the in.).
- .3 Water coils shall have serpentine circuiting arranged for counter flow between the air and water.
- .4 Coils shall be suitable for 860 kPa (125 psig) water pressure for low pressure systems and suitable for 1720 kPa (250 psi) water pressure for high pressure systems.
- .5 Coils shall be complete with plugged drain and vent connection, readily accessible.
- .6 Face velocity shall not exceed 3.81 m/s (750 fpm) for heating coils and 2.54 m/s (500 fpm) for cooling coils.
- .7 Provide dielectric couplings to ensure galvanic action does not occur between dissimilar metals.

2.1.4. Refrigerant coils shall provide cooling by the direct expansion of refrigerant inside the tubes. The refrigerant shall be distributed to the various coil circuits through a venturi type distributor having a low pressure drop and arranged for down-feed having male sweat connection. A maximum of 12 refrigerant circuits shall be supplied from a single distributor.

- .1 Provide two distributors when more than 12 circuits are required. The refrigerant shall be distributed from the multi-outlet distributor to the coil circuits through round seamless copper tubes, 8 mm OD or 6 mm OD (5/16 in. OD or 1/4 in. OD).

- .2 Refrigerant coils shall be tested at 2070 kPa (300 psi) air pressure under water, cleaned, dehydrated and sealed with a dry nitrogen charge. Coil shall be suitable for working pressures up to 125 kPa (250 psi).
- .3 Where indicated on Drawings, refrigeration coils shall be horizontally split to match the refrigerant system.
- 2.1.5. Provide cooling coils in accordance with the Cooling Coil Schedule. All air pressure drops shall be based on wet coils.
- 2.1.6. Provide heating coils in accordance with the Heating Coil Schedule.
- 2.1.7. Provide all coils with a maximum dry-coil pressure drop of 187 Pa (0.75 in. wg.) at 2.54 m/s (500 fpm).
- 2.1.8. Drain pans below each cooling coil shall be fabricated from minimum 0.9525 mm thick (0.0375 in - 20 USS gauge) Type 304L stainless steel sheet and formed stainless steel angles, and shall extend full length of coil, double sloped at a minimum of 2% to prevent standing water with pan projecting beyond the coil. Projections shall be 75 mm (3 in.) on the air inlet side and 300 mm (12 in.) on the air leaving side of the coil. Drain pans shall be welded construction with 50 mm (2 in.) diameter stainless steel nipple for drain connection.
- 2.1.9. Cooling coil support racks shall be Type 304L stainless steel.
- 2.1.10. Coils for installation with vertical airflow shall be suitable for this orientation. Cooling coils in the vertical airflow orientation to be A-frame and/or suitably angled to prevent condensate bypassing the drain pan.
- 3. Execution
- 3.1. INSTALLATION
- 3.1.1. Coils shall be pitched and installed as required in the manufacturer's installation instructions. The lowest cooling coil shall be at least 150 mm (6 in.) above the floor of the unit so that it does not sit in water.
- 3.1.2. Install blank-off panels between coils and plenums to ensure no air by-pass occurs.
- 3.1.3. Install stainless steel drain pan below each cooling coil.

END OF SECTION

23 82 33.00 Convactor Radiators

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Shop Drawings: Submit Shop Drawings of convactor radiators, including unit capacities, sizes, piping, connections, and construction details. Shop Drawing shall clearly show the amount of expansion on each section, and method of control.

1.2.2. Mock-up: Install in one 900 mm (3 ft, 0 in.) length of convactor radiator unit with enclosures, piping, valves, and other incidentals completely piped up for Engineer's Representative's review.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Radiators shown as Type 'A' shall be RENTAL model , Sterling model , or Rattling model .

2.1.2. Radiators shall have capacity shown when supplied with water entering at 71.1 deg. C. (160 deg. F.) leaving at 60 deg. C. (140 deg. F.) and with air entering at 21.1 deg. C. (70 deg. F.).

2.1.3. Provide steel double panel radiators of the lengths and in locations as indicated, and of capacities and lengths as shown on the Drawings.

2.1.4. The double heating panel radiation shall be of one-piece all-welded steel construction, consisting of a pair of flattened water tube panels welded to headers at each end. Welded to the inside of each panel shall be steel corrugated fins to increase the convective output of the radiator. The fins shall start at no less than 75 mm (3 in.) from the end of the radiator, and shall have no less than 32 fins per foot. The radiators shall include an integral heavy gauge (2.28 mm = 0.09 in. minimum) all-welded perforated top grille, which will cover the top of all of the finned areas.

2.1.5. The headers shall include all necessary inlet, outlet and vent connections as required. Standard connection sizes are 12 mm (½ in.) NPT tapered thread for supply and return piping, and 3.175 mm (1/8 in.) for the vent connection. Internal baffling is provided where required for proper water flow.

2.1.6. The panel radiation shall be capable of being mounted to typical stud wall construction without additional blocking or strapping. Appropriate wall mounting brackets shall be provided with the radiation.

2.1.7. Provide pressure ratings for the radiation as follows: MEDIUM working pressure of maximum 586 kPa (85 psig) and maximum test pressure of 758 kPa (110 psig).

- 2.1.8. Panel radiation expansion shall not exceed 1/64 inch per foot of radiation at 215 deg. F. The installer shall provide adequate expansion compensation for each radiator.
- 2.1.9. Panel radiation shall be cleaned and phosphatized in preparation for the powder coat finish. The radiation is then finish painted with a gloss powder coat finish, for a total paint thickness of 2-3 mils (0.002 in. - 0.003 in.). The color shall be "Runtal White".
- 2.1.10. Ribbed pipe cover trims, finished to match the radiators shall be provided with the radiation.
- 2.1.11. Runtal-Flex connectors shall be used where appropriate to provide expansion compensation for the radiators.
- 2.1.12. Type B convactor radiators shall be Dunham-Bush, Engineered Air, Sigma, Rittling, or Sterling.
- 2.1.13. Convactor radiators shall be complete with:
 - .1 Convactor elements consisting of copper tubes, aluminum fins and steel or cast iron headers, suitable for 1035 kPa (150 psi) working pressure.
 - .2 Steel supports for element.
 - .3 Plenum case shown painted matt black complete with supply air grille steel covering convactor element, valves and fittings and complete with access doors or openings to valves.
 - .4 Keeney type manually operated air vents with 6 mm (1/4 in.) O.D. copper tubing connected to air chamber, accessible without removing enclosure and mounted on end panel or on front panel of recessed convactor radiator.
- 2.1.14. Convactor radiators shall be sizes shown on Drawings.
- 2.1.15. Convactor radiators shall be code rated for the capacity shown when supplied with water entering at 82.2 deg. C. (180 deg. F.) leaving at 71.1 deg. C. (160 deg. F.) and with air entering at 18.3 deg. C. (65 deg. F.).

3. Execution

3.1. NOT USED

END OF SECTION

23 82 39.00 Unit Heaters

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings in accordance with Section 20 05 03.00 - SHOP DRAWINGS.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Unit Heaters shall be Dunham-Bush, Engineered Air, Trane, Sigma, Rittling, or Sterling for horizontal or downward air discharge as shown.

2.1.2. Provide each unit heater complete with:

- .1 Direct driven propeller fan and motor.
- .2 Heating coil with copper tubes and aluminum fins
- .3 Adjustable air outlet diffuser or adjustable louver cone diffuser.
- .4 Enamel finish prime coated.
- .5 Manual starter on unit

2.1.3. Programmable wall thermostat with range 4.4 deg. C. to 26.7 deg. C. (40 deg. F. to 80 deg. F.). Thermostat shall cycle fan and valve in sequence .

2.1.4. Space temperature sensor and controls are specified under Section 23 09 00.00 BUILDING AUTOMATION SYSTEM (BAS) OPEN SYSTEM.

2.1.5. Unit heaters shall have capacities as shown in the Unit Heater Schedule.

3. Execution

3.1. INSTALLATION

3.1.1. Install in accordance with manufacturer's current installation guidelines.

END OF SECTION

23 82 39.13 Cabinet Heaters

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. WARRANTY

1.2.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Cabinet Heaters shall be Dunham-Bush, Engineered Air, Trane, Sigma, Rittling, or Sterling.

2.1.2. Cabinets shall be of type shown and shall be not less than 1.5189 mm thick (0.0598 in. - 16 MSG) steel, prime coated. Provide access to the control specified below with an access panel beside discharge grille.

2.1.3. Unit shall not vibrate or rattle at any speed.

2.1.4. For floor and wall mounted units, temperature controllers shall be Honeywell, Powers, Johnson, Penn or White Rodgers with bulb firmly clamped in bulb holder in return air stream. For ceiling mounted units provide a wall thermostat with range, 5 to 25 deg. C. (41 to 77 deg. F.). Temperature controller shall cycle fan.

2.1.5. Temperature sensor and controls are specified under Section 23 09 00.00 - BUILDING AUTOMATION SYSTEM.

2.1.6. Permanent type filters of cleanable aluminum shall be concealed from sight.

2.1.7. Cabinet heaters shall have capacities as shown (on Drawings) in the Cabinet Heater Schedule when supplied with water entering at 82.2 deg. C. (180 deg. F.) and leaving at 65.6 deg. C. (150 deg. F.) and with air entering at 15.6 deg. C. (60 deg. F.).

2.1.8. Provide electronically commutated motor (ECM) type motors.

3. Execution

3.1. INSTALLATION

3.1.1. Install a two-speed fan switch and manual starter inside of wall and floor units. For ceiling mounted units install switch on wall adjacent to unit and install starter on unit. Provide all interconnecting wiring.

3.1.2. Install in accordance with manufacturer's current installation guidelines.

3.1.3. Install remote bulb temperature controller inside of wall and floor units. For ceiling mounted units install temperature controller on wall adjacent to unit. Provide all interconnecting wiring.

END OF SECTION

23 82 39.14 Electric Cabinet Heaters

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings of all items supplied in accordance with requirements of Section 20 05 03.00 - SHOP DRAWINGS.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Provide Electric Cabinet Heaters:

- .1 Steel, prime coated casing with minimum thickness of 1.27 mm (0.05 in. – 18 GA).
- .2 Tubular finned heating element.
- .3 Provide access to the control specified below with an access panel beside discharge grille.
- .4 Internal vibration isolation and construction quality to prevent vibration or rattling at any speed
- .5 High-limit temperature control with automatic reset.
- .6 Fan delay to purge residual heat.
- .7 Acceptable manufacturers are Ouellet, Reznor, or Indeeco.

2.1.2. For floor and wall mounted units, provide temperature controllers with bulb firmly clamped in bulb holder in return air stream. For ceiling mounted units, provide a wall thermostat with range, 5 to 25 deg. C. (41 to 77 deg. F.). Program temperature controller to cycle fan and heating element. Acceptable manufacturers are Honeywell, Powers, Johnson, Penn or White Rodgers.

2.1.3. Conceal all permanent type filters of cleanable aluminum from sight.

2.1.4. Provide Electric Cabinet heaters with sizes, capacities and other design parameters shown on Drawings or in schedules. Provide model suitable for installation type (exposed, recessed) noted.

2.1.5. Provide Electric Cabinet heaters with a single point 208/1/60 electrical connection that powers all components including but not limited to

- .1 Fan motor
- .2 Control panel
- .3 Safeties

2.1.6. Provide electronically commutated motor (ECM) type motors.

3. Execution

3.1. INSTALLATION

3.1.1. Install a two-speed fan switch and manual starter inside of wall and floor units. For ceiling mounted units install switch on wall adjacent to unit and install starter on unit. Provide all interconnecting wiring.

3.1.2. Install in accordance with manufacturer's current installation guidelines.

3.1.3. Install remote bulb temperature controller inside of wall and floor units. For ceiling mounted units install temperature controller on wall adjacent to unit. Provide all interconnecting wiring.

END OF SECTION

23 82 39.19 Electric Wall / Ceiling Heaters

1. General

1.1. WORK INCLUDED

1.1.1. Conform to Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

1.1.2. Conform to Section 26 05 01.00 - GENERAL INSTRUCTIONS FOR ELECTRICAL SECTIONS.

1.2. SUBMITTALS

1.2.1. Submit Shop Drawings of all items supplied in accordance with requirements of Section 20 05 03.00 - SHOP DRAWINGS.

1.3. WARRANTY

1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.

2. Products

2.1. MATERIALS

2.1.1. Commercial Electric Wall Heater

.1 Acceptable Products:

.1 Indeeco WCI Series

.2 Ouellet OAC Series

.3 Reznor EHC Series

.4 Stelpro WF

.2 Construction:

.1 18 gauge steel grille

.2 Polyester powder coat finish. Coordinate colour with Architect and Owner.

.3 Recessed mount / surface mount.

.4 Element: tubular steel finned elements.

.5 Fan Motor: permanently lubricated totally enclosed motor. Each fan capable of 160 cfm at 55 dB(A).

.6 Remote control package with 24 V relay and transformer. Capable of being controlled and monitored by the BAS system.

.7 Fan on / off switch

.8 Disconnect switch

.3 Performance:

.1 As shown in the equipment schedules.

2.1.2. Architectural Electrical Wall Heater

.1 Acceptable Products:

- .1 Indeeco WAI Series
 - .2 Ouellet OAWH Series
 - .3 Reznor EHA
 - .4 Stelpro WFA
 - .2 Construction:
 - .1 Extruded aluminum grille
 - .2 Polyester powder coat finish. Coordinate colour with Architect and Owner.
 - .3 Recessed mount / surface mount.
 - .4 Element: tubular steel finned elements.
 - .5 Fan Motor: permanently lubricated totally enclosed motor. Each fan capable of 160 cfm at 55 dB(A).
 - .6 Remote control package with 24 V relay and transformer. Capable of being controlled and monitored by the BAS system.
 - .7 Fan on / off switch
 - .8 Disconnect switch
 - .3 Performance:
 - .1 As shown in the equipment schedules.
- 2.1.3. European Style Electrical Wall Heater
- .1 Acceptable Products:
 - .1 Indeeco EWI Series
 - .2 Ouellet OVE Series
 - .2 Construction:
 - .1 20 gauge steel grille
 - .2 Polyester powder coat finish. Coordinate colour with Architect and Owner.
 - .3 Surface mount.
 - .4 Element: stitched ribbon-type elements.
 - .5 Fan Motor: permanently lubricated totally enclosed motor. Each fan capable of 70 cfm at 42.5 dB(A).
 - .6 Remote control package with 24 V relay and transformer. Capable of being controlled and monitored by the BAS system.
 - .7 Fan on / off switch
 - .8 Disconnect switch
 - .3 Performance:
 - .1 As shown in the equipment schedules.
- 2.1.4. Small Electrical Wall Heater
- .1 Acceptable Products:
 - .1 Indeeco WLI Series
 - .2 Ouellet OVS Series
 - .3 Reznor EHL
 - .2 Construction:
 - .1 22 gauge steel grille

- .2 Polyester powder coat finish. Coordinate colour with Architect and Owner.
 - .3 Recessed mount / surface mount.
 - .4 Element: tubular steel finned elements.
 - .5 Fan Motor: permanently lubricated totally enclosed motor. Each fan capable of 40 cfm at 38 dB(A). (80 cfm at 41.3 dB(A))
 - .6 Remote control package. Capable of being controlled and monitored by the BAS system.
 - .7 Disconnect switch
 - .3 Performance:
 - .1 As shown in the equipment schedules.
- 2.1.5. Register Style Electric Wall Heater
- .1 Acceptable Products:
 - .1 Indeeco WRI Series
 - .2 Ouellet OVR Series
 - .2 Construction:
 - .1 20 gauge steel grille
 - .2 Polyester powder coat finish. Coordinate colour with Architect and Owner.
 - .3 Recessed mount / surface mount.
 - .4 Element: tubular steel finned elements.
 - .5 Fan Motor: permanently lubricated totally enclosed motor. Each fan capable of 40 cfm at 38 dB(A). (80 cfm at 41.3 dB(A))
 - .6 Remote control package. Capable of being controlled and monitored by the BAS system.
 - .7 Disconnect switch
 - .3 Performance:
 - .1 As shown in the equipment schedules.
3. Execution
- 3.1. INSTALLATION
- 3.1.1. Follow manufacturer's published installation instructions.
 - 3.1.2. Locate where shown on the Drawings.
 - 3.1.3. Recessed mount or surface mount as indicated.
 - 3.1.4. Install thermostat on wall away from direct flow of heated air.
 - 3.1.5. Connect to BAS as appropriate.
 - 3.1.6. Commercial Electric Wall Heaters
 - .1 Bottom of unit at least 250 mm (10 in) above finished floor and away from adjacent walls.
 - 3.1.7. Architectural Electric Wall Heaters
 - .1 Bottom of unit at least 250 mm (10 in) above finished floor and away from adjacent walls.

- 3.1.8. European Electric Wall Heaters
 - .1 Bottom of unit at least 300 mm (12 in) above finished floor.
- 3.1.9. Small Electric Wall Heaters
 - .1 Bottom of unit at least 250 mm (10 in) above finished floor.
- 3.1.10. Register Style Electric Wall Heaters
 - .1 Bottom of unit at least 250 mm (10 in) above finished floor.

END OF SECTION

23 82 39.20 Electric Unit Heaters

1. General
 - 1.1. WORK INCLUDED
 - 1.1.1. Conform to Section 20 05 00.00 – GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
 - 1.2. SUBMITTALS
 - 1.2.1. Submit Shop Drawings of all items supplied in accordance with requirements of Section 20 05 03.00 - SHOP DRAWINGS.
 - 1.3. WARRANTY
 - 1.3.1. Provide a warranty in accordance with the requirements of Section 20 05 00.00 - GENERAL INSTRUCTIONS FOR MECHANICAL SECTIONS.
2. Products
 - 2.1. MATERIALS
 - 2.1.1. Provide Electric Unit Heaters:
 - .1 Totally enclosed and thermally protected direct drive propeller fan and motor.
 - .2 Steel tubular heating element.
 - .3 High-limit temperature control with automatic reset.
 - .4 Fan delay to purge residual heat.
 - .5 Adjustable air outlet diffuser or adjustable louver cone diffuser.
 - .6 Enamel finish prime coated steel casing with minimum thickness of 1.27 mm (0.05 in. – 18 GA).
 - .7 Acceptable manufacturers include Ouellet, Reznor, Dimplex, Stelpro, Chromalox or Indeco.
 - 2.1.2. Provide wall thermostat with range 4.4 deg. C. to 26.7 deg. C. (40 deg. F. to 80 deg. F.). Program thermostat to cycle fan and electric coil. Acceptable manufacturers include Honeywell, Power, Johnson, Penn or White Rodgers.
 - 2.1.3. Provide Electric Unit heaters with capacities and other design parameters as shown in schedules.
 - 2.1.4. Provide electric unit heaters with a single point 208 1/60 electrical connection that powers all components including but not limited to
 - .1 Fan motor
 - .2 Control panel
 - .3 Safeties

3. Execution

3.1. INSTALLATION

3.1.1. Suspend unit heaters from ceiling or mount on wall as indicated.

3.1.2. Install in accordance with manufacturer's current installation guidelines.

END OF SECTION