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MECHANICAL SPECIFICATIONS

**FOR
WEST SCARBOROUGH NEIGHBOURHOOD
COMMUNITY CENTRE (WSNCC)
313 PHARMACY AVENUE, TORONTO, ON
MECHANICAL & LIGHTING SYSTEM UPGRADE**

**TO
CITY OF TORONTO
CORPORATE REAL ESTATE MANAGEMENT**

DATED

AUGUST 7, 2025

ISSUED FOR TENDER

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MCW Project No. 22241M

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PART 2 - PRODUCTS

- 2.01 NIL

PART 3 - EXECUTION

- 3.01 NIL

PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Submit Shop Drawings, Product Data and Samples as specified herein.
- .2 Designate in the Construction Schedule, or in a separate coordination schedule, dates for submission and dates that reviewed Shop Drawings, Product Data and Sample will be required. Give due consideration for review time required by the Consultant, with a minimum of fifteen (15) working days required. The submission of Appendix 'B' will be considered an acceptable submittal schedule.
- .3 All shop drawings will be submitted directly to our office, at TOR.ShopDrawings@mcw.com; with a copy of the transmittal sent to the Architect. All shop drawings will be returned through the Architect's office. In order to expedite the process, MCW requests that all shop drawings be submitted electronically in pdf format. Upon MCW's review stamped shop drawings will be returned electronically in pdf format.
- .4 Prepare a schedule of shop drawings, not later than four weeks after the award of the Contract, indicating drawing submission and equipment delivery dates. Refer to specification and to the attached Shop Drawing Submittal Schedule for equipment requiring shop drawing submission.
- .5 All data and dimensions on shop drawings, product data and sample information to be based on units (Imperial or Metric) as shown on the contract documents.
- .6 Shop Drawings with errors or omissions and deviations will be returned "Not Reviewed".
- .7 The Contractor's responsibility for deviations in submission from the requirements of Contract Documents is not relieved by the Consultant's review of submittals, unless a deviation on the submittal is noted as such in writing and has been accepted by the Consultant.
- .8 Keep one (1) reviewed copy of each submission on site.
- .9 Make all submittals in accordance with Division 01, to suit submittal procedures.
- .10 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) material Safety Data sheets (MSDS) in accordance with Division 01.

1.02 SHOP DRAWINGS

- .1 Review and stamp Shop Drawings, Product Data and Samples prior to submission to the Consultant. Confirm that necessary requirements have been determined and verified and that each submittal has been checked and co-ordinated with requirements of the Work and the Contract Documents. Submittals not stamped, signed, dated and identified as to the specific project, will be returned without being examined and shall be re-submitted when completed.
- .2 Shop Drawings being submitted where the size, capacity or voltage are different from the specified piece of equipment, the specified data and alternate data must be highlighted (e.g. spec. pump P-4 20 HP, 1500 GPM, 575V, the alternate is 15 HP, 1470 GPM, 575V, 3PH) on the front cover sheet.
- .3 Submit drawings in a clear and thorough manner:
 - .1 Identify details by reference to drawing No. and detail, schedule or room numbers as shown on Contract Documents.
 - .2 Include manufacturer installation instructions and details.
 - .3 Minimum sheet size and larger sheets to be multiples of 8½" x 11".
 - .4 Indicate materials, methods of construction and attachment or anchorage, erection diagrams, connections, explanatory notes and other information necessary for completion of Work. Where articles or equipment attach or connect to other articles or equipment, indicate that such items have been co-ordinated. Indicate cross references to design drawings and specification.

- .5 Adjustments to shop drawings by the Consultant do not change the cost of the work. If adjustments affect the cost of Work, advise through normal channels in writing prior to proceeding with the Work.
- .6 Make changes in shop drawings as directed by the Consultant. Resubmit and note any revisions other than those requested.
- .7 If only minor adjustments are made, shop drawings to be returned and fabrication and installation of work to proceed.
- .4 Determine and verify:
 - .1 Field measurements.
 - .2 Field construction criteria.
 - .3 Catalogue numbers and similar data.
 - .4 Conformance with Specifications.
- .5 Co-ordinate each submittal with requirements of the Contract documents.
- .6 Each Shop Drawing will be stamped by the Consultant in the following format:
 - ☐ NOT REVIEWED ☐ REVIEWED
 - ☐ RESUBMIT ☐ REVIEWED AS MODIFIED
 - ☐ NOT SPECIFIED BY MCW, REVIEWED FOR MEP ONLY
- .7 This review by the Consultant is for the sole purpose of ascertaining conformance with the general design concept. This review shall not mean that the Consultant approved the detail design inherent in the shop drawings, responsibility for which shall remain with this Subcontractor submitting same, and such review shall not relieve this Subcontractor of his responsibility for errors or omissions in the shop drawings or of his responsibility for meeting all requirements of the contract documents. The Contractor is responsible for dimensions to be confirmed and correlated at the job site, for information that pertains solely to fabrication.
- .8 Products not specified by MCW are reviewed to confirm compliance with services provided only. Any changes required between provided services and shop drawing requirements will be identified for coordination between trades.
- .9 Shop drawings shall be accompanied by a complete copy of the attached "Shop Drawing Submittal Sheet" Section 20 05 01, Appendix 'A'.
- .10 "Resubmit" Shop Drawings or Shop Drawings requiring additional information will have to be forwarded or returned to our office, at TOR.ShopDrawings@mcw.com in a timely fashion to allow time for review again, along with revised scheduling or delivery date changes as a result of having to provide additional information or resubmission.
- .11 Shop drawings must bear the stamp and signature of the submitting sub-contractor as well as the general contractor to indicate that the shop drawings or catalogue cuts are in conformance with all requirements of the drawings, that they have co-ordinated this equipment with other equipment which is related and/or connected and that they have verified all dimensions to ensure the proper installation of equipment including recommended service space and without interference with the work of other trades. Ensure that mechanical and electrical co-ordination is complete before submitting drawings for review. Incomplete or improperly submitted shop drawings will be returned as "Resubmit".
- .12 Begin no fabrication or work which requires submittals until return of submittals reviewed by Consultant.
- .13 Quality assurance Submittals:
 - .1 Make all submittals in accordance with Section 20 05 05.

- .2 Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .14 Submit manufacturer installation instructions.
- .15 All submittals **MUST** be submitted using the same units (IP/SI) as shown on equipment schedules and drawings.
- 1.03 **PRODUCT DATA**
 - .1 Where specified, Manufacturer's standard schematic drawings, catalogue sheets, diagrams, schedules, performance charts, illustrations and other standard descriptive data is acceptable provided there is conformance with the following:
 - .1 Clearly identify pertinent products or models.
 - .2 Show performance characteristics and capacities.
 - .3 Show dimensions and clearances required.
 - .4 Show wiring or piping diagrams and controls.
 - .2 Manufacturer's standard schematic drawings and diagrams may require modifications to drawings and diagrams to provide information applicable to the Work.
 - .3 Provide information specifically applicable to the Work.
- 1.04 **SAMPLES**
 - .1 Samples are to be provided in accordance with Division 01.
 - .2 Samples to be labelled, of sufficient size and quantity to clearly illustrate:
 - .1 Functional characteristics integrally related parts and attachment devices.
 - .2 Full range of colour, texture and pattern.
 - .3 Field Samples and mock-ups:
 - .1 Erect, at the project site and in location acceptable to the Consultant.
 - .2 Fabricate each sample and mock-up complete and finished.
 - .3 Remove mock-ups at conclusion of Work or as specified by the Consultant.
- 1.05 **CLOSE-OUT SUBMITTALS**
 - .1 Make all submittals in accordance with Section 20 05 05.
- 1.06 **CO-ORDINATION/INSTALLATION DRAWINGS**
 - .1 Follow the requirements of section 20 05 05.
- 1.07 **SUBMISSION REQUIREMENTS**
 - .1 Submit promptly to approved schedule and in sequence to prevent submission delay in the Work.
 - .2 Submission requirements:
 - .1 Shop Drawings: Acceptable submissions are: Submit shop drawings electronically as agreed to during the kick off meeting with the Consultant.
 - .2 Product Data: Submit a copy for each O & M Manual.
 - .3 Samples: Submit as specified, or as requested during the shop drawing review period.
- 1.08 **RESUBMISSION REQUIREMENTS**
 - .1 Make corrections or changes to the submittals noted by the Consultant and resubmit.
 - .2 Shop Drawings and Product Data:

- .1 Revise drawings or data, and resubmit as noted on the initial submittal.
- .2 Indicate any changes which have been made other than those noted by the Consultant.
- .3 Samples: Submit new samples as required for initial submittal as soon as possible after notification of the rejection of the original submission and mark "resubmitted samples".

1.09 DISTRIBUTION

- .1 Distribute reproductions of Shop Drawings and copies of Product Data which carry the Consultant's stamp to all parties as specified by Division 01 General Requirements.
 - .1 Job site file
 - .2 Project record document file
 - .3 Other affected contractors
 - .4 Subcontractors
 - .5 Supplier or fabricator (as applicable)
 - .6 Operations Manual

PART 2 - PRODUCTS

2.01 NIL

PART 3 - EXECUTION

3.01 NIL

END OF SECTION 20 05 01

SHOP DRAWING SUBMITTAL SHEET

Project:	West Scarborough Neighbourhood Community Centre 313 Pharmacy Avenue, Toronto, On Mechanical And Lighting System Upgrade	Date:	
Project No.	22241M	Submittal No.	
Section:			
Equipment Description			
Contractor:			
Sub-Contractor:			
Suppliers Name:			
Manufacturer:			
Catalogue No.:			
Variations From Tender Documents			

Engineer: MCW Consultants Ltd.
207 Queen's Quay West, Suite 615
Toronto, Ontario
M5J 1A7

MECHANICAL GENERAL REQUIREMENTS SECTION 20 05 01 – APPENDIX ‘B’ PROJECT: West Scarborough Neighbourhood Community Centre 313 Pharmacy Avenue, Toronto, On Mechanical And Lighting System Upgrade PROJECT No: 22241M		SHOP DRAWING SUBMITTAL SCHEDULE DIVISION 20, 21 22, 23 & 25						Date: July 23, 2025	
SECTION	DESCRIPTION (List Equipment Example only Edit to Suit)	MANUFACTURER	SHOP DRAWING				DELIVERY		COMMENTS
			SUBMITTED		RETURNED				
			SCHED	ACTUAL	SCHED	ACTUAL	SCHED	ACTUAL	
20 05 10	Valves Expansion Tanks Expansion Compensators Strainers Thermometers and Gauges Fire Stopping Products Air separators Specialties Access doors								
20 05 20	Bases, Isolators, Silencers								
20 05 25	Insulation								
20 05 30	Variable Frequency Drives								
20 05 35	Motor Starters								
20 05 70	Water Treatment Equipment								
23 21 23	Pumps								
23 31 13	Ductwork								
23 33 10	Dampers								

MECHANICAL GENERAL REQUIREMENTS SECTION 20 05 01 – APPENDIX 'B' PROJECT: West Scarborough Neighbourhood Community Centre 313 Pharmacy Avenue, Toronto, On Mechanical And Lighting System Upgrade PROJECT No: 22241M		SHOP DRAWING SUBMITTAL SCHEDULE DIVISION 20, 21 22, 23 & 25						Date: July 23, 2025	
SECTION	DESCRIPTION (List Equipment Example only Edit to Suit)	MANUFACTURER	SHOP DRAWING				DELIVERY		COMMENTS
			SUBMITTED		RETURNED		SCHED	ACTUAL	
			SCHED	ACTUAL	SCHED	ACTUAL			
23 37 13	Grilles and Diffusers								
23 37 20	Louvres, Intakes & Vents								
23 51 00	Breeching Gas Vents and Stacks								
23 52 00	Heating Boilers								
23 57 00	Heat Exchangers								
23 64 30	Air Cooled Chillers								
23 74 00	Packaged Outdoor HVAC equipment								
23 74 20	ERVs								
23 81 40	Water Source Unitary Heat Pumps								
25 01 01	BAS equipment and components								

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- 1.11 EMBEDDED MECHANICAL SYSTEM'S DRAWINGS
- 1.12 SLEEVING DRAWINGS
- 1.13 SHOP DRAWINGS
- 1.14 ACCEPTABLE MANUFACTURERS AND ALTERNATES
- 1.15 RECORD DRAWINGS
- 1.16 PRODUCT STANDARDS AND ALTERNATIVES
- 1.17 TEMPORARY SERVICE
- 1.18 PATENTS
- 1.19 RIGHTS RESERVED
- 1.20 EXPEDITING AND DELIVERIES
- 1.21 WORK IN EXISTING BUILDING AREAS
- 1.22 SUPERINTENDENCE
- 1.23 TRIAL USAGE, TESTS AND COMMISSIONING
- 1.24 COMPLETION
- 1.25 WARRANTIES
- 1.26 INSTRUCTIONS TO OWNER'S STAFF
- 1.27 OPERATING AND MAINTENANCE MANUALS AND CLOSE-OUT DOCUMENTS
- 1.28 MECHANICAL LIST OF MANUFACTURERS, SUBTRADES & PRICES
- 1.29 CASH ALLOWANCES
- 1.30 VALUATION OF CHANGES
- 1.31 UTILITY SERVICES
- 1.32 DELIVERY, STORAGE AND HANDLING
- 1.33 CLEANING

PART 2 - PRODUCTS

- 2.01 NIL

PART 3 - EXECUTION

- 3.01 NIL

PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with requirements of Division 01, General Requirements and all documents referred to therein.

1.02 APPLICATION

- .1 This Section applies to and is part of all Sections of Division 20, 21, 22, 23 and 25.
- .2 Perform All Work specified herein by experienced and licensed personnel.

1.03 DEFINITIONS

- .1 Wherever the term "The Consultant" is used in the Division 20, 23 and 25 Drawings and Specifications it means MCW Consultants Limited, Queen's Quay Terminal, 207 Queen's Quay West, Suite 615, Toronto Ontario, Canada M5J 1A7 (Phone 416-598-2920).
- .2 Wherever the term "install" (and tenses of "install") is used in the Division 20, 23 and 25 Drawings and Specifications it means install and connect complete.
- .3 Wherever the term "supply" is used in the Division 20, 23 and 25 Drawings and Specifications it means supply only for installation by other subtrades or under separate contract.
- .4 Wherever the terms "Provide" or "Provision of" are used in relationship to equipment, piping, other materials and systems specified for the Work of Divisions 20, 23 and 25, it means "Supply, Install and Connect and make operable to specified performance". Wherever the terms "Provide" or "Provision of" are used in connection with services such as testing, balancing, start-up, preparation of Drawings and commissioning for any part of the Work of Divisions 20, 23 and 25, it means procure, prepare, supervise, take responsibility and pay for these services.
- .5 Wherever "Drawings and Specifications" are referred to, it means "the Contract Documents".
- .6 Wherever the terms "Authorities" or "Authorities having jurisdiction" are used in the Division 20, 21, 22, 23 and 25 Drawings and Specifications it means any and all agencies that enforce the applicable laws, ordinances, rules, regulations or codes of Ontario. Refer to Division One.
- .7 Wherever the term "Work" is used in the Divisions 20, 23 and 25 Drawings and Specifications it means all equipment, permits, materials, labour and Services to provide a complete Mechanical system(s) installation as described and detailed on the Drawings and in the Specifications.
- .8 Wherever the term "Performance" is used in the Divisions 20, 23 and 25 Drawings and Specifications in relation to specified equipment, it means the specified capacity of that equipment as it applies to provide air, steam or water flow, heating and/or cooling within the specified conditions of operation including air, steam and water pressures, physical space limitations and noise levels.
- .9 Wherever the term "Acceptable" is used in the Divisions 20, 23 and 25 Drawings and Specifications it means acceptable to the Consultant.
- .10 "Basis of Design" refers the mechanical design inherent in the Contract Documents to establish a specific performance requirement and may refer to specific Equipment or Products that have been used to establish an energy performance benchmark, space constraint, or structural load, or may refer to a specific duct or piping arrangement, or may refer to a particular operating sequence, or other similar consideration specific to the design. Basis of Design Equipment or Products are detailed in the Equipment Schedules and drawings.
- .11 "Acceptable Manufacturer", "Standard of Acceptance", "Alternative Manufacturer", "Acceptable Alternative" and similar language that describes manufacturers other than the manufacturer used as the Basis of Design shall all have the same meaning throughout the Contract Documents. Acceptable Manufacturers may be used in the Work in lieu of the Basis of Design manufacturers subject to conditions stipulated elsewhere in the Mechanical Division Contract Documents. Refer to section 20 05 05.

1.04 WORK INCLUDED

- .1 Sections of Divisions 20, 23 and 25 are not intended to delegate functions nor to delegate Work and supply to any specific trade. The Work of Divisions 20, 23 and 25 includes all labour, materials, equipment, permits and tools required for a complete and working installation as described in the Divisions 20, 23 and 25 Specifications and Drawings and is not necessarily limited to items in the following Sections:

20 05 01	Shop Drawings, Product Data and Samples
20 05 05	Mechanical Work General Instructions
20 05 10	Basic Mechanical Materials and Methods
20 05 20	Mechanical Vibration Control
20 05 25	Mechanical Insulation
20 05 30	Variable Frequency Drives
20 05 35	Motor Starters – Low Voltage
20 05 40	Demolition and Revision Work
20 05 70	Water Treatment
20 08 10	Mechanical Commissioning

PLUMBING AND DRAINAGE

22 05 10	Plumbing and Drainage
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HEATING, VENTILATION AND AIR CONDITIONING

23 05 00	Common Work Results for HVAC
23 21 23	Hydronic Pumps
23 31 13	Ductwork
23 33 00	Air Duct Accessories
23 33 10	Dampers
23 33 53	Duct Liners
23 33 55	Acoustic Silencers
23 37 13	Diffusers, Registers & Grilles
23 37 20	Louvres, Intakes & Vents
23 51 00	Breeching, Chimneys & Stacks
23 52 00	Heating Boilers
23 57 00	Heat Exchangers for HVAC
23 64 30	Air Cooled Chiller
23 74 00	Packaged Outdoor HVAC Equipment
23 74 20	Packaged Outdoor ERV
23 81 40	Air & Water Source Unitary Heat Pumps

BUILDING AUTOMATION AND CONTROLS

25 01 01 Building Automation System (BACNET)

1.05 REGULATORY REQUIREMENTS

- .1 Comply with requirements of all Municipal, Provincial and Federal Bylaws and Ordinances as well as requirements of Utilities such as Ontario Gas Utilization Code.
- .2 Do not reduce quality of any part of the Work specified and/or shown on the Drawings by following regulatory requirements.
- .3 In general and as applicable, perform all Work of Divisions 20, 23 and 25 to comply with physical and chemical properties, characteristics and performance requirements of recognized associations and agencies as listed herein and in the following:

ACCGH	-	American Conference of Governmental Industrial Hygienists
AMCA	-	Air Moving & Conditioning Association
ADC	-	Air Diffusion Council
ANSI	-	American National Standards Institute
ARI	-	Air Conditioning & Refrigeration Institute
ASCII	-	American Standard Communication Information Interchange
ASHRAE	-	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASME	-	American Society of Mechanical Engineers
ASTM	-	American Society for Testing and Materials
AWWA	-	American Water Works Association
CGA	-	Canadian Gas Association
CGSB	-	Canadian General Standards Board
CIRI	-	Canadian Industrial Risk Insurers
CSA	-	Canadian Standards Association
CTI	-	Cooling Tower Institute
EIA	-	Electronic Industry Association
FCC	-	Fire Commissioner of Canada
FM	-	Factory Mutual
ISA	-	Instrument Society of America
IAO	-	Insurers Advisory Organization
MMC	-	Marsh McLennan Insurance Protection Consultants
MTC	-	Ministry of Transportation and Communication
NBCC	-	National Building Code of Canada
NFPA	-	National Fire Protection Association
OBC	-	Provincial Ontario Building Code
OFM	-	Local Fire Codes or Standards Ontario Fire Marshall
MOEE	-	Ontario Ministry of Environment And Energy
OML	-	Ministry of Labour and Workmen's Compensation Requirements
OWRA	-	Ontario Plumbing Code

- TSSA – Technical Standards & Safety Authority
- UL – Underwriter's Laboratories Inc.
- ULC – Underwriter's Laboratories of Canada

- .4 Where any code, regulation, bylaw, standard, contract form, manual, printed instruction, and installation and application instruction is quoted it means, unless otherwise specifically noted, latest published edition at time of Permit adopted by and enforced by local governing authorities having jurisdiction. Include for compliance with revisions, bulletins, supplementary standards or amendments issued by local governing authorities.

1.06 STANDARDS

- .1 Provide new materials and equipment of proven design and quality. Provide current models of specified equipment manufactured in Canada or the United States of America, unless specified otherwise with published ratings certified by recognized North American testing and standards agencies.
- .2 Provide Canadian made materials and equipment to maximize Canadian content in the Work
- .3 Comply with ASHRAE/IES 90.1 Standards in the supply and installation of all parts of the Work.
- .4 Comply with Regulations Amending the Energy Efficiency Regulations P.C. 2004-965, 1 September 2004 for the following equipment:
 - .1 Water Chiller - To meet the requirements of CSA C743.
 - .2 Electric Water Heater - To meet the requirements of CAN/CSA C191-00.
 - .3 Gas Fired Water Heater - To meet the requirements of CSA – P.3-04.
 - .4 Large Air Conditioner, Heat Pumps and Condensing Units - To meet the requirements of CAN/CSA –C746 (current edition).
- .5 Conform to the best modern practices of workmanship and installation methods and employ only skilled tradesmen working under the direction of fully qualified personnel.
- .6 Materials and products provided and used must be in accordance with Division 01, to suit sustainable requirements.

1.07 PERMITS, FEES & INSPECTIONS

- .1 Apply for, obtain, and pay for all permits, licenses, inspections, examinations and fees required for Work of Divisions 20, 21, 22, 23 and 25. Also submit, if required by the Authorities, information such as heat loss calculations, and other data that may be obtained from the Consultant. Should the Authorities require the information on specific forms, fill in these forms by transcribing thereto the information as provided by the Consultant.
- .2 If the municipality is structured as a "single permit jurisdiction", the Contractor will apply, pay for and obtain the municipal building permit. In this case, the Divisions 20, 21, 22, 23 and 25 Subcontractor has no financial obligation for permit application except for permits not covered in the "single permit".
- .3 Arrange for inspection of all Work by the Authorities having jurisdiction over the Work. On completion of the Work, present to the Consultant the final unconditional certificate of acceptance of the inspecting Authorities.
- .4 Arrange and pay for inspection of all Work by TSSA for Piping Systems including pressure testing of existing gas piping system. On completion of the Work, present to the Consultant the final unconditional certificate of acceptance of the inspecting Authorities.
- .5 In case of conflict, codes and regulations take precedence over the Contract Documents. In no instance reduce the standard or scope of work or intent established by the Drawings and Specifications by applying any of the codes referred to herein.

- .6 Before starting any work, submit the required number of copies of Drawings and Specifications to the Authorities for their approval and comments. Comply with any changes requested as part of the contract, but notify the Consultant immediately of such changes. Prepare and submit any additional drawings, details or information as may be required.

1.08 CONTRACT DRAWINGS

- .1 The Drawings for Mechanical Work are performance drawings, diagrammatic, intended to convey the scope of work and indicate general arrangement and approximate location of apparatus, fixtures and pipe runs. The Drawings do not intend to show Architectural and Structural details.
- .2 Do not scale Drawings. Obtain information involving accurate dimensions from dimensions shown on Architectural and Structural Drawings, and by site measurement.
- .3 Make, at no additional cost, any changes or additions to materials, and/or equipment necessary to accommodate structural conditions (pipes or ducts around beams and columns and other structural elements).
- .4 Alter, at no additional cost, the locations of materials and/or equipment as directed that do not necessitate additional material.
- .5 Install ceiling mounted or exposed components (e.g. diffusers, sprinkler heads, grilles) in accordance with reflected ceiling drawings or floor plans.
- .6 Confirm on the site the exact location and mounting elevation of outlets and fixtures as related to existing Mechanical and Electrical components and Architectural and Structural details.

1.09 EXAMINATION OF THE PLACE OF THE WORK AND DOCUMENTATION

- .1 Prior to submitting tender, carefully examine conditions at the place of the work which could affect the Work of this Division. Refer to and examine all Contract Documents.
- .2 Verify that materials and equipment can be delivered to the Place of the Work and that sufficient space and access is available to permit installation thereof in locations shown on the Drawings.
- .3 Verify location and elevation of existing services (water, electrical, sanitary, storm sewers, equipment, ductwork and piping) which may affect the Tender and Work of this Division. Repair any damage to existing underground services caused by neglect to determine and mark out the location of such services prior to excavation work commencing.

1.10 CO-ORDINATION DRAWINGS

- .1 The Mechanical Trade Contractor shall take the lead role in preparation of electronic CAD interference/coordination model. Use all other disciplines electronic drawings as basis for preparation of interference/coordination model. Position all Mechanical Trade and Sub-trade services to accommodate the work of other Construction Trades.
- .2 The tender documents including, the CAD model are not complete, nor fully coordinated. The model is not to be considered sufficiently detailed to build from.
- .3 Continuously update the interference/coordination model to accurately reflect all instructions issued by the architect and consultants in whatever format these instructions are issued. Assume for Bid submission purposes, that an updated CADmodel will not be issued with each instruction.
- .4 Prior to commencement of work, submit for Consultant review the Mechanical Trade Contractor shall fully develop their own interference/coordination model using models from all other Construction Trades, and fully coordinate the installation prior to fabrication or installation of any services on site. All sub-trades whose work is affected by the information presented on each of these interference/coordination models shall sign-off on the drawings and thereby agrees to coordinate their parts of the work. Submit the completed interference/coordination model for review using the same procedures as specified for Shop Drawings.

- .5 Coordinate equipment placement to ensure that all components will have adequate access for operation, service and maintenance prior to commencement of Work. Services shall be laid out in an organized manner, including running services in parallel or at right angles from one another where these are exposed. Adequate access points shall be provided to service, maintain and operate the equipment as required.
- .6 Use the project's Architectural [CAD] [Revit] model as the starting point for the creation of interference/coordination model. The contractor's drawings will show angles, braces, supports, and similar equipment that are not in the design model. Use the electrical contractor's model and not the electrical design files; use the structural steel contractor's model and not the structural design files.
- .7 Prepare interference/coordination model in conjunction with other Construction Trades, wherever a potential conflict due to the positioning of Mechanical Trade Contractor equipment, piping, ductwork or other Work exists.
- .8 Dimension proposed location of Mechanical Trade Contractor Work with respect to building elevations and established grid lines.
- .9 Prepare fully dimensioned details of all shafts, duct spaces and pipe spaces. Show sleeving, recessed and formed holes required in concrete for Mechanical Trade Contractor Work. Include information pertaining to access, clearances, tappings, housekeeping pads, drains and electrical connections.
- .10 Base information used to prepare interference/coordination model on reviewed Shop Drawings.
- .11 Provide field interference/coordination model showing the position of various services when required by Consultant.
- .12 The Mechanical Trade Contractor shall be responsible for the full coordination of all mechanical services with the existing building, new construction, and all new and existing services from all Construction Trade disciplines.
- .13 Submit a list of access doors and panels showing proposed type, size and location. The interference/coordination model shall incorporate Architectural details including reflected ceiling plans prior to submission.
- .14 Revise or alter the arrangement of work that has been installed without proper coordination, study and review, in order to conceal the work behind finishes, or to allow the installation of other work, at no additional cost. If any conflicts are identified submit alternate proposal to the consultant for review prior to proceeding with any work.
- .15 All shut-off valves, balancing devices, air vents, equipment and similar products, particularly such products located above suspended ceilings must be located for easy access for servicing and/or removal. Products which do not meet this location requirement are to be relocated to an accessible location at no additional cost.
- .16 The Contractor and their Sub-trades shall take complete responsibility for remedial work that results from failure to coordinate the work prior to fabrication, purchasing and/or installation. Pay for the cost of alterations to other work required by the alterations work made necessary due to a lack of preparing a comprehensive interference/coordination model.

1.11 EMBEDDED MECHANICAL SYSTEM'S DRAWINGS

- .1 Prepare embedded mechanical system's drawings, showing size and location of elements including any conduit and inslab services required.
- .2 Prepare insert setting drawings for work to be cast into concrete and/or mortared into masonry elements.
- .3 Submit embedded mechanical system's drawings to the structural engineer for review.

1.12 SLEEVING DRAWINGS

- .1 Prepare sleeving drawing in conjunction with all affected Trades. Showing sleeves and openings for passage through structure, and all inserts, equipment bases, sumps, pits and supports, and relate these to suitable grid lines and elevation datum.
- .2 Submit sleeving drawings to the structural engineer for review.

1.13 SHOP DRAWINGS

- .1 Conform to requirements of Section 20 05 01.

1.14 ACCEPTABLE MANUFACTURERS AND ALTERNATES

- .1 The manufacturers as listed in the equipment schedules and drawings are listed as the Basis of Design.
- .2 All manufacturers differing from the Basis of Design who are listed as "Acceptable Manufacturer", "Standard of Acceptance", "Alternative Manufacturer", "Acceptable Alternative" and similar language are considered as alternates.
- .3 Whenever the contractor intends to provide a product different than the Basis of Design it will be considered an alternate, regardless of it being listed as an "Acceptable Manufacturer", "Standard of Acceptance", "Alternative Manufacturer", "Acceptable Alternative". It is the contractor's responsibility to verify that the equipment performance, weight, connection, wiring, power requirements and dimensions are in line with the characteristics of the product listed as the Basis of Design. If different than the Basis of Design, the contractor shall coordinate with other trades and cover all costs associated with any modifications required to accommodate the proposed equipment/product.

1.15 RECORD DRAWINGS

- .1 Meet the requirements of Division 01 and the following.
- .2 Suitably store and protect Record "As-Constructed" or "As-built" Drawings on site and make available at all times for inspection.
- .3 Record inverts of underground piping at building entry/exit and below floor slab at each branch, riser base, change in direction as well as at least three points on straight runs.
- .4 Show locations of access doors and panels and identify the equipment and components that they serve.
- .5 Transfer all Record Drawings information to the Mechanical Trade Contractor's CAD model prior to submission to Consultant for review.
- .6 Submit Record "As-Constructed" or "As-built" Drawings for review in PDF format and hard copy for review. Submit reviewed Record "As-Constructed" or "As-built" Drawings in an editable CAD format with the O&M Manuals.
- .7 The drawings for this Project have been prepared on a CAD system using AutoCAD. For the purpose of producing record (as-built) drawings, copies of contract drawings may be purchased from the Consultant based on the following rates plus H.S.T.:

For 1 to 10 CAD files \$ 550

For 11 to 20 CAD files \$ 650

For 21 to 50 CAD files \$ 850

For 51 to 100 CAD files \$ 1,350

For greater than 100 CAD files, charge \$20.00 per file plus \$500.

In using the drawings from the Consultant to produce record drawings, the contractor is deemed to have agreed to take full responsibility for any and all information on the drawings and hold MCW Consultants Ltd. harmless for any discrepancies.

1.16 PRODUCT STANDARDS AND ALTERNATIVES

- .1 Provide new material and equipment as specified and to acceptance of the Consultant. Manufacturers' names are listed to set a standard of quality, performance, capacity, appearance and serviceability. Acceptable alternative Manufacturers are also listed, and their products may be used in the Work subject to conditions stipulated in paragraph .3 of this Article.
- .2 Where no other acceptable Manufacturers are indicated, provide only as specified. Requests for acceptance of manufacturers not listed must be submitted not less than seven working days prior to closing date of the tender. Submissions must bear proof of acceptance by the Consultant.
- .3 Assume full responsibility for ensuring that when providing acceptable alternative Manufacturers, all performance, space, weight, connections (mechanical and electrical), power and wiring requirements, are within the scope of the item specified, and costs for any variances therefore are included in the tender. Equipment requiring greater than specified energy requirements and greater installation and service space requirements will not be accepted.
- .4 All electrically operated equipment and electrical materials to bear the label of approval of CSA or be so stamped or have special approval of the Authorities. All material, wiring and devices to conform to the Canadian Electrical Code for the purpose for which they are to be used. All electrical equipment to be designed and manufactured in accordance with applicable EEMAC and ANSI specifications.
- .5 All gas fired equipment to bear the label of the CGA or be so stamped.
- .6 All plumbing products such as fixtures, faucets, flush valves and shower heads to bear the label of approval of the CSA or be so stamped.

1.17 TEMPORARY SERVICE

- .1 Refer to Division 01 regarding temporary services, contractor's shop, storage and other such facilities. Temporary heat and ventilation is not included in the Work of Divisions 20, 21, 22, 23 and 25.
- .2 Do not use any of the permanent Mechanical Systems during construction or unless specific written acceptance is obtained from the Consultant.
- .3 The use of permanent facilities for temporary construction service such as for testing, commissioning and demonstration of operation will not affect in any way the commencement day of the warranty period. Refer to Division 01.

1.18 PATENTS

- .1 Pay all royalties and license fees, and defend all suits or claims for infringement of any patent rights, and save the Owner and Consultant harmless of loss or annoyance on account of suit, or claims of any kind for violation or infringement of any letters patent or patent rights, by this Subcontractor or anyone directly or indirectly employed by him or by reason of the use by him or them of any part, machine, manufacture or composition of matter on the work, in violation or infringement or such letters patent or rights.

1.19 RIGHTS RESERVED

- .1 Rights are reserved to issue any additional Detail Drawings, which in the judgement of the Consultant may be necessary to clarify the Work, and such Drawings shall form a part of the Contract.

1.20 EXPEDITING AND DELIVERIES

- .1 Comply with requirements of Division 01.
- .2 Continuously check and expedite delivery of equipment and materials. If necessary, inspect at the source of manufacture.

- .3 Ensure that materials and equipment are delivered to the site at the proper time and in such assemblies and sizes so as to enter into the building and to be moved into the spaces where they are to be located without difficulty. Perform any cutting and patching involved in getting assemblies into place.
- .4 Continuously check and expedite the flow of necessary information to and from all parties involved.
- .5 Immediately inform the Consultant of any difficulties in delivery of equipment.
- .6 Provide delivery records updated monthly.

1.21 WORK IN EXISTING BUILDING AREAS

- .1 Perform work in existing areas to best suit available space and not interfere with or obstruct use of existing facilities.
- .2 Cut, modify and extend, as shown in the Contract Documents or as directed by the Consultant, existing materials and equipment to be reused or relocated to suit the Work. Use new materials to match existing systems that are modified or extended.
- .3 Scan and/or x-ray all concrete slabs to identify the appropriate location to cut, trench and/or core prior to commencing any work. Submit the results of the scan and/or x-ray in a report format to the structural engineer for review prior to cutting, trenching and/or coring. This contractor shall ensure that there are no interferences with other existing services prior to commencing any work.
- .4 Refer to Section 20 05 40.

1.22 SUPERINTENDENCE

- .1 Maintain at this job site, at all times, qualified personnel and supporting staff with proven experience in erecting, supervising, testing and adjusting projects of comparable nature and complexity.

1.23 TRIAL USAGE, TESTS AND COMMISSIONING

- .1 Include, as part of the Work, trial usage of Mechanical Systems and equipment for the purpose of testing and commissioning and assisting Owner's staff in learning operational and maintenance procedures.
- .2 Assist in trial usage over a length of time sufficient to confirm specified equipment capacities and operating characteristics. Maintain full responsibility for all mechanical equipment and systems required to temporarily operate during trial usage. Warranty period commencement for any equipment operated during trial usage will not occur until all Mechanical Work is substantially complete. Warranty period commencement is to be applied only to equipment that is put into full continuous service prior to Substantial Completion of the Mechanical Work.
- .3 Provide all testing required on Mechanical System components and equipment where, in the opinion of the Consultant, specified performance is not being achieved.

1.24 COMPLETION

- .1 After successful completion of tests and adjustments, remove temporary covers, and strainers, and obstructions to flow. Drain, flush and refill piping systems as often as required until all piping is clear of all debris.
- .2 Provide a clean set of filters on each air handling system and heat pump.
- .3 Provide new filter elements in pump seal filters.
- .4 Leave Mechanical work in specified working order.
- .5 Provide spare components as specified in Section 25 01 01.

1.25 WARRANTIES

- .1 Comply with requirements of Division 01.

- .2 Provide all required labour, parts and components required to service all installed items for a warranty period of at least one (1) year unless otherwise stated longer in individual specification sections.
- .3 Include for all costs for cutting and patching, removal of equipment and restoration materials and work and repairs to other equipment affected in performance of warranty work.
- .4 All warranties commence from the date of Substantial Performance of the Work, unless stated differently in individual specification sections.
- .5 Provide warranty certificates showing the name of the firm giving the warranty, dated and acknowledged. Where a specific piece of equipment has an extended warranty or one differing from the base warranty requirements, provide a separate warranty certificate.
- .6 Refer to individual specification sections in Divisions 20, 23, 25 for further warranty requirements.

1.26 INSTRUCTIONS TO OWNER'S STAFF

- .1 Instruct the Owner's designated staff on all aspects of the operation of systems and equipment. Advise the Consultant at least one week in advance of the schedules of all instruction sessions.
- .2 Obtain the services of Subtrade and Manufacturers' representatives to provide information and instructions on each part of the Mechanical Work and on items of equipment.
- .3 Submit documentation of training to the Consultant immediately following final inspections, stating for each system or item of equipment:
 - .1 Date and time instructions commenced for each system.
 - .2 Duration (hours) instructions were given for each system.
 - .3 Names of Owner's staff receiving instructions.
 - .4 Other parties present (Manufacturer's representative, consultants, etc.).
 - .5 Signatures of each of the Owner's staff in attendance.

1.27 OPERATING AND MAINTENANCE MANUALS AND CLOSE-OUT DOCUMENTS

- .1 Refer to Division 01 Close-Out Submittals and Close-Out Procedures.
- .2 Secure and assemble all necessary literature describing the operation and maintenance of all equipment provided. Complete and submit documentation for review to Consultant eight (8) weeks prior to substantial completion.
- .3 Provide 3 copies of Operating and Maintenance Manuals in hardcopy and Electronic PDF format copies on Optical media or USB storage device. Mount or connect digital copy to hard copy binders.
- .4 Provide the following on substantial performance of the work:
 - .1 One set of valve charts set in glazed frames mounted on the project as directed by the Consultant.
 - .2 Air and water balancing report.
 - .3 As constructed drawings including building automation system shop drawings.
- .5 Three manuals assembled in three ring binders with index tabs, each containing:
 - .1 This Subcontractor's name, address and telephone/fax numbers.
 - .2 Suppliers and Subtrades names and telephone numbers.
 - .3 Equipment data sheets (dimensions, capacities, electrical characteristics, wiring diagrams) along with equipment manufacturer's recommended spare parts lists.
 - .4 Maintenance, operating and lubricating instructions and schedules for each item of equipment.

- .5 As-built Wiring diagrams for each item of equipment.
- .6 Copies of valve charts for the project.
- .7 Shop Drawings and Product Data: provide final copies of complete sets of "Reviewed" or "Reviewed as Modified" Shop Drawings and other Submittals including Interference/Coordination Model, Embedded Mechanical System's Drawings, and Sleeving Drawings.
- .8 Warranties: include one copy each of the Contractor's warranty, Manufacturers' warranties longer than one year, the bond, and any service contract provided by the contractor. Provide section index.
- .9 Certifications by Inspection Agency: collect and include copies of the following inspection certification reports:
 - .1 Plumbing and Gas Standards
 - .2 Building Standards and Fire Prevention
 - .3 Boilers and Pressure vessel
 - .4 Utility Companies
 - .5 Other Reports Required by Authorities
- .10 Certificates for:
 - .1 Boiler start up and commissioning
 - .2 Chiller and refrigeration system start up and commissioning
 - .3 Water treatment
 - .4 Rooftop HVAC Equipment start-up and commissioning
 - .5 Rooftop Heating and Ventilation Equipment start-up and commissioning
 - .6 Control and Building Automation Systems commissioning
 - .7 Fuel oil pumping systems commissioning
 - .8 Variable speed electric drives commissioning
 - .9 Piping pressure tests (domestic water, non-potable, fire protection heating/cooling piping) certifying system tested, pressure held, time of test and date and certification by the Consultant or commissioning agent.
 - .10 Extended warranties.

1.28 MECHANICAL LIST OF MANUFACTURERS, SUBTRADES & PRICES

- .1 Submit with the tender the List of Manufacturers, Subtrades and prices.
- .2 If specified or acceptable alternative Manufacturers are not listed or more than one Manufacturer per item is listed, or Manufacturers not specified are listed, the Consultant will have the option of making the selection of the Manufacturers.
- .3 Substitution of listed Manufacturers or Subtrades after close of Tender will not be accepted.
 - .1 The lowest or any particular bid will not necessarily be accepted.
 - .2 The criteria to be considered by the Owner in awarding the contract will include a combination of price, scheduling, expertise, qualifications and such other conditions as may be determined by the Owner to be in the Owner's own best interests.
 - .3 Additions, alterations, deletions or other irregularities in the Tender Form may, but will not necessarily, result in the Owner's rejection of the bid.
 - .4 The Bidder acknowledges that there will be no claim against, or entitlement to damages from, the Owner by reason of the Owner's rejection of this bid or of all bids.

1.29 CASH ALLOWANCES

- .1 Cash allowances are listed in Division 01.

1.30 VALUATION OF CHANGES

- .1 All changes for additional work shall include;
 - .1 The actual breakdown cost of labour and materials plus:
 - .1 Where the work is performed by a Subcontractor to the Trade Contractor, the Subcontractor shall include no more than 5% for overhead and 5% for Profit. The Trade Contractor shall include no more than 5% for overhead and 5% for Profit.
 - .2 Where the work is performed by the Trade Contractor's own forces the, the Trade Contractor shall include no more than 5% for overhead and 10% for Profit.
 - .2 Itemized cost breakdown for all equipment.
- .2 All credits for deleted work shall include;
 - .1 Where the work is performed by a Subcontractor to the Trade Contractor, credits for deleted work shall include the Subcontractors' actual breakdown cost of labour and materials plus no less than 5% of such amount for overhead and profit. The Trade Contractor shall provide for an additional no less than 5% credit of the Subcontractors' total credit on account of the Trade Contractor's overhead and profit.
 - .2 The actual breakdown cost of labour and materials and no less than 5% of such amount for overhead and profit where the work is performed by the Trade Contractor.
 - .3 Itemized cost breakdown for all equipment.
- .3 The Trade Contractor shall at the request of the Owner or Consultant provide all required supplementary documentation for any change (the amounts shall be exclusive of HST).
- .4 Hourly labour rates must be included with the tender submission and be done at MCA rates.

1.31 UTILITY SERVICES

- .1 Coordinate, arrange, and pay for all required municipal service and utility connections, natural gas as shown on the Drawings, complete with all required metering. Install all metering equipment as well as service connections in accordance with municipal and utility requirements. Pay for all inspection fees arising out of the installation of these services.
- .2 Bear all costs and co-ordinate with Enbridge to provide a natural gas service from the nearest street main into the building. Pay for all inspection fees, metering devices and any work performed by Enbridge.

1.32 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Division 01 to suit Common Product Requirements.
- .2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
- .3 Protect on site stored or installed absorptive material from moisture damage.
- .4 Packing, shipping, handling and unloading:
 - .1 Deliver materials to site in original factory packaging or unopened packages clearly labeled with, manufacturer's name, address, product identification, equipment tag identification/s and ULC markings.
 - .2 Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.
- .5 Storage and Protection:

- .1 Store and protect all equipment and materials from exposure to harmful weather conditions and at temperature and humidity conditions recommended by manufacturer in enclosed shelter.
- .2 Repair any damage to the satisfaction of the manufacturer and the Consultant.
- .6 Waste Management and Disposal:
 - .1 Separate waste materials for re-use and/or recycling in accordance with Division 01, to suit Construction/Demolition Waste Management and Disposal
 - .2 Remove from site and dispose of packaging materials at appropriate recycling facilities.
 - .3 Collect and separate for disposal paper, plastic, polystyrene, corrugated cardboard, & packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan (WMP).
 - .4 Separate for re-use and/or recycling and place in designated containers Steel, Metal and Plastic waste in accordance with Waste Management Plan (WMP).
 - .5 Divert unused metal materials from landfill to metal recycling facility as approved by the Consultant.
 - .6 Place materials defined as hazardous or toxic in designated containers.
 - .7 Handle and dispose of hazardous materials in accordance with CEPA, TDGA, and Regional and Municipal regulations.
 - .8 Ensure emptied containers are sealed and stored safely.
 - .9 Fold up metal and plastic banding, flatten and place in designated area for recycling.

1.33 CLEANING

- .1 General
 - .1 Comply with General Conditions of the Contract, Supplementary Conditions and other Sections of Division 01.
 - .2 Conduct cleaning and disposal operations to comply with local ordinances and anti-pollution laws.
 - .3 Store volatile and toxic wastes in covered metal containers and remove from premises daily.
 - .4 Prevent accumulation of wastes which create hazardous conditions.
 - .5 Provide adequate ventilation during use of volatile or noxious substances.
 - .6 Use only cleaning materials and methods recommended by manufacturer of surface to be cleaned.
- .2 Construction Cleaning
 - .1 Perform cleaning operations as specified in Division 01 and in accordance with manufacturer's recommendations.
 - .2 At all times, maintain the premises free from accumulation of waste material and waste caused by the Contractor's work.
 - .3 In cases of disagreement or non-removal of waste material, the Owner may have waste removed from site at the Contractor's own expense.
 - .4 Dumping of waste, debris, surplus materials, etc. on Owner's property is strictly prohibited. Obtain permit and provide on-site dump containers for collection of waste materials and debris.
 - .5 Broom clean and keep dust free, daily, all rooms, surfaces and areas.

- .6 Maintain roads and walks clean and free of dirt and mud due to work of this Contract. Provide ice and snow removal for walks which will be used exclusively by Contractor and/or Subcontractor's forces.
- .3 Final Cleaning
 - .1 In preparation for Total Performance or occupancy, conduct final inspection of sight exposed surfaces and of accessible concealed spaces.
 - .2 Upon completion and verification of performance installation, remove all waste, equipment, tools, scaffolding, surplus materials, temporary protection, etc. and leave work in a clean and orderly condition.
 - .3 Remove grease, dust, dirt, stains, labels, fingerprints and other foreign materials from sight exposed interior and exterior finished surfaces.
 - .4 Upon completion of project or as required, remove all temporary buildings erected, all temporary construction aids, barriers and enclosures, all temporary utilities, hoists, access road sand walks, etc., leaving site in clear, tidy and satisfactory condition pending acceptance from the Owner.
 - .5 Brush clean all surfaces and areas of the Work.
 - .6 Vacuum clean and remove debris from the inside of air handling systems, fans, ducts, coils and terminal units.
 - .7 Clean exposed surfaces of Mechanical equipment, ductwork and piping. Polish plated work.
 - .8 Comb all bent fins to proper configuration on all coils in air handling units, fan coil units, entrance heaters and on finned radiation elements.
 - .9 Replace all temporary air filters with specified filters on all heating, cooling and ventilating equipment.
 - .10 Upon completion of work of each trade, thoroughly clean work and leave in a condition acceptable to Consultant and Owner.

PART 2 - PRODUCTS

2.01 NIL

PART 3 - EXECUTION

3.01 NIL

END OF SECTION 20 05 05

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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Section 20 05 05 Mechanical Work General Instructions.

1.02 SUBMITTALS

- .1 Submit shop drawings on access doors, valves, strainers, expansion tanks, thermometers and gauges, expansion compensators, piping restraints, grooved end components, motor starters and motor control centers in accordance with Section 20 01 05.

PART 2 - PRODUCTS

2.01 ACCESS DOORS

- .1 Provide rounded safety corners hinged access doors as constructed of primed 16 gauge steel as manufactured by William Brothers or Acudor equal to fire rating of wall or ceiling in which installed.
- .2 Provide doors with minimum size of 300mm x 300mm (12" x 12"). Access doors to be sized of adequate size to permit service of equipment and/or resetting dampers. Provide minimum size of 600mm x 460mm (24" x 18") where personnel entry is required. Provide minimum size of 600mm x 750mm (24" x 30") where personnel entry is required for regular equipment maintenance.
- .3 Provide for plaster surfaces recessed 16 ga. prime painted steel door and welded metal lath, ready to take plaster. Provide with concealed hinge and stainless steel studs with brass sleeves.
- .4 Provide for tiled surfaces, recessed type 16 ga. primed steel (stainless steel for ceramic tile and shower areas) doors to suit type and dimension of tile used. Size door to be as close as possible to 300mm x 300mm (12" x 12") by fitting to single or multiple tile dimensions. Provide with concealed hinges and stainless steel studs with brass sleeves.
- .5 Provide, to suit wall surface or type of construction, other factory prime coated access doors of welded 16 gauge steel, flush type with concealed hinges, lock and anchor straps.
- .6 Lay in type ceiling tiles, properly marked, may serve as access panels.
- .7 Access doors in fire rated construction shall be ULC listed and labelled, meeting the requirements of Authorities having jurisdiction and rated to maintain the fire separation integrity.

2.02 PIPE AND FITTINGS

- .1 Corrosion Prevention
 - .1 Provide V line insulating couplings from Watts, or accepted alternative, dielectric couplings, for prevention of galvanic corrosion at specific points where connections are required between copper, brass or bronze and black or galvanized steel piping.
 - .2 Acceptable Manufacturers:
 - .1 Watts,
 - .2 EPCO,
- .2 All fittings 50mm (2") and below connecting to equipment: Use unions, extra heavy duty pattern, having ground joints, brass seats and diagonal screws.
- .3 Connections to equipment 65mm (2½") and above: Flanged, standard weight provided with ring gaskets.
- .4 Cooling coil condensate: drainage grade copper tubing with copper drainage fittings with 50 50 solder.
- .5 Chilled water, condenser water, glycol solution circuits, and Heating:

- .1 Piping:
 - .1 Working Pressure up to and including 1035 kPa (150 psi): Schedule 40 ASTM specification A53 Grade A or B wrought steel black pipe with heavy cast iron threaded fittings rated at 1380 kPa (200 psi WOG) for pipe sizes up to and including 50mm (2").
 - .2 Working Pressure up to and including 1035 kPa (150 psi): Schedule 40 ASTM specification A53 wrought steel black pipe with schedule 40 black steel welding fittings rated at 1380 kPa (200 psi WOG) for pipe sizes 65mm (2½") and over.
 - .3 Type L copper to ASTM B88 with 95/5 soldered wrought copper pressure fittings to ANSI B16.22 for piping system rated at 1035 kPa (150 psi WOG) for pipe sizes up to and including 50mm (2").
- .2 Fittings:
 - .1 For pipe fittings up to and including 50mm (2"):
 - .1 Up to 862 kPa (125 psi WSP) Soldered: Wrought bronze or cast copper, ASTM B32, solder joint fittings, ANSI/ASME B16.18 or B16.22.
 - .2 Up to 862 kPa (125 psi WSP) Threaded: Banded black cast iron, ASTM A126, threaded, ANSI/ASME B16.4, Class 125, ASTM A126
 - .3 1035 kPa (150 psi WSP) Threaded: Galvanized malleable iron, threaded, ANSI/ASME B16.3, Class 150.
 - .4 1725 kPa (250 psi WSP) Threaded: Banded black cast iron, ASTM A126, threaded, ANSI/ASME B16.4, Class 250, and ANSI/ASME B1.20.1
 - .2 For pipe fittings 65mm (2½") and up to 600mm (24"):
 - .1 Welded: Black steel, butted welded, ASTM A234/A234M, ANSI/ASME B16.9, each stamped by manufacturer for conformance and working pressure.
 - .2 Up to 862 kPa (125 psi WSP) Flanged: Cast iron flanged fittings, ANSI/ASME B16.1, Class 125.
 - .3 Victaulic couplings to CSA Standard B242 for fire protection, heating, chilled water and condenser water is acceptable provided that this application meets the approval of the Municipal Authorities who have jurisdiction at the place of the Work.
 - .1 Rigid Couplings: Ductile iron to specification A536. In mechanical rooms use grooved couplings to be designed with angle bolt pads to provide a rigid joint. Victaulic style 107N or 07. In mechanical rooms use grooved couplings to be designed with angle bolt pads to provide a rigid joint. Victaulic style 107 and 07.
 - .2 Flexible Couplings – Ductile iron to specification A536. Flexible grooved couplings shall be used where system flexibility is desired. Noise and vibration reduction at mechanical equipment connections is achieved by installing three flexible couplings near the vibrations source in lieu of braided flex connectors. Victaulic Style 77 or 177.
 - .3 AGS "W" Series Couplings (350mm (14") and Larger): Victaulic Style W07 (rigid) and Style W77 (flexible) two housings cast with a wide key profile and flat bolt pads for metal-to-metal contact, wide-width FlushSeal® gasket, and plated steel bolts and nuts.

- .4 Gaskets: Water Services EPDM Grade "E", with green colour code identification, conforming to ASTM D-200 for water services up to 110°C (230°F) or Grade "EHP" EPDM, with red colour code identification, conforming to ASTM D-2000 for water services up to 120°C (250°F).
- .5 Fittings Victaulic full flow fittings manufactured of ductile iron to ASTM A 536 Grade 65 4 12 or steel to ASTM A-53, Grade B, with grooved ends designed to accept Victaulic couplings.
- .4 For pipe sizes 100mm (4") and smaller (for heating and cooling application only):
 - .1 Press fittings by Viega Model Mega Press is acceptable for use in steel piping.
 - .1 Viega MegaPress shall conform to ASTM F3226, IAPMO PS117, ICC LC1002, ASME B31.1, B31.3, or B31.9. MegaPress fittings ½-inch thru 4-inch for use with schedule 5 thru 40 ASTM A53 carbon steel pipe.
 - .2 MegaPress fittings shall only be used for system pressure up to 1379 kPa (200 psi).
 - .3 Press Connect Fitting shall carry CRN numbers
 - .4 Press Connect fitting shall have Viega Smart Connect technology to detect unpressed fittings shall be integrated into the body of the fitting.
 - .5 1/2 inch thru 2 inch fittings shall have stainless-steel grip ring with bidirectional teeth, 304 stainless separator ring, EPDM or FKM sealing element at each press connection. 2-1/2 inch thru 4 inch shall have stainless-steel grip ring with bidirectional teeth, PBT separator ring, and FKM sealing element at each press connection
 - .6 There shall be no mixing of manufacturers.
 - .7 The manufacturer's installation instructions shall be strictly adhered to.
 - .8 Special attention shall be given to the required two step pressure test.
 - .9 Initial test for unpressed fitting detection per manufacturer's installation manual
 - .10 Full pressure test in accordance with code requirements
 - .11 Installers shall be field trained by Viega factory representative. .
 - .12 Approved manufacturer: Viega
 - .2 Press fittings by Viega Model Pro Press is acceptable for use in copper piping.
 - .1 Viega ProPress Bronze, or copper shall conform to ASTM F3226, ICC LC 1002, ASME B16.51, IAPMO PS 117, NSF 61, and NSF 61-G or NSF 372. . ProPress fittings ½-inch thru 4-inch for use with ASTM B88 copper tube type L and ½-inch up to include 1-1/4-inch annealed copper tube.
 - .2 ProPress fittings shall only be used for system pressure up to 2068 kPa (300 psi).
 - .3 Press Connect Fitting shall carry CRN numbers.

- .4 Cast copper alloy fittings Alloy: Copper alloy - UNS C12200 Zero Lead silicon bronze alloy - C87710 (cast) or C87700 (machined) Shall not be bismuth bronze or yellow brass.
- .5 EPDM elastomeric sealing element shall be peroxide cured for resistance to chloramines
- .6 Press Connect fitting shall have Viega Smart Connect technology to detect unpressed fittings shall be integrated into the body of the fitting
- .7 2-1/2 inch thru 4 inch fittings shall have stainless-steel grip ring with bidirectional teeth, PBT separator ring, and EPDM sealing element at each press connection.
- .8 There shall be no mixing of manufacturers.
- .9 The manufacturer's installation instructions shall be strictly adhered to.
- .10 Special attention shall be given to the required two step pressure test. Initial test for unpressed fitting detection per manufacturer's installation manual. Full pressure test in accordance with code requirements.
- .11 Installers shall be field trained by Viega factory representative.
- .12 Approved manufacturer: Viega
- .3 Material of press fit fittings to be same material as the piping.
- .4 All products to be complete with CRN number and to be acceptable by the Authority Having Jurisdiction. Manufacturer to provide substantiation upon request by the Authorities.
- .3 Flanges: Provide either flat-face or raised-face flanges as required to match flange faces on valves and equipment.
 - .1 Up to 862 kPa (125 psi WSP) Threaded: Threaded cast iron flanges, ANSI/ASME B16.1, Class 125.
 - .2 1035 kPa (150 psi WSP): Weld neck or slip-on steel flanges, ASTM A181/A181M, Class 60, ANSI/ASME B16.5, Class 150.
 - .3 1725 kPa (250 psi WSP) Threaded: Threaded cast iron flanges, ANSI/ASME B16.1, Class 250.
- .4 Flange Bolts:
 - .1 Up to 862 kPa (125 psi WSP): ASTM A307, Grade B, square-head machine bolts with heavy hex-nuts.
 - .2 Above 862 kPa (125 psi WSP): ASTM A193/A193M, Grade B7 bolts, with Grade 7 nuts.
- .5 Unions for sizes up to 50mm (2"):
 - .1 Up to 862 kPa (125 psi WSP) Soldered: Wrought bronze or copper, ground joint, solder end unions.
 - .2 1035 kPa (150 psi WSP) Threaded: ASTM A197/A197M, ANSI/ASME B16.39, Galvanized malleable iron unions with ground joints, brass seat, threaded ends.
- .6 Sanitary Drainage Internal:
 - .1 Buried:

- .1 Cast iron pipe and fittings to CSA B70.
- .2 Where buried and accepted by Authorities: PVC or ABS pipe and fittings to CSA CAN 3 B181.1 M85 (ABS) CAN 3 B181.2 M85 (PVC) B182.1, B182.2, (large diameter PSM PVC). B182.3, (large diameter IPS PVC).
- .2 Suspended:
 - .1 Cast iron pipe and fittings to CSA B70.
 - .2 DWV copper to ASTM B306 with 50 50 soldered cast brass drainage fittings to CSA B158.1 or wrought copper fittings to ANSI B16 29.
- .7 Sanitary Drainage External:
 - .1 Cast iron or approved ABS or PVC with solvent weld or ring gasket joints as specified for internal buried pipe.
 - .2 Concrete to CSA Standard A257.
- .8 Vent Piping:
 - .1 DWV Grade copper to ASTM B306 76 with 50 50 soldered cast brass or wrought copper drainage fittings to CSA B158.1 and ANSI B16 29 respectively or cast iron pipe and fittings to CSA B70.
- .9 Domestic Water:
 - .1 System pressure rated for 1380 kPa (150psi).
 - .2 Code and Standards:
 - .1 ASTM B88 Standard Specification for Seamless Copper Water Tube.
 - .2 ASME B16.15 Cast Bronze Threaded Fittings, Class 150 and 250
 - .3 ASME B16.18 Cast Copper Alloy Solder Joint Pressure Fittings
 - .4 ASME B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
 - .5 ASME B16.24 Cast Copper Alloy Pipe Flanges and Flanged fittings Class 150, 300, 400 and 600.
 - .6 CSA B242 Groove and Shouldered Type Mechanical Couplings
 - .7 AWS A5.8 Brazing Filler Material
 - .8 ASTM B32 Specification for Solder Metal
 - .9 ASTM B-312 Standard Specification for Stainless Steel Piping.
 - .3 When providing copper piping, all products serving the domestic water service shall be provided with copper and/or bronze fittings and components. When providing stainless steel piping, stainless steel fittings and components shall be used.
 - .4 Above Grade:
 - .1 Type L copper, hard drawn, marked certified for compliance with ASTM B88 Standard, with 95/5 soldered, wrought copper or cast bronze pressure solder fittings to ANSI B16.22 and ANSI B16.18 respectively.
 - .2 Stainless Steel:
 - .1 304L stainless steel, Schedule 10 marked certified for compliance with ASTM A312/ASME SA-312 Standard for pipe sizes 75mm (3") and larger.
 - .2 Fittings: 304L stainless steel fittings to ASTM A-774 and A-403.

- .3 Brass or bronze threaded fittings to ASME B16.15. Brass or bronze flanges or flanged fittings to ASME B16.24. Flanged joints to AWWA C111 and bolts to ASTM A307 and nuts to ASTM 563. Silver brazing alloy to AWS Classification BCuP-5.
- .4 Method of joint connection:
 - .1 Soldered for pipes up to 65mm (2 ½").
 - .2 Brazed for pipes 75mm (3") or higher
 - .3 Grooved fittings may be used for exposed area.
- .5 For pipe sizes 100mm (4") and smaller:
 - .1 Press fittings by Viega Model Pro Press and MegaPress is acceptable for use in copper and stainless steel domestic water piping distribution systems.
 - .1 Copper Press-Connect Fittings:
 - .1 Viega ProPress Bronze, or copper shall conform to ASTM F3226, ICC LC 1002, ASME B16.51, IAPMO PS 117, NSF 61, and NSF 61-G or NSF 372. . ProPress fittings ½-inch thru 4-inch for use with ASTM B88 copper tube type L and ½-inch up to include 1-1/4-inch annealed copper tube.
 - .2 ProPress fittings shall only be used for system pressure up to 2068 kPa (300 psi).
 - .3 Press fittings shall have a valid Ontario Building Material Evaluation Commission Authorization (BMEC).
 - .4 Press Connect Fitting shall carry CRN numbers.
 - .5 Cast copper alloy fittings Alloy: Copper alloy - UNS C12200 Zero Lead silicon bronze alloy - C87710 (cast) or C87700 (machined) Shall not be bismuth bronze or yellow brass.
 - .6 EPDM elastomeric sealing element shall be peroxide cured for resistance to chloramines
 - .7 Press Connect fitting shall have Viega Smart Connect technology to detect unpressed fittings shall be integrated into the body of the fitting
 - .8 2-1/2 inch thru 4 inch fittings shall have stainless-steel grip ring with bidirectional teeth, PBT separator ring, and EPDM sealing element at each press connection.
 - .9 The manufacturer's installation instructions shall be strictly adhered to.
 - .10 Special attention shall be given to the required two step pressure test. Initial test for unpressed fitting detection per manufacturer's installation manual. Full pressure test in accordance with code requirements.
 - .11 Installers shall be field trained by Viega factory representative.
 - .12 Approved manufacturer: Viega (no exceptions).
 - .2 Stainless Steel Press-Connect Fittings:
 - .1 Viega LLC; MegaPress Stainless 316

- .2 Viega MegaPress Stainless 316 shall conform to ASTM F3226, ICC LC 1002, IAPMO PS 117, ASME B31.1, B31.3, or B31.9, NSF 61, and NSF 61-G or NSF 372. MegaPress Stainless 316 fittings ½-inch thru 2-inch for use with schedule 5 thru 40 ASTM A 312 stainless steel pipe. MegaPress Stainless 316 fittings 2½-inch thru 4-inch for use with schedule 10 thru 40 ASTM A 312 stainless steel pipe. ProPress fittings shall only be used for system pressure up to 2068 kPa (300 psi).
- .3 Press Connect Fitting shall carry CRN numbers.
- .4 EPDM elastomeric sealing element shall be peroxide cured for resistance to chloramines
- .5 Press Connect fitting shall have Viega Smart Connect technology to detect unpressed fittings shall be integrated into the body of the fitting
- .6 1/2 inch thru 2-inch fittings shall have stainless-steel grip ring with bidirectional teeth, 304 stainless separator ring, and EPDM sealing element at each press connection. 2-1/2 inch thru 4 inch shall have stainless-steel grip ring with bidirectional teeth, PBT separator ring, and EPDM sealing element at each press connection
- .7 The manufacturer's installation instructions shall be strictly adhered to.
- .8 Special attention shall be given to the required two step pressure test. Initial test for unpressed fitting detection per manufacturer's installation manual. Full pressure test in accordance with code requirements.
- .9 Installers shall be field trained by Viega factory representative.
- .10 Approved manufacturer: Viega (no exceptions).
- .5 Buried piping:
 - .1 Soft temper type K with soldered fittings to the previously mentioned standards.
- .6 Victaulic products for domestic water services (hot and cold), to be rated for operating conditions of -34°C to +120°C (-29.2°F to 250°F) and 2067 kPa (300 psi).
 - .1 Couplings: ductile iron coated with copper alkyd enamel to ASTM A - 536. Flanges to be copper alkyd enamel coated to ANSI class 125 for cast iron and class 150 for steel. Couplings shall be "Installation Ready" stab-on couplings designed with angle bolt pads to provide a rigid joint, complete with EPDM gasket. Victaulic Style 607.
 - .2 Fittings: grooved copper to ASTM B-75 and grooved bronze castings to ASTM B-584 with copper tube dimensioned grooved ends (flaring of tube and fitting ends to IPS dimensions is not permitted).
 - .3 Gaskets: grade EHP EPDM to ASTM D-2000 (UL/ULC classified in accordance with ANSI/NSF-61 for hot (82°C) and cold (30°C) domestic water service).
 - .4 Acceptable Alternative: Gruvlok (Entire system by one manufacturer).

- .7 Soldered Fittings in Potable Water Systems: Provide lead, antimony, cadmium and zinc free solders composed of tin/copper/silver or nickel components that are acceptable to Authorities having jurisdiction.
- .10 Natural gas piping: Provide as required by the Authorities having jurisdiction as follows:
 - .1 Buried:
 - .1 ASTM A53 Schedule 40 seamless wrought steel with Schedule 40 wrought steel butt welding fittings to ANSI B16.9. Provide complete with Shaw Pipe Yellow Jacket® high density dual layer polyethylene coating for external protection, and yellow insulated tracer wire for future location.
 - .2 Provide continuous 75 mm (3") wide yellow PVC warning tape with "CAUTION BURIED PIPELINE BELOW" wording at 750 mm (30") intervals located above pipe approximately 250 mm (10") below grade.
 - .2 Suspended:
 - .1 ASTM A53 Schedule 40 seamless wrought steel with schedule 40 threaded malleable fittings to ANSI standard B16.3; welded in concealed areas and X rayed if required by Authorities having jurisdiction.
 - .2 ASTM A53 Schedule 40 wrought steel seamless with schedule 40 wrought steel butt welding fittings to ANSI B16.9. Welding procedures to comply with standards as required by the Authorities having jurisdiction.
 - .3 Connections to equipment: provide extra heavy duty pattern unions with ground joints, brass seats and threads to ANSI B1.20.1. Where flanges are required, provide standard weight type to ANSI B16.1 with neoprene gaskets.
 - .4 MegapressG:
 - .1 MegapressG as manufactured by Viega shall only be used for piping up to and including 2" upon acceptance by the local authority.
 - .2 Pipe: Carbon steel pipe shall conform to ASTM A53. Pipe schedule (pipe wall thickness) shall conform to the standard referenced dimensions for Schedule 40.
 - .3 Fittings: Cold Press Mechanical Joint Fitting shall conform to material requirements of ASTM A420 or ASME B16.3 and performance criteria ANSI LC-4/CSA 6.32. Sealing elements for press fittings shall be HNBR. Sealing elements shall be factory installed or an alternative supplied by fitting manufacturer. Press ends shall have SC (Smart Connect™) technology design (leakage path). MegaPress fittings with Smart Connect technology assure leakage of liquids and/or gases from inside the system past the sealing element of an un-pressed connection.
 - .4 Piping and fittings shall comply with ANSI LC-4/CSA 6.32 and the latest edition of NFPA-54.
 - .5 Fittings shall comply to the requirements of ASTM F3226.
- .11 Provide Polypropylene acid resistant Enfield Electrofusion below grade up to the acid interceptor installed in accordance with manufacturers recommendations. Pipe to be certified in accordance with CAN/CSA-B181.3. All joints to be thermally welded with the applicable fusion equipment and adaptors to transition to borosilicate glass at floor level if required. Humidifier Low Pressure Steam:
 - .1 Use type 'L' copper. Steam condensate if applicable can be the same.
 - .2 When applicable use manufacturer supplied hoses at humidifier.
- .12 Condensing Appliances Drain Piping:

- .1 Use materials approved by the authority having jurisdiction. In the absence of other authority, 316 Stainless Steel, PVC and CPVC pipe must be CSA or ULC certified and comply with ASTM D1785 or D2845.

2.03 VALVES

- .1 All valves to have minimum certified rating of 1380 kPa (200 psi) WOG. Refer to Section 23 05 05 for fire protection service valves.
- .2 Conform to requirements of ANSI, ASTM, ASME, and applicable MSS standards.
- .3 Manufacturer:
 - .1 Provide valves of same manufacturer throughout, where possible.
 - .2 Provide valves with manufacturer's name and pressure rating clearly marked on body (per MSS-SP-25).
 - .3 Product shall carry valid CRN (Canadian Registration Number) issued by respective Provinces.
- .4 Valve Materials:
 - .1 Bronze: to ASTM B62 (406°F/208°C) or B61 (550°F/288°C) as applicable
 - .2 Brass: to ASTM B283 C3770
 - .3 Cast Iron: to ASTM A126, Class B (353°F/178°C) at 125 PSIG.
 - .4 Forge Steel: to ASTM A105N (800°F/427°C)
 - .5 Cast Steel: to ASTM A216WCB (800°F/427°C)
- .5 Testing and Design:
 - .1 MSS-SP-80 - Bronze, Gate & Check Valves.
 - .2 MSS-SP-110 - Ball Valves.
 - .3 MSS –SP-70, 85, 71 - Cast Iron Gate, Globe & Check Valve.
 - .4 MSS-SP-72 - American Valve
 - .5 MSS-SP-67 – Kitz, Butterfly Valves.
 - .6 API 602 – Forge Steel Valves (Design)
 - .7 API 598 – Cast Steel Valves, Forge Steel Valves (Testing)
 - .8 API 609 – WKM High Performance BFV
- .6 Gate valves:
 - .1 50mm (2") and smaller with bronze body and rising stem: Jenkins #810, Crane #428, Newman Hattersley #T607, Red and White #293.
 - .2 Valves for copper ends: Jenkins #813J, Crane #1334, Grinnell #3000, Toyo 299 or Newman Hattersley #T607, Kitz #44.
 - .3 Gate valves 65mm (2½") and up: Iron body, bronze trim, OS&Y, rising stem, Jenkins #454J, Crane #465 ½, Toyo #421A, Grinnell #6060A or Newman Hattersley #504, Kitz #72.
 - .4 For valves 150 mm (6") and greater where mounted overhead, provide O. S. & Y. valves with chain wheel operation - length of chain to be determined on site.
- .7 Ball valves:
 - .1 Up to 50 mm (2"):
 - .1 Brass and/or bronze body, full port, PTFE seats, double O-Ring design or PTFE packing, chrome plated solid bronze ball, lever handle.

- .2 1034 kPa (150 psig) / 4137 kPa (600 psig) WOG rating.
- .3 Kitz 58 (threaded) or 59 (solder), Crane 9201 (threaded) or 9202 (solder), Toyo 5044E (threaded) or 5049A (solder), Watts FBV-4 (threaded) or FBVS-4 (solder), Apollo 77F-100 (threaded) or 77F-200 (solder), Nibco T-FP600A (threaded) or S-FP600A (solder), Victaulic Series 722.
- .2 It is preferable that ball valves be used in place of gates valves for sizes 12 to 50 mm (1/2" to 2").
- .8 Globe valves:
 - .1 50mm (2") and smaller: Grinnell #3240, Jenkins 106B, Crane #7, Toyo #221, or Newman Hattersley #13, Kitz #9.
 - .2 Valves 50mm (2") and smaller for copper ends: Grinnell #3240SJ, Jenkins #1068AP, Crane #1312, Red and White #212, Newman Hattersley Fig. 13 with adapters, Kitz #10.
 - .3 Valves 2 1/2" and greater, iron body, bronze seat and disc: Jenkins #234J, Crane #351, Red & White #400A, Newman Hattersley #731.
- .9 Butterfly valves:
 - .1 Flanged:
 - .1 Enameled cast iron lug type body, stainless steel disc, blow-out proof stainless steel stem, EPDM seat
 - .2 Bi-directional tight shut-off to 1100 kPa (150 psi)
 - .3 Bi-directional dead-end service to 345 kPa (50 psi)
 - .2 Grooved end:
 - .1 65 – 300 mm (2 1/2" – 12"):
 - .1 Enameled ductile iron body, stainless steel disc, blow-out proof stainless steel stem, EPDM seat
 - .2 Rated to 2068 kPa (300 psi) and bi-directional dead-end service capable to full rated pressure.
 - .3 Standard of acceptance: Victaulic Vic-300 MasterSeal
 - .2 350 – 600 mm (14" – 24"):
 - .1 PPS coated ductile iron body, PPS coated ductile iron disc, EPDM disc/seal, blow-out proof stainless steel stem, PPS coated
 - .2 Rated to 2068 kPa (300 psi) and bi-directional dead-end service capable to full rated pressure.
 - .3 Standard of acceptance: Victaulic Vic-300 AGS.
 - .3 Stainless steel 50 – 200 mm (2" – 8"):
 - .1 Stainless steel body and disc conforming to ASTM A351 Grade CF8M. Grade "E" EPDM seat, UL Classified in accordance with ANSI/NSF 61 for cold +73°F/+23°C and hot +180°F/+82°C potable water service and ANSI/NSF 372.
 - .2 Rated to 2068 kPa (300 psi) and dead-end service capable to full rated pressure.
 - .3 Standard of acceptance: Victaulic Series 461.
 - .4 Copper ends 65 – 150 mm (2-1/2" – 6"):

- .1 Body material shall be bronze with copper tube dimensions, aluminum bronze disc with grade "CHP" fluoroelastomer seat. Suitable for water service with temperature range of -34C to +110C (-30F to 230F).
- .2 UL Classified in accordance with ANSI/NSF 61 for cold +73°F/+23°C and hot +180°F/+82°C potable water service and ANSI/NSF 372.
- .3 Rated to 2068 kPa (300 psi) and dead-end service capable to full rated pressure.
- .4 Standard of acceptance: Victaulic Series 608N
- .3 Handles and operators:
 - .1 Up to and including 100mm (4"): lever with infinite adjustment.
 - .2 150mm (6") and over: wheel/gear operated.
 - .3 Provide chain operator where mounted overhead.
- .4 It is preferable, except for gas and steam services, that butterfly valves be used in place of gate valves for sizes 65 mm (2½") and greater.
- .5 As manufactured by Challenger, Centerline, Keystone, DeZurick, Crane, Jenkins, Bray, Victaulic
- .10 Swing check valves - other than at pump discharge:
 - .1 50mm (2") and smaller: Grinnell #3320, Jenkins #4092, Crane #37, Toyo #236, Newman Hattersley #47, Victaulic Series 712, Kitz #22.
 - .2 65mm (2½") and larger: Iron body, brass trim, flanged: Grinnell #6300A, Jenkins #587, Crane #373, Toyo #435JA, Newman Hattersley #651, Kitz #78.
 - .3 At pump discharge use wafer type check valve as manufactured by Grinnell #300, Victaulic Series 716H/716 or W715, Streamflo, Checkrite or M & G #1515WM5S with 316 stainless steel disc.
- .11 Domestic water valves:
 - .1 Gate valves 50mm (2") and under, soldered
 - .1 For pressure up to 150 psig, MSS SP-80, Class 150, bronze body, solid wedge bronze disc, rising stem, screw in, or union bonnet.
 - .2 Kitz 43, Crane 1334, Jenkins 813J, Newman Hattersley T608 and Nibco S-131
 - .2 Gate valves 50 mm (2") and under, threaded
 - .1 1000 kPa (150 psi), to MSS SP-80, Class 150, bronze body, solid wedge disc, rising stem, screw in, or union bonnet.
 - .2 Kitz 42, Crane 431, Jenkins 281OJ, Newman Hattersley T608 and Nibco T-131
 - .3 Gate valves 65mm (2½") and over flanged
 - .1 850 kPa (125 psi), to MSS SP-70, Class 125, cast iron body with flat faced flange, bronze or bronze faced solid wedge disc with bronze seat rings, rising stem, OS & Y, bolted bonnet.
 - .2 Kitz 72, Crane 465 ½, Jenkins 454J, Newman Hattersley #504 and Nibco F-617-O.
 - .3 1000 kPa (150 psi), to ASTM A216 grade WCB, Class 150, cast steel body with raised faced flange, flexible Type 416 stainless steel disc and hard faced seat rings, rising stem, OS & Y, bolted bonnet.
 - .4 Kitz 150 SCLS, Crane 47XUT and Jenkins J1009B8F

- .4 Globe valves 50mm (2") and under, soldered
 - .1 850 kPa (125 psi), to MSS SP-80, 300 CWP, bronze body, renewable composition PTFE disc, threaded over bonnet, lock shield handles as indicated.
 - .2 Kitz 10, Crane 1334/1320, Jenkins 813J and Nibco S-235-Y.
- .5 Globe valves 50 mm (2") and under, threaded
 - .1 1000 kPa (150 psi), to MSS SP-80, Class 150, bronze body, renewable composition PTFE disc, union bonnet, lock shield handles as indicated.
 - .2 Kitz 09, Crane 7TF, Jenkins 106BJ, Nibco T-235-Y and Newman Hattersley 13.
- .6 Swing check valves 50 mm (2") and under, threaded
 - .1 850 kPa (125 psi), to MSS SP-80, Class 125, bronze body, bronze swing disc, regrindable seat, screw-in cap
 - .2 Kitz 22, Crane 37, Jenkins 4073J, Newman Hattersley 47 and Nibco T-413
- .7 Swing checks 65mm (2½") and over, flanged
 - .1 850 kPa (125 psi), to MSS SP-71, Class 125, cast iron body with flat faced flange, renewable bronze seat rings, bronze faced iron or bronze disc, bolted cap.
 - .2 Kitz 78, Crane 373, Jenkins 587J, Newman Hattersley 651 and Nibco F-918
- .8 Swing check valves 50 mm (2") and over, grooved:
 - .1 2065 kPa (300 psig), ductile iron body with spring-assisted disc.
 - .2 Victaulic series 719, NPS 2 ½ to 4 and Victaulic series 779, NPS 4 to 14
- .9 Ball valves up to 50 mm (2"):
 - .1 1000 kPa (150 psi), two piece bronze body and chrome plated bronze ball, PTFE seat rings, solder joint or NPT to copper adapters, full port.
 - .2 Kitz 58 and 59, Crane 9302 and 9322, Jenkins 201J and 202J, Nibco S-FP-600 and T-FP-600 and Newman Hattersley 1969F and 1999.
- .10 Viega Valves (Propress, Megapress and MegapressG):
 - .1 MegaPress Press-Connect Valves (Hydronic systems only):
 - .1 Approved for use with carbon steel pipe shall conform to ASTM A53, A106, A135 or A795. Pipe schedule (pipe wall thickness) shall conform to the standard referenced dimensions for Schedule 5 to 40. Valves shall conform to MSS-110, ASME B31 and IAPMO Z1157. Ball valve shall be equipped with a full port, 316 stainless steel ball, blowout-proof 316 stainless steel stem, adjustable packing nut, PTFE stem seals, 304 stainless steel locking handle, 3-piece body and zinc nickel coated steel press ends.
 - .2 EPDM:
 - .1 Temperature range 0-250 F and max CWP 250. EPDM sealing element at each press connection
 - .3 FKM (Pipe Size 2" and smaller)
 - .1 Temperature range 14-284 F (with temperature spikes up to 356 F) and max CWP 250. FKM sealing element at each press connection
 - .4 FKM (Pipe Size 2 ½" to 4)

- .1 Temperature range 14-284 F (with temperature spikes up to 356 F) and max CWP 200. FKM sealing element at each press connection
- .5 Sealing element shall be uniform in size/thickness and shall be free from manufactured deformities or indentations.
- .6 Press ends shall have 420 stainless steel grip & 304 stainless steel separator rings.
- .7 Press Connect valves shall have the Viega Smart Connect feature integral to the fitting body to detect unpressed valves during the testing process.
- .8 Color-coded markings on exterior of fitting for readily identifying/inspecting sealing element type.
- .9 Approved manufacturer: Viega LLC (no exceptions).
- .2 ProPress and Cast Copper Alloy Press-Connect Valves (Domestic water only):
 - .1 Approved for use with copper tubing conforming to ASTM B88 or B75. When pressing onto B88 copper tube, types K, L, and M may be used. Tempers O60 and O50, known as "soft copper", are limited to nominal sizes 1/2" to 1-1/4". Temper H58, known as "hard copper", may be used with nominal sizes 1/2" to 4".
 - .2 Valves shall conform to IAPMO Z1157, NSF 61-372, NSF U.P. Code and listed by NSF to Commercial Hot water. Temperature range 0-250 F and max CWP 250.
 - .1 Ball valve shall be equipped with a full port, 316 stainless steel ball, blowout-proof Eco Brass® stem, reinforced PTFE seats, lockable metal handle, 2-piece zero lead bronze body with press ends.
 - .2 Peroxidically cured EPDM elastomeric sealing element
 - .3 Sealing element shall be uniform in size/thickness and shall be free from manufactured deformities or indentations.
 - .4 420 stainless steel grip & PBT separator rings for 2-1/2" to 4" sizes.
 - .5 Press Connect valves shall have the Viega Smart Connect feature integral to the fitting body to detect unpressed valves during the testing process.
 - .6 Color-coded markings on exterior of fitting for readily identifying/inspecting sealing element type.
 - .3 Approved manufacturer: Viega LLC (no exceptions).
- .3 MegaPress 316 Stainless Steel Press-Connect Valves (Domestic water only):
 - .1 Approved for use with stainless steel pipe conforming to ASTM A312. MegaPress 316 1/2" to 2 fittings can be used with Schedule 5 to Schedule 40 stainless steel pipe and 2 1/2" to 4 fittings can be used with Schedule 10 to Schedule 40 stainless steel pipe.
 - .2 Valves shall conform to MSS SP-110, ASME B31, IAPMO Z1157, NSF 61-372, NSF U.P. Code and listed by NSF to Commercial Hot water. Temperature range 0-250 F, max CWP 250 up to 2", and max CWP 200 from 2 1/2" to 4"

- .1 Ball valve shall be equipped with a full port, 316 stainless steel ball, blowout-proof 316 stem, reinforced PTFE seats, lockable metal handle, 3-piece stainless steel body with stainless steel press ends.
- .2 Peroxidically cured EPDM elastomeric sealing element
- .3 Sealing element shall be uniform in size/thickness and shall be free from manufactured deformities or indentations.
- .4 420 stainless steel grip & 304 stainless steel separator rings.
- .5 Press Connect valves shall have the Viega Smart Connect feature integral to the fitting body to detect unpressed valves during the testing process.
- .6 Color-coded markings on exterior of fitting for readily identifying/inspecting sealing element type.
- .3 Approved manufacturer: Viega LLC (no exceptions).
- .4 MegaPressG Carbon Steel Press-Connect Valves (Natural Gas only):
 - .1 Approved for use with ASTM A53 Schedule 10 to 40 carbon steel pipe.
 - .2 Shall be listed to CSA 6.32 / ANSI LC-4 or CSA 6.32a / ANSI LC-4a
 - .3 1/2" to 2" Iron Pipe Size.
 - .4 Sealing Element: HNBR elastomeric sealing element rated to 125 psi (max) with a temperature range of -40 to 180 degrees (F). Sealing element shall be uniform in size/thickness and shall be free from manufactured deformities or indentations.
 - .5 420 stainless steel grip ring.
 - .6 304 stainless steel separator ring
 - .7 Press Connect valves shall have Smart Connect Technology to detect unpressed fittings during the testing process.
 - .8 Color-coded markings on exterior of fitting for readily identifying/inspecting sealing element type.
 - .9 Approved manufacturer: Viega LLC (no exceptions).
- .12 Balancing cocks:
 - .1 50mm (2") and smaller: DeZurick series 425. 65mm (2½") and larger: Flanged DeZurick Series 100. Both types to be complete with memory stops.
- .13 Gas valves, CGA approved - lubricated plug type: 12 to 50 mm (½" to 2"): Hattersley #170M. 65 mm (2½") and greater, flanged: Newman Hattersley #171M.
- .14 Corporation stops and site service valves:
 - .1 Corporation Stops 2" to 12": Cambridge Brass "Century" brass body ball valve with connections to suit piping. Ball to be stainless steel with teflon seats. Provide cast iron housing with threaded cover to suit depth of bury.
 - .2 Valves 2" to 12" FM, UL and ULC approved: Kennedy Valve mod. 4701 to AWWA standard C509. Flanged epoxy coated cast iron body, non-rising stem, 2" operating nut and post plate complete with Clow Canada Series 900-S/900-C adaptor flange/restrainer where connection to PVC pipe is required. Provide extension stem and cast iron housing complete with cover to suit depth of bury. Valves as manufactured by Clow are also acceptable.
- .15 Balancing Valves:

- .1 Where specified at items of equipment and where shown on schematic piping diagrams, provide circuit balancing valves. Each valve to have features as follows:
 - .1 Manual Balancing Valves:
 - .1 All manual balancing valves shall incorporate the following features:
 - .1 'Y' pattern, equal percentage globe style.
 - .2 With tamperproof balance setting, positive shut-off and drain.
 - .3 Valves shall provide precise flow measurement, precision flow balancing, positive drip-tight shut-off.
 - .4 Valves shall provide multi-turn 360° adjustment with micrometer type indicators located on the valve handwheel.
 - .2 Up to 50 mm (2"):
 - .1 Bronze, brass or brass alloy body.
 - .2 2068 kPa (300 psi) maximum working pressure, 121°C (250°F) maximum operating temperature.
 - .3 Armstrong model CBV, Victaulic TA Series 78KH (male NPT x female NPT), 786H (solder end), 787H (female NPT threaded end), Bell & Gossett model CB, Hattersley model 1732.
 - .3 65 mm (2.5") and over:
 - .1 Cast or ductile iron body.
 - .2 ANSI 125 flanged connections or grooved connections.
 - .3 Armstrong model CBV, Victaulic TA Series 788 (flanged end), 789 (grooved end), Bell & Gossett model CB, Hattersley model MH737.
 - .2 Automatic Balancing Valves:
 - .1 All automatic balancing valves shall incorporate the following features:
 - .1 Valve shall be accurate to within +/-5% of set GPM within the valve's pressure control range.
 - .2 Valve shall have a maximum differential pressure control range of 60 psi.
 - .3 Valve body shall include two integrated pressure/temperature ports.
 - .4 Valve shall maintain a constant flow rate, regardless of pressure fluctuations in the system (pressure independent operation).
 - .2 Up to 50 mm (2"):
 - .1 Ductile iron body.
 - .2 2517 kPa (365 psi) maximum working pressure, 121°C (250°F) maximum operating temperature.
 - .3 Victaulic TA Series 76T (female x female threaded NPT / solder), 76B (female x female threaded NPT / solder, with ball valve kit), 76K (male x female threaded NPT / solder / union), 76V (male x female threaded NPT / solder / union, with ball valve kit), Bell & Gossett Circuit Sentry Flo-Setter II model FS (NPT female) or AF (NPT female/solder with union tailpiece).
 - .3 65 mm (2.5") and over:

- .1 Ductile iron body.
- .2 2517 kPa (365 psi) maximum working pressure, 110°C (230°F) maximum operating temperature.
- .3 Victaulic TA Series 76G (grooved ends)

2.04 HANGERS AND PIPING SUPPORTS

.1 Hangers:

- .1 Provide adjustable Clevis type equal to Grinnell Fig. 65 for pipe sizes up to and including 65mm (2½"). For pipe sizes 75mm (3") and over, provide adjustable Clevis type equal to Grinnell Fig. 260. Use rod sizes as recommended by the manufacturer. Provide Grinnell FM approved Fig. 104 split swivel or Fig. 69 swivel type hangers on fire protection piping. On copper piping, provide copper plated type hanger or separate piping from hanger with an approved insulating tape or plastic coating. Grinnell adjustable ring type fig. 97 and fig. 97c (coated) are acceptable on copper piping up to 65 mm (2½"). Where insulation covers hanger, refer to Section 20 05 25.
- .2 Provide oversized hangers to pass over insulation on all cold water piping. Refer to detail drawings and Section 20 05 25.
- .3 For corrosive environments (pool areas) shall be stainless steel.

.2 Piping supports:

- .1 For roof mounted piping, provide pipe roller supports with clamps as manufactured by Portable Pipe Hangers installed to Manufacturer's specifications. Use PPH model SS-8R or PP10 with roller for piping up to 65mm (2½") and use model PS-1-2 for pipes over 75mm (3") and up to 200mm (8"). For refrigeration piping and conduits, use PPH model PS1-2. For pipes over 75mm (3"), use PPH-RB18 with clamps, base and all other applicable support. Supports to be aluminium with stainless steel clamps and rollers. Membrane pads to be close-cell extruded polystyrene insulation equal to Dow Chemical Roofmate.
- .2 For roof mounted gas piping: On stable flatbed roof, use pipe supports by Quick Block with oversized stainless steel clamps for roof mounted gas piping up to 125mm (5"). Supports for gas piping must be CGA certified & listed and meeting the requirement of gas code B149.1.
- .3 For pipe risers, provide supports equal to Grinnell Fig. 40, black carbon steel, sized to carry the operating weight of the piping.
- .4 Provide complete pipe support systems including bases, framing, hangers, rollers, clamps, guides and other devices required for supporting piping on roof and elsewhere as indicated on the Drawings as manufactured by Portable Pipe Hangers Inc.
 - .1 System to be an engineered prefabricated portable pipe support system specifically designed to be installed on roof surfaces without penetrations, flashing or damage to the roofing material. Components to consist of recycled rubber and plastic bases, structural steel frame and suitable pipe hangers and supports custom designed to fit the specified piping and actual conditions of service.
 - .2 Shop Drawings and Product Data: Submit for all products proposed for use, describing physical characteristics, sizes, patterns, and method of installation. Provide evidence that proposed adhesives for setting bases are compatible with, and will not damage or cause deterioration to roofing system. Provide certified test reports, prepared by an independent testing laboratory, showing conformance to specified quality standards representing average results for production.

- .3 Prior to installation of Work, ensure that installers thoroughly understand all installation requirements. Provide the services of the Manufacturer's representative to review the installation and all required instructions. Arrange for the Manufacturer's representative to inspect during installation and on completion and to issue a report attesting to compliance with Manufacturer's requirements. Provide a copy of this report for inclusion in the Project Manual.
- .4 Deliver all materials to the site of the Work in the Manufacturer's original packaging.
- .5 Warranty: Provide certified copies of the manufacturer's product warranty covering pipe support bases against deterioration for the same duration as roofing warranty.
- .6 Bases: black injection molded and pressed recycled plastic and rubber to ASTM D695-91, D790-92, D1929-19a, with inserts for square tubing or threaded rod as required and designed to support the weight of piping as shown on the Drawings.
- .7 Framing: B Line 40 mm (1 $\frac{5}{8}$ ") B22TH or 47 mm (1 $\frac{7}{8}$ ") BTS22TH, fabricated of steel to ASTM A570-92, Grade 33, roll formed of 2.7 mm thick (12 gage) steel into 3-sided tubular shape and continuously welded and perforated with 14mm ($\frac{9}{16}$ ") holes at 47mm (1 $\frac{7}{8}$ ") centers on 3 sides.
- .8 Framing: B Line 40 mm (1 $\frac{5}{8}$ ") B22TH or 47 mm (1 $\frac{7}{8}$ ") BTS22TH, fabricated of stainless steel to ASTM A 167, type 304 or 316 roll formed of 2.7 mm thick (12 gage) steel into 3-sided tubular shape and continuously welded and perforated with 14mm ($\frac{9}{16}$ ") holes at 47mm (1 $\frac{7}{8}$ ") centers on 3 sides.
- .9 Pipe Supports and Hangers: to MSS SP-58 and MSS SP-69. Supports and hangers to be fabricated of carbon steel stainless steel the same as for framing.
- .5 63 mm (2 $\frac{1}{2}$ ") and smaller: Single roller supports for piping subject to expansion and contraction; 3 Sided channels and pipe clamps.
- .6 76 mm (3") and larger: Rollers clevis hangers, to allow for expansion and contraction without movement of the bases.
- .7 Provide all clamps, bolts, nuts, washers, and other devices as required for a complete system.
- .8 Finishes:
 - .1 Metal surfaces: Hot dip galvanize metal framing, supports and hangers with coatings free of roughness, whiskers, unsightly spangles, icicles, runs, barbs, sags, droplets, and other surface blemishes. Galvanizing to conform to ASTM A123 for tubing and ASTM A153 for hardware and accessories.
 - .2 Metal surfaces: Stainless steel surfaces to have mill finish.
 - .3 Bases: Black as molded.
- .9 Verify that roofing system is complete, and roof surfaces are smooth and flat and are ready to receive Work.
- .10 Verify that roof temperature is a minimum of 15.5°C. (59.9°F) for proper adhesive performance.
- .11 Use care in installation of portable pipe support systems not to damage roofing, flashing, equipment or related materials.
- .12 Clean surfaces of roof to receive portable pipe support bases. Remove gravel from gravel surfaced roofs, remove dirt, dust, oils, and other foreign materials from all roofs. Prime existing membrane with a primer that is compatible with existing components in the roofing system.
- .13 Locate bases and support framing as indicated on drawings and as specified herein.

- .14 Ensure that pipe deflection does not exceed 1/240th of the span and in no case that spacing exceeds 3m (10 ft.).
- .15 Set bases with adhesive in accordance with manufacturer's installation instructions. Accurately locate and align bases. Where applicable, replace gravel around bases after installation.
- .16 Set framing posts into bases and assemble framing structure. Provide galvanized fasteners for galvanized framing, and stainless steel fasteners for stainless steel framing.

2.05 INSERTS

- .1 Use only factory made, threaded or toggle type inserts as required for supports, and anchors, properly sized for the load to be carried.
- .2 Use factory made expansion shields where inserts cannot be placed, but only as accepted by the Consultant and for light weights.
- .3 Do not use explosive activated tools except with written acceptance of the Consultant.

2.06 SLEEVES

- .1 Piping: Machine cut schedule 40 steel pipe, medium cast iron or 18 gauge galvanized steel; refer to detail drawings.
- .2 Ductwork: At fire dampers refer to detail drawings: Other locations formed to accommodate duct size or access opening as required.

2.07 AIR VENTS

- .1 Provide air vents as manufactured by Maid O Mist No. 7 series or Braukmann. Where system pressure exceeds 345 kPa (50 psig) provide air vents with 1035 kPa (150 psig) rating.

2.08 EXPANSION TANKS

- .1 Provide in sizes as shown 1380 kPa (200 psi) in equipment schedules expansion tanks meeting current ASME and CSA code requirements designed for a maximum working pressure of 1035 kPa (150 psi) constructed of mild steel with prime painted finish and complete with sight glass and all necessary tappings in combination with Filtrol valve and automatic vent.
- .2 Acceptable Manufacturers: O'Connor, Clemmer, Amtrol, Expanflex.

2.09 ANCHORS, GUIDES AND EXPANSION COMPENSATORS

- .1 Provide hangers, supports, anchors, guides, expansion compensation and restraints for all vertical piping risers and horizontal piping for all services including but not limited to, heating, cooling, domestic water (all), drainage (all), fuel oil, gas, fire protection.
- .2 Mechanical contractor is to review all structural drawings and in particular refer to the "structural Deformation" drawing for building movement and or shrinkage. If this drawing is not available the contractor must obtain this information direct from the structural consultant.
- .3 Design Standards: Expansion Joint Manufacturer Association, ASTM B31.1, ASTM B31.9, ASHRAE and Manufacturers Standardization Society.

- .4 All vertical risers and horizontal piping for all services including but not limited to, heating, cooling, domestic water (all), drainage (all), fuel oil, gas, fire protection subjected to thermal expansion and/or contraction including building movement and building contraction shall be supported by spring isolators and central anchors designed to ensure loading within design limits at structural support points. The riser design must be prepared and submitted for approval by the same isolation vendor supplying the HVAC mechanical equipment isolation and must include the initial load, initial deflection, change in deflection, final load and change in load at all spring support locations. In order to minimize load changes, the initial spring deflection must be at least 4 times the thermal movement. The isolation vendor shall provide and design all brackets at riser spring and anchor locations where standard clamps lack capacity or do not fit. The contractor must install and adjust all isolators under the supervision of the designing isolation vendor or his representative. The submittal must also include anchor loads when installed, cold filled, and at operating temperature. Include calculated pipe stress at end conditions and branch off locations as well as installation instruction. The support spring mounts to be Type SLF, anchors Type ADA, telescoping guides Type VSG, all as manufactured by Mason Industries, Inc.
- .5 Hangers, supports, anchors, guides, expansion compensation, spring isolators and restraints to be designed and selected to withstand all static and dynamic loading conditions which act upon the piping system and associated equipment. The Mechanical Contractor is responsible to engage a Professional Engineer for the design of all hangers, supports, anchors, guides, expansion compensation, spring isolators and restraints systems based on piping material used and final layout of piping risers. The Mechanical Contractor is also responsible to provide detailed shop drawings showing calculations and equipment details of all anchors, guides and compensation for all systems with potential for thermal expansion/contraction and/or loads due to weight or thrust including heating and cooling mains, fan coil or heat pump risers and domestic water risers. These shop drawings to bear the signed seal of a Professional Engineer licensed to practice in the appropriate discipline and place of work. These shop drawings to include all details of construction including but not limited to the following:
 - .1 Static and dynamic forces at each anchor.
 - .2 Manufacturer's cut sheets for anchors.
 - .3 Thermal compensation calculations.
 - .4 Manufacturer's cut sheets for compensation equipment.
 - .5 Manufacturer's cut sheets for guides.
 - .6 Amount of expansion per floor and amount of expansion between each anchor based on Actual temperature of pipe when anchors were installed.
 - .7 Distance between floors.
- .6 Make adjustments as necessary to satisfy the requirements of Structural Division.
- .7 No anchors to be installed prior to shop drawings being reviewed and approved by Structural Division.
- .8 Expansion compensation supplier to be responsible for site review/inspection of all devices and verification that all compensation devices are in the neutral position after anchoring and verification that any temporary spacing device, locking tabs, etc. have been removed prior to any heating or cooling system start up. Upon completion of review/inspection the mechanical contractor to issue a detailed report to the Consultant, including photos and including location of each device, signed by supplier confirming that each compensation device has been reviewed.
- .9 Anchors, guides, expansion compensation shown on the drawings are for information only. Mechanical Contractor to be responsible to provide all elements of the system as described above.

- .10 Selection of compensators to meet the pressure rating of each system. Compensators in domestic water application to meet the requirement of NSF 61. Bellows type expansion compensators not to be used for compensation on fan coil or heat pump risers. Provision to be made for seismic protection in seismic zones. Acceptable manufacturer: Mason Industries.
- .11 Provide proper protection of all branch lines which are subject to the temperature difference and/or movement of vertical risers. Proper support, spring hangers and/or stainless steel braided hoses may be used for the protection of the piping systems.
- .12 Professional engineering design services for detailed design of anchors, compensation and guides from the following companies will be accepted:
 - Tecoustics Ltd.
5036 South Service Road
Burlington, ON L7L 5Y7
(905) 681-6077
 - Pressure Vessel Engineering Ltd.
120 Randall Drive
Suite B
Waterloo, ON
(519) 880-9808
 - Victaulic
123 Newkirk Road
Richmond Hill, ON L4C 3G5
(905) 780-5418

2.10 STRAINERS

- .1 Provide where shown on the drawings, strainers as manufactured by Kitz, Mueller or Spirax Sarco:
 - .1 50 mm (2") and smaller:
 - .1 863 kPa (125 psig) / 1379 kPa (200psi) WOG rating
 - .2 Cast bronze body, screwed cap, Y-pattern, threaded or soldered ends.
 - .3 Kitz 15 (threaded)/16 (soldered), Mueller 351M (threaded)/353 1/2MM (soldered)
 - .2 65 mm (2½") and greater:
 - .1 Class 125
 - .2 Cast iron body, bolted cover, Y-pattern, flanged ends.
 - .3 Kitz 80, Mueller 758
- .2 Unless noted otherwise, provide an integral strainer for pressure relief valves, pressure regulating valves and backflow preventers.
- .3 Strainer baskets:
 - .1 Type 304 stainless steel or Monel,
 - .1 2" and smaller strainer size:
 - .1 20 mesh perforations for water
 - .2 2 ½" to 4" strainer size:
 - .1 1.57mm (0.062") perforations for water

- .3 5"-10" strainer size
 - .1 3.17mm (0.125") perforations for water
- .4 10" and larger size
 - .1 3.17mm (0.125") perforations for water
- .5 For pump suction service, provide 3.175mm (0.125") perforations.
- .4 Combination strainers and pump inlet diffusers, with screens as specified above, manufactured by S.A. Armstrong Ltd. (Suction Guide), Victaulic (Style 731) or Taco Model SDO are also acceptable.

2.11 THERMOMETERS AND GAUGES

- .1 Pressure Gauges:
 - .1 Gauges where indicated on the drawings: Winters model P1S-100 Series to ANSI B40.100 grade "1A" level with SI and Imperial scales 115mm (4½") complete with ball valves and PSN B snubbers. Scale: To meet operating pressure ranges. 0-700 kPa (0-100 psi).
 - .2 Provide brass, bronze or copper fittings only.
- .2 Thermometers
 - .1 Provide liquid filled thermometers complete with brass separable wells as shown on the Drawings and as manufactured by Weis, vari-angle with 230 mm (9") scale. Range: 0°C to 50°C (32°F to 122°F) for chilled and condenser water and 10°C to 150°C (50°F to 302°F) for hot water with both Celsius and Fahrenheit scales.

2.12 WIRING

- .1 Electric power wiring for equipment (connection of motors through starters and disconnects) provided by electrical trades is specified in Division 26. Electrically operated equipment: to CSA Standard and bear Certification label. All high voltage wiring shall be provided by Division 26 following the specifications provided.
- .2 All low voltage (control) wiring between the motor and equipment / instrumentation to be provided by this division.
- .3 Provide motor control wiring (at any required voltage) between starter panels and control components to all requirements specified for similar wiring in Division 26.
- .4 Provide wiring of items supplied by equipment manufacturers such as filter advance motors and control, high level alarms, low water cut offs, anti-vibration lock outs, flow switches, remote and local thermostats for unitary heating equipment and rooftop HVAC units, sump pump alternators, level controllers, water treatment equipment, and oil/grease interceptor alarms, and control wiring between starters and control panels (e.g. air cooled condensers, cooling towers and condensing units). Also provide wiring for communications interface panels, sensors, oil pumps, purge pumps and oil heaters supplied with water chillers. Refer also to Section 25 01 01.

2.13 ELECTRIC MOTORS

- .1 CSA labelled, and except where specifically noted, all motors below 560 Watt (3/4 HP): 120 volt, single phase, 60 cycle. 560 Watt (3/4 HP) and over: 600 volt 3 phase, 60 cycle refer to Electrical Drawings and Mechanical Equipment Schedules for exact details. Motors to meet NEMA standards for maximum sound level ratings under full load. Service factor on all motors to be 1.15.
- .2 Motor bearings: to be permanently lubricated ball type for motors up to and including 3725 W (5 hp). Bearings for all motors over 3725 W to be self-aligning greaseable ball bearings sized to provide life of at least 50,000 hours under belt driven service.
- .3 Single Phase Motors: Provide permanent split capacitor type. Motors 14.9 kW (20 hp) and greater: Provide thermistor over temperature protection for each winding, wire in series, with leads terminated in the motor junction box.

- .4 All motors over 186 W (1/4 HP) to be TEFC. All motors over 1 HP to be high efficiency type with ratings based on statistically valid Quality Control procedures conforming to ANSI/IEEE 112 (Ref. 10), Test Method B (dynamometer), using NEMA MG1 (MG1-12.54 and MG1-12.55) (Ref.11), and conforming to efficiency ratings as defined in Table 10.4.1.A (a) under SB-10 of Ontario building Code. Motors to be approved under the Canadian Electrical Safety Code.
- .5 For motors used with variable frequency drives, provide Class H motor winding insulation and be inverter duty type manufactured to NEMA Standard MG-1 part 31 "Definite purpose inverter-fed motors". Ensure that drive Manufacturer reviews motor shop drawings prior to releasing order.
- .6 Acceptable electric motor manufacturers: Westinghouse, CGE, Reliance, Brook-Crompton, Marathon, US Motors, WEG and Siemens.

2.14 MOTOR STARTERS – LOW VOLTAGE

- .1 Electric motor starters for all motorized mechanical equipment are to be provided by Divisions 20, 21, 22, 23 and 25. Refer to Section 20 05 35 Motor Starters – Low Voltage for the requirements of motor starters.

2.15 AIR SEPARATORS

- .1 The Air Separator shall be designed, constructed, and stamped in accordance with Section VIII, Division I of the ASME Boiler and Pressure Vessel Code, and registered with the National Board of Boiler and Pressure Vessel Inspectors.
- .2 The Air Separator shall be rated for 1034kPa (150psi) maximum working pressure.
- .3 The Air Separator shall have a maximum temperature rating of 350°F (177°C).
- .4 The Air Separator body shall be made of cast iron or carbon steel.
- .5 The Air Separator body shall be three times the nominal inlet/outlet pipe diameter.
- .6 The Air Separator shall include threaded blow down connection to allow for sediment to be regularly cleaned out of the unit.
- .7 The Air Separator shall include a threaded air removal connection on top of the unit so an air vent or expansion/compression tank can be connected, allowing collected air to be removed from the unit. Provide automatic air vent at each air separator.
- .8 The Air Separator shall be available with either NPT end connections (50mm thru 75mm sizes only), flanged end connections, or grooved end connections. Flange end connections should be designed according to ANSI Standards.
- .9 Unless otherwise indicated, air separators are to be line sized.
- .10 Acceptable manufacturers: Xylem Bell and Gossett, Armstrong, Taco, or Consultant approved equal.

2.16 MECHANICAL IDENTIFICATION

- .1 Generally, in existing buildings, equipment nameplates and tagging shall be the same as the existing tags for equipment being replaced, or an extension of existing tagging for any new equipment. Exact nameplate wording and sizes must be reviewed and confirmed by the Consultant prior to manufacture and installation.
- .2 Equipment Nameplates
 - .1 Provide apparatus (including electric motors) with proper nameplates affixed thereto, showing the size, name of equipment, serial number and all information usually provided, which also includes voltage, cycle, phase and horsepower of motors and the name and address of the Manufacturer.

- .2 Nameplate wording shall also include equipment tag information, generally to be as per drawings (i.e. EF-1, AHU-1, etc.), and is to include equipment service and building area/zone served.
- .3 Nameplates for equipment suspended above floor level or generally not within easy viewing from floor level are to be increased in size so as to be easily readable from floor level.
- .3 Valve Tags
 - .1 Valve tags are to be coloured, 40 mm (1-½") square, 2-ply laminated plastic with bevelled edges, red-white, green-white, yellow-black, etc., to match piping identification colour, each complete with a 3.2 mm (1/8") diameter by 100 mm (4") long brass plated steel bead chain, and four lines of engraved maximum size identification wording, i.e.:
 VALVE V12
 200 mm (8")
 CHILLED. WATER
 NORMALLY OPEN
- .4 Pipe Identification
 - .1 Standard pipe identification to be Smillie McAdams Summerlin Ltd., Brady or Primark Manufacturing Inc. vinyl plastic with indoor/outdoor type vinyl ink lettering and directional arrows, as follows:
 - .1 For pipe less than or equal to 150 mm (6") diameter, coiled type snap-on markers of a length to wrap completely around pipe or pipe insulation;
 - .2 For pipe larger than 150 mm (6") diameter, saddle type strap-on markers with 2 opposite identification locations and complete with nylon cable ties.
 - .2 All pipe identification tags must include the pipe size.
 - .3 Identification wording and colours for pipe identification materials are to be as follows:

PIPE SERVICE	IDENTIFICATION COLOUR	LEGEND
domestic cold water	Green	XØ -DOM. COLD WATER
domestic hot water supply	Green	XØ -DOM. HW SUPPLY
domestic hot water recirculation	Green	XØ -DOM. HW RECIRC.
storm drainage	Green	XØ -STORM
sanitary drainage	Green	XØ -SAN.
plumbing vent	Green	XØ -SAN. VENT
natural gas	to Code	XØ -to Code, c/w pressure
natural gas vent	to Code	XØ -to Code
heating water supply	Yellow	XØ -HTG. WTR. SUPPLY
heating water return	Yellow	XØ -HTG. WTR. RETURN
heating water drain	Yellow	XØ -HTG. WTR. DRAIN

PIPE SERVICE	IDENTIFICATION COLOUR	LEGEND
glycol heating supply	yellow	XØ -GLY. HTG. SUPPLY
glycol heating return	Yellow	XØ -GLY. HTG. RETURN
glycol heating drain	Yellow	XØ -GLY. HTG. DRAIN
Glycol heat reclaim return	Yellow	XØ -GLY. HTG. RECLAIM R.
Glycol heat reclaim supply	Yellow	XØ -GLY. HTG. RECLAIM S.
Condenser water supply	Green	XØ -COND. WTR. SUPPLY
Condenser water return	Green	XØ -COND. WTR. RETURN
Chilled water supply	Green	XØ -CH. WTR. SUPPLY
Chilled water return	Green	XØ -CH. WTR. RETURN
Chilled water drain	Green	XØ -CH. WTR. DRAIN

.5 Duct Identification

- .1 Duct identification is to be custom made Mylar stencils with 50 mm (2") high lettering to accurately describe duct service, i.e. "AHU-1 SUPPLY", complete with a directional arrow, and coloured ink with ink pads and roller applicators. Ink colour is generally to be black but must contrast with lettering background. Supply, return and exhaust ducts shall all be properly identified.

PART 3 - EXECUTION

3.01 INSTALLATION

- .1 Install equipment, ductwork, conduit and piping in a workmanlike manner to present a neat appearance and to function properly to the acceptance of the Consultant. Install ducts and pipes parallel and perpendicular to building planes. Install piping and ductwork concealed in chases, behind furring, or above ceiling. Install exposed systems grouped to present a neat appearance. Comply with manufacturer's installation instructions.
- .2 Install gauges and thermometers to permit easy observance from floor level.
- .3 Install all equipment and apparatus with adequate space allowance for wiring, maintenance, adjustment and eventual replacement.
- .4 Install control devices to guarantee proper sensing. Shield elements from direct radiation and avoid placing them behind obstructions.
- .5 Include in the Work all requirements of Manufacturers shown on shop drawings.
- .6 Install all ceiling mounted components (Diffusers, Grilles,) in accordance with reflected ceiling Drawings.
- .7 Leave space clear and install all work to accommodate future materials and/or equipment and to accommodate equipment and/or materials supplied by other trades. Verify spaces in which work is to be installed. Install pipe and ductwork runs to maintain maximum headroom and clearances and to conserve space in shaft and ceiling spaces.
- .8 Confirm on the site the exact location of equipment and fixtures. Confirm location of equipment supplied by other trades and mechanical requirements thereof.

- .9 Where FMP "flow measurement port" is shown on the Drawings, make installation as described on the Detail Drawings and in a location as shown on the schematic piping drawings. Install the flow measurement port in straight run of pipe at least 3 m (10 ft. +/-) downstream from any valve, thermometer, tee, elbow or any other pipeline device.

3.02 EQUIPMENT CONNECTIONS

- .1 Install piping connections to pumps and all other equipment without strain at the pipe connections. Remove, where requested by the Consultant, bolts in flanged connections or disconnect piping after the installation is complete to demonstrate that the piping has been so connected.
- .2 Provide shut off valves on supply and return piping connections on all items of equipment.
- .3 Provide flexible connectors on supply and return piping connections on all based mounted pumps.
- .4 Corrosion Prevention: Install dielectric couplings as specified in Part I at:
 - .1 Connections to copper/aluminum perimeter convectors, radiant ceiling panels and coils with copper connections in steel piping systems.
 - .2 Connections between copper and steel pipe.
 - .3 Connections to cooling coil condensate drains.
 - .4 Steel Valves used in a copper or copper alloy piping system. In this case, use brass or bronze valves whenever possible.
 - .5 Connections to expansion tanks and domestic hot water tanks in copper piping systems.
 - .6 In either steel or copper piping systems, do not put short black steel nipples and individual black steel fittings between brass or bronze components such as valves use only copper, brass or bronze components. Use a minimum of eight times the mass of steel pipe or components between any two brass, bronze or copper fittings or components.
 - .7 Do not use copper alloy (brass and bronze) fittings and valves in place of specified dielectric couplings.
 - .8 Steam boilers: Connections to the boilers are to be swing joints. Provide a minimum of 600mm (24") piping for swing joints.

3.03 DRAINS

- .1 Pipe all discharge from relief valves and drains from equipment, outside air plenum/louvre, chemical pot feeders and tanks to nearest floor drain or suitable receptacle.
- .2 Provide 20mm (¾") ball valves with hose ends, caps and chains at strainers, all piping system low points, pumps, coils and at each piece of equipment.
- .3 Provide deep seal traps (150mm trap seal) on all air handling equipment condensate drains and on floor drains located within air handling unit plenums. Provide trap seal primers on all floor drain traps and gash traps.

3.04 PIPING SYSTEM INSTALLATION

- .1 Install all piping in accordance with the best practices of the trade.
- .2 The piping shown on the drawings is diagrammatic for clearness in indicating the general run and connections and may or may not be, in all instances, shown in its true position. Take responsibility for the proper erection of systems of piping in every respect suitable for the work intended and as described herein.
- .3 Keep plugged or capped all openings in pipe or fittings during installation.
- .4 Install piping to avoid any interference with the installation or removal of equipment, other piping and ducts.

- .5 Install all valves, strainers and specialties to permit easy operation and access. On horizontal piping, install valves in an upright position. Where there are space constraints mount valves at a 45 deg. off vertical maximum. Install strainers to provide easy strainer basket removal.
- .6 Install systems to provide thorough drainage and air elimination.
- .7 During welding or soldering procedures, provide a fire retardant cloth, mat or blanket to protect the structure, and adequate fire protection equipment at all locations where work is being done. Close off shaft or confined areas with a fire retardant mat or cloth to prevent sparks or pieces of hot metal from falling down the shaft or area way.
- .8 Provide long turn pipe fittings having not less than pipe wall thickness. Provide line size tees. Where branch lines are more than two sizes smaller than the main, weldolets may be used.
- .9 Where steel piping is required to be buried, apply two coats of Densopaste (Denso of Canada Ltd.) primer to all buried surfaces after assembly and testing. Hot or cold applied tape as manufactured by Tapecoat, selected for the application and applied to manufacturer's instructions, is also acceptable.
- .10 Where it is necessary to offset piping to avoid obstructions, use 45 degree rather than 90 degree elbows.
- .11 Provide suitable cleanouts on every other change in direction and slope all condensate drip drains.
- .12 Make all threaded pipe joints on water piping using a thread paste or teflon tape suitable for the service for which the pipe is to be used. Use of hemp or similar materials on threaded joints will not be permitted.
- .13 For Grooved Couplings and Fittings: Comply with manufacturer's installation instructions for all products. Ensure that grooved pipes are in compliance with the current manufacturer's specifications and recommendations.
 - .1 Ensure that the "A" dimension, i.e. the area from the pipe end to the front edge of the groove is free from indentations, scores, seams, projections or roll marks.
 - .2 Use only lubricants which are nontoxic and non-injurious to the gasket material.
 - .3 Upon completion of assembly, the bolt pads of each coupling must be fully drawn together, except for HP 70 (Victaulic) couplings in sizes to 100mm (4").
 - .4 All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
 - .5 The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. .
 - .6 A factory-trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. Factory-trained representative shall periodically review the product installation as requested by the Consultant. Contractor shall remove and replace any improperly installed products.
- .14 Natural Gas Piping: Install in accordance to relevant Codes. Provide vents to atmosphere for all safety switches and regulators as required by Code. Provide approved type pipe supports under roof mounted piping and install all supports according to Code and manufacturer's instruction. Refer to the Gas Code for spacing requirements.
- .15 Install all piping requiring insulation with sufficient clearance to apply, seal and finish the insulation.
- .16 Provide sufficient space between piping to install valves arranged in straight rows or equally spaced steps. Valve wheels, handles and operators to be easily accessible and operable.

- .17 Do not install horizontal piping within masonry walls. Any piping installed in this manner will not be accepted.
- .18 Use only non-ferrous metals in high humidity areas.
- .19 Do not suspend any equipment, piping, ducting or any other mechanical components from formed hollow steel decking.
- .20 Acid waste and vents: Vents to be taken directly to roof vents and installed separately from non-acid waste systems. Vents to be C.I. where they pass through building roof. Provide fibreglass protective packing at sleeves. Provide rigid fibreglass pads (sections of pipe covering) at all support points in accordance with manufacturer's instructions.
- .21 Sanitary and storm piping: Provide all necessary restraining devices for all vertical and horizontal piping in major piping offsets or where turn of direction occurs. Restraining devices are to be an engineered product and designed solely for restraining application. Installation of restraining devices to be provided according to manufacturer's requirement.
- .22 Underground sanitary and storm piping: Underground sanitary and storm piping required to be hung under structure slab are to be cast iron piping meeting the requirements of the Authorities having jurisdiction.
- .23 Victaulic Piping:
 - .1 Victaulic Certified Contractor Training:
 - .1 The grooved coupling manufacturer's (the "manufacturer") factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and installation of grooved joint products. All contractor field personnel installing Victaulic couplings must have completed the Victaulic Certification Program. This shall be at the expense of the installing contractor
 - .2 Victaulic Inspection Services:
 - .1 A Victaulic factory trained representative shall periodically visit the job site and review the installation for best practices. Victaulic product that has been examined and has not met the visual inspection criteria for proper installation must be corrected and re-examined by Victaulic Inspection Services prior to the completion of the project. The installing Contractor shall correct any identified deficiencies.
 - .2 Victaulic product that has been examined and has not met the visual inspection criteria for proper installation must be corrected and re-examined by Victaulic Inspection Services prior to the completion of the project. Any Victaulic product that has not been corrected or was not examined will not be considered as part of the successful completion of Victaulic Inspection Services.
 - .3 Application:
 - .1 Upon completion of the manufacturer's inspection of the installation and any identified corrections, the manufacturer must provide the owner or purchaser with a warranty on manufacturer's products and their installation. The manufacturer shall provide a letter confirming that upon review, all products were adequately installed and the system meets their installation requirements. The manufacturer must determine the number of fittings that need to be reviewed in order to provide this sign-off documentation. This letter shall be included as part of the close-out documentation.
- .24 Viega Propress, Megapress and MegapressG Installation:

- .1 Installers shall attend a manufacturer's installation training course and obtain certification as having been trained and qualified to join piping with press-connect valves. On-site training and credentialing by manufacturer's representative is acceptable.
 - .2 Installer shall be a qualified installer, licensed within the jurisdiction, and familiar with the installation of press-connect bronze, copper, carbon steel or stainless steel valves.
 - .3 Press-connect bronze, copper, carbon steel or stainless steel valves shall be installed using proper tool, actuator, jaws, and rings as instructed by the manufacturer.
 - .4 A Viega factory trained representative shall periodically visit the job site and review the installation for best practices. Viega product that has been examined and has not met the visual inspection criteria for proper installation must be corrected and re-examined by Viega Inspection Services prior to the completion of the project. The installing Contractor shall correct any identified deficiencies.
 - .5 Upon completion of the manufacturer's inspection of the installation and any identified corrections, the manufacturer must provide the owner or purchaser with a warranty on manufacturer's products and their installation. Viega shall provide a letter confirming that upon review, all products were adequately installed and the system meets their installation requirements. The manufacturer must determine the number of fittings that need to be reviewed in order to provide this sign-off documentation. This letter shall be included as part of the close-out documentation.
- .25 Provide a stainless steel drip pan under all piping installed in: electrical, communications, security, CACF rooms or any room in which valuables can be damaged (ex. Locker Rooms). Drip pans to be sloped and piped to the nearest funnel floor drain.

3.05 CONTROL COMPONENTS

- .1 Install all pipe line devices required by the Section 25 01 01 sub-contractor such as flow switches, valves and separable wells for temperature controllers and sensors.

3.06 DIRT ACCUMULATION IN CONTROL VALVES

- .1 Remove any dirt accumulated under seats of automatic control valves during the first year's operation. Replace damaged valve parts at no additional cost to the Owner.

3.07 FIELD WELDING

- .1 Included in the scope of work, make arrangements and pay for registration and inspection by TSSA, for the following pressure piping systems:
 - .1 Steam piping including condensate piping at pressure 100 kPa (15 psig) or higher.
 - .2 Service water piping at design temperature above 121°C (250°F) or at design pressures at and above 1070 kPa (160 psig)
 - .3 Chilled water and cooling water at design temperatures above 65°C (150°F) or design pressures above 1725 kPa (250 psig)
 - .4 Fuel oil piping at pressure 690 kPa (100 psig) or higher
 - .5 Compressed air, greater than 19mm (¾"), at pressures and over 100 kPa (15 psig)
 - .6 Medical gas piping system
 - .7 Other piping system as required certification by the Authorities Having Jurisdiction.
- .2 Piping standards to ASME B31.1 Code for Pressure Piping, for registered pressure piping system.
- .3 Welding to be carried out using approved procedures by welders certified for pressure piping by TSSA.
- .4 Arrange and pay for services of an Inspection Company specializing in making and interpreting x-rays of pipe welds. Examine a minimum of 10% of welds in piping carrying:

- .1 Steam at 700 kPa (100 psi) or over using random selection procedure.
- .2 Any service where the system pressure exceeds 1034kPa (150 psi).
- .3 Any service where the system pressure is less than 1034kPa (150 psi) but the pipe sizing carrying such service is larger than 200 mm (8").
- .5 Only persons holding current welding certificates for the applications required for the Work to be permitted to do any welding. Qualify welders according to ASME equivalent testing procedures. Do not use welders, on or off site work who are not qualified for the work. Maintain records for all qualification testing, and provide copies to the Consultant on request.
- .6 Identify work in accordance with codes and standards. Welds shall be full penetration, continuous and without defects. After deposition, each layer of weld shall be cleaned to remove slag and scale by wire brushing or grinding, then chipped where necessary to prepare for proper deposition of the next layer. The weld reinforcement shall not be less than 1/16" (1.6 mm) and not more than 1/8" (3.2 mm) above the normal surface of the joined sections. The reinforcement shall be crowned at the centre and shall merge into the base material without excessive shoulder or undercut.
- .7 Welding shall be made by machine or manual shielded metallic arc process. Direct current shall be used exclusively with the base material on the negative side of the line. Electrodes used shall be an approved all position rod type.
- .8 Perform all welding to Standards specified by Authorities.
- .9 Do not weld to structural members of the building.
- .10 Provide a copy of TSSA registration and include with Maintenance Manuals.

3.08 HANGERS

- .1 Hanger rods may be attached to beam or joist clamps, brackets, or concrete inserts. Explosive actuated tools are not permitted. Do not weld to structural steel unless accepted by the Consultant.
- .2 Install hangers to the following table.

STEEL PIPE	
Nominal Pipe Size	Distance Between Supports
Up to 32mm (1¼")	2,400mm (8 ft.)
40mm (1½") - 65mm (2½")	3,000mm (10 ft.)
75mm (3") and over	3,600mm (12 ft.)

COPPER TUBING	
Nominal Pipe Size	Distance Between Supports
Up to 20mm (¾")	1,800mm (6 ft.)
20mm (¾") - 25mm (1")	2,400mm (8 ft.)
32mm (1¼") - 50mm (2")	3,000mm (10 ft.)
65mm (2½") and over	3,600mm (12 ft.)

- .3 Installation of Portable Pipe Hangers Inc. pipe supports:

- .1 Verify that roofing system is complete, and roof surfaces are smooth and flat and are ready to receive Work.
- .2 Verify that roof temperature is a minimum of 15.5°C (59.9°F) for proper adhesive performance.
- .3 Use care in installation of portable pipe support systems not to damage roofing, flashing, equipment or related materials.
- .4 Clean surfaces of roof to receive portable pipe support bases. Remove gravel from gravel surfaced roofs, remove dirt, dust, oils, and other foreign materials from all roofs. Prime existing membrane with a primer that is compatible with existing components in the roofing system.
- .5 Locate bases and support framing as indicated on drawings and as specified herein.
- .6 Ensure that pipe deflection does not exceed 1/240th of the span and in no case that spacing exceeds 3m (10 ft.).
- .7 Set bases with adhesive in accordance with manufacturer's installation instructions. Accurately locate and align bases. Where applicable, replace gravel around bases after installation.
- .8 Set framing posts into bases and assemble framing structure. Provide galvanized fasteners for galvanized framing, and stainless steel fasteners for stainless steel framing.

3.09 AIR VENTS

- .1 Provide air vents on water piping at all high points in the system and at each piece of equipment. Provide ball valves on automatic vents.
- .2 Provide automatic air vents on piping mains except where a possibility from water damage would occur, in which case, use manual vents.
- .3 Provide manual air vents at each piece of equipment.
- .4 For all vents, except for screw driver operated type at convectors and unitary heating equipment, provide 9mm (3/8") copper drains to nearest floor drain.

3.10 EXPANSION JOINTS

- .1 Install expansion loops, joints and compensators in accordance with the Drawings and manufacturer's instructions in regard to proper length, anchoring and guiding, pre compression, removal of spacers and testing.

3.11 ANCHORS, GUIDES AND EXPANSION COMPENSATORS

- .1 Install all hangers, supports, anchors, guides, expansion compensators and restraints per manufacturer's recommendations and per the requirements of the Professional Engineer responsible for the provision of the detailed shop drawings for hangers, supports, anchors, guides, expansion compensation and restraints.
- .2 Manufacturers to provide field verification of the installation during construction phase and provide sign off letters upon completion of installation.

3.12 PROTECTION

- .1 Cover openings in equipment and cover equipment where damage may occur from weather. Cover temporary openings in ducts and pipes with polyethylene sheets, until final connection is made. Cover all items cast into concrete floors or walls such as floor drains and cleanouts prior to pour, with heavy plastic tape or duct tape.
- .2 Cover and seal, with polyethylene sheeting, all equipment, coils and motors in place during construction to prevent entry of dust, paint and debris.

3.13 RIGGING OF EQUIPMENT

- .1 Provide all rigging, hoisting and handling of equipment as necessary in order to place the equipment in the designated area in the building.
- .2 Direct this work by qualified personnel normally engaged in rigging, hoisting and handling of equipment.

3.14 CONCRETE

- .1 Except as specifically indicated on the Mechanical Drawings or where indicated on the Architectural or Structural Drawings as provided by other Sections, provide all concrete work required for mechanical work (bases, curbs, anchors, thrust blocks, manholes, catch basins) in accordance with requirements of Division 3. Provide reinforced concrete housekeeping pads (equipment bases) at least 100 mm (4") high under all floor mounted equipment. Provide 150 mm (6") high bases under equipment with cooling coils to provide sufficient clearance for deep seal condensate traps.
- .2 Provide in good time, all inserts, sump frames, anchors etc., required to be built into forming for mechanical services.
- .3 Equipment to be supported on concrete floors to have reinforced concrete housekeeping pad; pads solidly anchored to the structural slab to meet seismic requirements as follows:
 - .1 Reinforced concrete with bar or mesh reinforcing.
 - .2 Minimum 4 inches (100 mm) high with cambered edges.
 - .3 Seismically attracted to structural floor with 10 mm rebar dowels on 3 feet by 3 feet (900 mm x 900 mm) grid.
 - .4 Drill and epoxy grout dowels 3 inches (75 mm) into concrete floor.
 - .5 Provide minimum 8 inches (200 mm) edges to allow for equipment seismic restraint devices.
 - .6 Provide layout field shop drawings for all housekeeping pads to the Consultant for review.

3.15 METALS

- .1 Steel construction required solely for the work of Mechanical trades and not shown on Architectural or Structural Drawings: Provided by Divisions 20, 21, 22, 23 and 25 to the acceptance of the Consultant. Prepare and submit installation drawings on any steel construction for acceptance of the Consultant. Provide one coat of primer on all steel supports located outdoors.

3.16 CUTTING AND PATCHING

- .1 Give timely notice concerning required openings. In work already finished the Contractor will perform all cutting and patching at the expense of Divisions 20, 21, 22, 23 and 25. Obtain the approval of the Consultant before doing any cutting.
- .2 Provide all cutting and patching for mechanical services penetrating walls, floors and roofs as shown on the Drawings. Cut only to suit dimensions required and for minimum clearances.
- .3 Seal around services passing through cut openings with materials commensurate with the fire rating of the wall, floor or roof. Ensure sealing is weatherproof for openings through exterior walls and roofs. Before sealing, provide prime coat of paint on all repaired surfaces.

3.17 LINTELS

- .1 Lintels for openings in masonry to conform to requirements given on structural drawings and as required by laws.
- .2 Pay all costs for lintels over openings required solely by the mechanical trades.

3.18 FLASHING

- .1 Flash all mechanical parts passing through or built into an outside wall, roof or a waterproof floor.
- .2 Provide copper flashing for sleeves passing through exterior walls or water proof floors.

- .3 Provide counter flashing on stacks, ducts and pipes passing through roofs to fit over flashing or curb.

3.19 INSTALLATION OF ROOF MOUNTED EQUIPMENT

- .1 Flashing of equipment bases and curbed openings for ductwork or roof mounted fans and flashing of roof drains and plumbing vents is specified in Division 07. Equipment bases and curbs for openings to be supplied and set in place by Divisions 20, 21, 22, 23 and 25. Refer to the Detail Drawings.

3.20 INSERTS, SLEEVES AND ESCUTCHEONS

- .1 Provide all sleeves required for ductwork, piping and access openings unless they are specifically shown on Architectural and Structural Drawings.
- .2 Place inserts only in portion of the main structure and not in any finishing material.
- .3 Supply and locate all inserts, holes, anchor bolts and sleeves in time when walls, floors and roof are erected.
- .4 Provide the following for pipe sleeves:
 - .1 Through interior walls, exterior walls above grade, interior non waterproof floors: Machine cut schedule 40 steel pipe, medium cast iron or 18 gauge galvanized steel.
 - .2 Through walls below grade, waterproof floors, floors in janitor's closets, equipment rooms, and kitchens: machine cut medium cast iron, DWV copper or copper sheet extended 100mm (4") above the floor and cut flush with the underside.
- .5 Provide the following for ductwork:
 - .1 Where fire dampers are not required in poured walls; removable wood box out of required size. In block or brick walls; masonry to be built around ducting.
 - .2 Where fire dampers are required; 18 gauge galvanized steel or heavier sleeves complete with steel angle framing both sides installed in accordance with requirements of Authorities. See also detail drawings.
 - .3 Through Equipment Room floors, provide 100mm (4") high concrete curbs for ductwork and any piping so spaced that sleeving is impractical.
- .6 Seal all sleeves as follows:
 - .1 Through fire rated walls and floors and within mechanical assemblies (ducts): Stop insulation flush with all wall and floor surfaces and seal space between duct or pipe and sleeve with ULC approved and listed fire stopping material as manufactured by Double AD Distributors Ltd. (416) 292-2361 or M. W. McGill and Associates Ltd. "Fire Bloc" (416) 291-8393 or Dow RTV Silicon Foam or "Metacaulk" as distributed by EMCO Ltd. (416) 742-6220.
 - .2 Approved and listed products from 3M and Hilti Fire Stop are acceptable.
 - .3 Through all non-fire rated walls and floors stop insulation, where applicable, at wall and floor surfaces. Ram pack ULC labelled mineral wool materials around piping and ductwork. Apply an approved caulking compound over the ram packed material on both sides.
 - .4 Through foundation walls: Use either of the two following methods:
 - .1 Cooperate with the Waterproofing trade and apply an approved caulking compound over ram packed mineral wool on both sides. Over this, on both sides, apply a layer of glassfab tape embedded in two coats of an approved mastic compound.

- .2 Provide Link-Seal Model S mechanical seal mechanism with stainless steel bolting, EPDM seal element and composite pressure plates as supplied by Power Plant Supply Company (905) 845-7951. Follow Manufacturer's instructions in all aspects of installation procedure.
- .5 Cover sleeves and openings around exposed piping in all finished areas with chrome plated escutcheons. Cover exposed duct sleeves in finished areas with an 18 gauge galvanized steel collar fixed to wall or floor.
- .6 Standpipe Riser penetrating floor/ceiling of Scissor Stairs shall be installed complete with firestop system as illustrated by Hilti Firestop System CAJ-1597 to provide the applicable code required 2 hour Fire and Temperature (FT) rating for stairs.

3.21 ACCESS PANELS AND DOORS

- .1 Install all concealed Mechanical equipment requiring adjustment or maintenance in locations easily accessible through access panels and doors. Install systems and components to result in a minimum number of access panels.
- .2 Access doors are required in walls, ceilings and ductwork for the following:
 - .1 Fire dampers and motorized dampers (for inspection, repair and resetting). Provide access doors on both upstream and downstream sides of automatic dampers.
 - .2 Duct mounted coils (duct access upstream and downstream sides for cleaning).
 - .3 Fan inlets and outlets (for inspection of impellers and vanes).
 - .4 At VAV terminal inlets for access to air flow measurement devices and for cleaning and servicing.
 - .5 Unitary heating/cooling equipment, such as heat pumps and fan coils, in ceiling spaces.
 - .6 Duct mounted smoke detectors (for inspection of in-duct sensors).
 - .7 Control valves and temperature control components.
 - .8 Expansion compensators, guides and anchors.
- .3 Indicate access panels on "As built" drawings and note at each location the items (i.e. equipment or valve no.) that access is being provided for.
- .4 Supply the Division 08 Subtrade with panels, doors or the frames therefore, complete with all pertinent information and pay that trade for installation.
- .5 Prepare detail drawings showing location and type of all access doors in co-ordination with other trades before proceeding with installation and submit for review.
- .6 Size access doors to provide adequate access and be commensurate with type of structure and architectural finish.
- .7 Ensure proper rating of doors in fire separations.
- .8 Provide lamacoid labels (white on black), screwed in place, on all access doors and access tiles listing items or equipment which access is being provided for.

3.22 PAINTING

- .1 Provide all exposed ferrous metal work on equipment with at least one factory prime coat, or paint one prime coat on job. Clean up or wire brush all equipment before painting. Finish painting is specified in Division 09. This Division is not required to prime coat or paint ductwork or piping. Except to apply two coats of Densopaste primer to cooling tower piping and steel support structures exposed to outdoors and casings of chilled water and domestic water booster pumps. Also paint built up air unit coil drip trays as shown on the detail drawings and paint ductwork internally at grilles refer to Section 23 31 13.

- .2 Co-ordinate with Subcontractor and provide all required assistance in identifying all piping circuits requiring colour coding in addition to natural gas, propane and fire protection piping.
- .3 For factory applied finishes, repaint or refinish surfaces damaged during shipment, erection or construction work.

3.23 MECHANICAL WORK IDENTIFICATION

- .1 Identify new exposed piping and ductwork in locations as follows:
 - .1 At every end of every piping or duct run;
 - .2 Adjacent to each valve, strainer, damper and similar accessory;
 - .3 At each piece of connecting equipment;
 - .4 On both sides of every pipe and duct passing through a floor, wall or partition, unless otherwise specified;
 - .5 At 6 m (20') intervals on pipe and duct runs exceeding 6 m (20') in length;
 - .6 At least once in each room, and at least once on pipe and duct runs less than 6 m (20') in length.
- .2 Unless otherwise specified identify new concealed piping and ductwork in locations as follows:
 - .1 At points where pipes or ducts enter and leave rooms, shafts, pipe chases, furred spaces, and similar areas;
 - .2 At maximum 6 m (20') intervals on piping and ductwork above suspended accessible ceilings, and at least once in each room;
 - .3 At each access door location;
 - .4 At each piece of connected equipment, automatic valve, etc.
- .3 Provide an identification nameplate for equipment provided as part of this project, including items such as control valves, motorized dampers, instruments, and similar products. Secure nameplates in place, approximately at eye level if possible, with stainless steel screws unless such a practice is prohibitive, in which case use epoxy cement applied to cleaned surfaces. Locate nameplates in the most conspicuous and readable location. Where equipment is locally switched (e.g. Room exhaust fans) provide identification plate at switch.
- .4 Paint new natural and/or propane gas piping with primer and 2 coats of yellow paint in accordance with local governing code requirements and requirements of Division 09. Identify piping at intervals as specified above.
- .5 Provide an identification nameplate for each motor starter or disconnect switch located in a motor control centre or on a motor starter panel, and on each individually mounted starter provided as part of mechanical work, and on each disconnect switch provided as part of the electrical work for motorized equipment provided as part of mechanical work.
- .6 Co-ordinate with Section 25 01 01 Building Automation System subcontractor and obtain list of automatically operated equipment and provide warning identification on lamacoid plate for each item as follows:

"Warning: This equipment may start at any time. Do not service without disconnecting power."
- .7 For electrically traced mechanical work, identification wording is to include "ELECTRICALLY TRACED".
- .8 Tag valves and prepare a valve tag chart in accordance with following requirements:
 - .1 Attach a valve tag to each new valve, except for valves located immediately at equipment they control;

- .2 Prepare a computer printed valve tag chart to list tagged valves, with, for each valve, the tag number, location, valve size, piping service, and valve attitude (normally open or normally closed);
- .3 If an existing valve tag chart is available at site, valve tag numbering is to be an extension of existing numbering and new valve tag chart is to incorporate existing chart;
- .4 Frame and glaze one copy of chart and, unless otherwise directed, affix to a wall in each main Mechanical and/or Equipment Room;
- .5 Include a copy of valve tag chart in each copy of operating and maintenance instruction manuals;
- .6 Hand an identified USB of valve tag chart to Owner at same time O&M Manuals are submitted.
- .9 Where shut-off valves, control dampers, sensors, and similar items which will or may need maintenance and/or repair are located above accessible suspended ceilings, provide round coloured ceiling tacks in ceiling panel material, or stickers equal to Brady "Quick Dot" on ceiling grid material to indicate locations of items. Unless otherwise specified, ceiling tack or sticker colours are to be as follows:
 - .1 HVAC piping valves and equipment: Yellow
 - .2 Fire protection valves and equipment: Red
 - .3 Plumbing valves and equipment: Green
 - .4 HVAC ductwork dampers and equipment: Blue
 - .5 Control system hardware and equipment: Orange

3.24 EXPOSED WORK

- .1 Wherever any mechanical work (plumbing, heating and sprinkler piping, ductwork, and associated thermal insulation) is exposed in finished areas, co-ordinate the work with the Consultant prior to installation. If unsatisfactory installation results due to not following this procedure, perform remedial work to the Consultant's acceptance.
- .2 For purposes of the foregoing, finished areas do not include parking garages and equipment rooms.

3.25 PIPING SYSTEMS CLEANING

- .1 System Preparation for Chemical Treatment
 - .1 During construction:
 - .1 Ensure reasonable care is exercised to prevent debris, dirt and other foreign material from entering the pipe.
 - .2 This is to include proper protection of piping on site prior to installation, temporary caps on partial systems, and complete evacuation of moisture within systems being hydrostatically pressure tested.
 - .2 Review connections for complete draining and venting of the systems with Division 20, 21, 22 23 and 25 Subtrades.
 - .3 Upon initial filling, utilize water meter to record capacity within each system.
 - .4 Do not install instrumentation components such as flow meters, orifice plates, pitot tubes, turbine meters until system flush is complete and confirmed by water treatment specialists.
 - .5 Control Valves:
 - .1 Prior to flushing and cleaning remove all terminal unit control valves 25 mm or smaller.

- .2 Coordinate with Divisions 20, 21, 22 23 and 25 Subtrades to provide temporary connections to ensure complete system circulation during cleaning.
- .3 Reinstall the control valves when the system flush and cleaning is complete.
- .4 Coordinate with Divisions 20, 21, 22 23 and 25 Subtrades to ensure that all control valves 25mm and larger and all other system valves are 100% open to ensure all pipes have flow.
- .6 Bypass plate heat exchangers, boilers, chillers, etc. during flushing and chemical treatment procedure.
- .7 Hydronic Terminal Units:
 - .1 Radiant panels, terminal box coils, unit heaters, heat pumps, radiation, force flows are not to be connected to heating piping during system flush.
 - .2 Install temporary connection between supply and return branch lines and connect to heating system after flushing is completed.
- .8 Construction Screens and filters
 - .1 Install all filter cartridges, beginning with larger micron size filters. The first few filter changes may be required every few hours to remove any suspended solids not removed by the final flushing. Filters changes will become less frequent as filter inspections reveal clean filters. Repeat this process with smaller micron filters.
 - .2 Remove construction screens from pumps and any other equipment once this process is complete.
- .9 Strainers:
 - .1 Remove, inspect and replace strainers on all systems before initial fill.
 - .2 Provide temporary strainers on systems without permanent strainers. Remove, clean and replace strainers until no further fouling occurs.
- .2 General Procedures for Systems Cleaning and Inhibiting
 - .1 Perform cleaning and chemical treatment activities in a continuous process without interruption.
 - .2 Perform a complete water analysis of the domestic water source before cleaning and filling. Submit report to Consultant.
 - .3 Submit a detailed written procedural report to Consultant before system cleaning, outlining the following:
 - .1 System status and description.
 - .2 Cleaning procedures, flow rates, elapsed time.
 - .3 Chemical cleaners and concentrations.
 - .4 Inhibitors and concentrations.
 - .5 Specific requirements to complete work.
 - .6 Special precautions for protecting piping system materials and components.
 - .4 Pipe cleaning to be completed after hydrostatic test.
 - .5 Flush through all low point drains of the piping system.
 - .6 Low Points:
 - .1 Inspect, clean of sludge and flush all low points with clean water after cleaning and degreasing process is completed.

- .2 Include disassembly of components as required.
- .3 All cleaning and flushing of low points, coils and boilers shall be done prior to final fill and chemical treatment.
- .7 Ensure flush velocity is adequate in all pipe mains and branches to ensure debris is removed.
- .8 Where necessary, create a loop at the end of the system to ensure no dead legs.
- .9 Circulation of Cleaning Solution:
 - .1 System pumps may be used for circulating cleaning solution provided velocities are adequate.
 - .2 If used for circulation, dismantle pump and inspect, replace worn parts, install new gaskets and seals. Turn over used seals.
- .3 Hydronic Systems Cleaning and Inhibiting Procedures
 - .1 Open high point vent(s).
 - .2 Fill systems completely with clean water from system low points; ensure air is completely vented from systems.
 - .3 Draw one sample of water from the filled piping and test it for colour, clarity, pH and conductivity.
 - .4 Circulate the system for a minimum of four hours at full flow. Flush low point drains, etc., while circulating to help remove any debris that has been dislodged. Flush with constant circulation until the flush water conductivity, pH and turbidity are approximately equal to the fresh water source. If the water is unusually dirty, drain and refill.
 - .5 Add chemicals for cleaning and recirculate for 1 hour.
 - .6 Draw one sample of water and test to confirm addition of cleaning chemical product at appropriate concentration.
 - .7 For closed loop systems, recirculate system cleaner at 60°C for a minimum 48 hours. Ensure that required temperature and velocity is maintained throughout. Frequently flush all low point drains, etc. while circulating to remove loosened debris.
 - .8 Drain system as quickly as possible. Safely dispose of the cleaner solution. Prior to discharging into sanitary drain confirm that it is acceptable to do so with the Authorities having jurisdiction. If disposal by sanitary drain is not acceptable, provide alternative means of removal of chemically treated water from site, complying with the requirements of the Authorities having jurisdiction.
 - .9 Flush the pipe with clean water until all the cleaner is out. Allow at least one day for flushing. Flush until the effluent is clear and flush water conductivity, pH and turbidity are equal to the fresh water source.
 - .10 The inspection and cleaning of all strainers is recommended after flushing. A simultaneous flush and fill with system recirculation is best during the final stages of the flushing to ensure that all the air is removed and all the cleaner is out. This is best accomplished by draining from the low points and adding water at the makeup point while ensuring the required system pressure, so as not to cause recirculation pump cavitation, is maintained.
 - .11 Provide final flush samples in 2 x 250 ml bottles to verify the cleaner is out. All samples should be dated and labelled as to system and location of sample. If the samples are coloured or foamy upon agitation, further flushing will be required. A written sign-off report will be provided to the Consultant.

- .12 Once cleaner is completely flushed from the system, corrosion inhibitor addition will take place. This must be done immediately following cleaning or the pipe will begin to rust and re-cleaning may be required.
- .13 Refill with water (fill from low points, vent from high points) and add inhibitors.
- .14 Circulate for 24 hours.
- .15 Test concentrations and adjust to recommended levels defined in procedural report.
- .16 Test glycol systems to prove concentration will resist freezing at intended freeze protection temperature.
- .17 Test inhibitor strength and record in procedural report.
- .4 Steam and Condensate System Cleaning and Inhibiting Procedure
 - .1 Isolate steam boiler(s) from piping system.
 - .2 Fill boiler to normal operating level.
 - .3 Add cleaner.
 - .4 Fire to 50% of design operating pressure.
 - .5 Blowdown boiler every 4 h including water columns, controls, skimmer lines and valves, test cocks and blowdown valves.
 - .6 Add water to return to operating level.
 - .7 Maintain procedure for 24 h.
 - .8 Allow boiler to cool, then drain, flush and inspect.
 - .9 Refill with clean softened water and immediately add chemical inhibitors.
 - .10 Condensate Dump:
 - .1 Dump condensate from steam system to sewer for a period of 96 h after initial operation.
 - .2 During this period, the boilers must be chemically treated with the inhibitors to assure complete removal of oils, grease and millscale from the steam/condensate system.
 - .3 Provide cooling water lines, if necessary.
 - .11 Open steam header to operating pressure and start continuous feed of an Octadecylamine (ODA) based filming amine blended with morpholine and or diethylaminoethanol based neutralizing amine, such as GE Water's Steamate NF4630 at 20 ppm to achieve a condensate pH of 7.5 to 8.0 for a period of not less than 48 hours. All condensate shall be discharged to drain.
 - .12 Collect condensate samples every twelve hours and retain for inspection by a qualified water treatment specialist.
 - .13 After 48 hours:
 - .1 In addition to the feed of Steamate NF4630, begin continuously feeding additional neutralizing amine blend of cyclohexylamine, morpholine and diethylaminoethanol, such as GE Water's Steamate NA5640 to achieve a pH of 8.3 to 9.0.
 - .2 Both products can be batched and fed together.
 - .3 pH measurements shall be supplemented with phenolphthalein ("P") alkalinity testing. The "P" alkalinity shall be maintained between 2 and 10 ppm in the condensate.
 - .14 Continue feeding the chemicals for another 48 to 96 hours.

- .15 Continue to collect condensate samples every 12 hours and retain for inspection by a qualified water treatment specialist. All condensate shall continue to be dumped to drain.
- .16 Testing:
 - .1 After minimum 7 days of steam and condensate purging, the condensate shall be tested for residual oil, hardness and iron.
 - .2 Approval shall be dependent on no detectable oil, not detectable calcium or magnesium hardness and suspended iron in the condensate of less than 100 ppb using a standard Babcock and Wilcox Millipore suspended iron test.
 - .3 Discontinue feed of filming amine blend (Steamate NF4630), but continue feeding neutralizing amine (Steamate NA5640) to maintain the 2-10 ppm "P" alkalinity the condensate.
- .5 Domestic Hot, Cold and Recirculating Water System
 - .1 Flushing:
 - .1 Before disinfecting, flush all foreign matter from the pipeline.
 - .2 Provide hoses, pumps, temporary pipes, ditches, etc., as required to dispose of flushing water without causing damage to adjacent properties.
 - .3 The flushing velocities shall be at least 1 m/s, for a period of 10 minutes.
 - .4 Open and close valves, hydrants, and services connections to ensure thorough flushing.
 - .5 For large diameter pipe, where it is impractical or impossible to flush the pipe at 1 m/s velocity, the pipeline shall be cleaned in place from the inside by brushing and sweeping, then flushing the line at a lower velocity.
 - .2 Disinfection:
 - .1 Pipes intended to carry potable water shall be disinfected before being placed in service.
 - .2 Disinfection procedures shall conform to AWWA C651 as hereinafter modified or expanded, and the requirements of any governing agency having jurisdiction.
 - .3 Ensure that the disinfection solution is distributed throughout the entire domestic water system.
 - .3 Disinfection Mixture:
 - .1 The mechanical contractor shall prepare the disinfection mixture with a chlorine-water solution having a free chlorine residual of 40 - 50 PPM.
 - .2 The disinfection mixture shall be prepared by injecting calcium or sodium hypochlorite and water into the piping and allowing it to flow at a measured rate so that water-chlorine solution is of the specified strength.
 - .3 If the calcium hypochlorite procedure is used, first mix the dry powder with water to make a thick paste, then thin to approximately a one percent solution (10,000 PPM Chlorine).
 - .4 If the sodium hypochlorite procedure is used, dilute the liquid with water to obtain a one percent solution.
 - .4 Point of Application:
 - .1 The chlorine mixture shall be injected into the piping to be treated at the beginning of the line, and through a corporation stop or suitable tap in the top of the line.

- .2 Water from the existing system or other approved sources shall be controlled so as to flow slowly into the newly installed pipe during the application of chlorine.
- .3 The rate of chlorine mixture flow shall be in such proportion to the rate of water entering the pipe that the combined mixture shall contain 40-50 PPM of free available chlorine.
- .4 Valves shall be manipulated so that the strong chlorine solution in the line being treated will not flow back into the line supplying the water.
- .5 Check valves shall be used if deemed necessary.
- .6 The chemical treatment representative shall analyze and record the free chlorine residual at the farthest fixtures from the injection point.
- .5 All valves, fixtures and other appurtenances shall be operated during disinfection to ensure that the disinfection mixture is dispersed into all parts of the line, including dead ends, new services and similar areas that otherwise may not receive the treated water.
- .6 Retention Period:
 - .1 Treated water shall be retained in the pipeline long enough to destroy all nonspore-forming bacteria.
 - .2 With proper flushing and the specified solution strength, 24 hours is adequate.
 - .3 At the end of the 24-hour period, the disinfection mixture shall have a strength of at least 25 PPM of chlorine.
 - .4 The chemical treatment representative shall analyze and record the free chlorine residual at the farthest fixtures from the injection point.
- .7 The above procedure shall be repeated at the mechanical contractor's expense if the free chlorine level drops below the minimum requirements.
- .8 Arrange and pay for water quality tests to be performed by an independent testing laboratory acceptable to the Consultant as follows:
 - .1 Test for chlorine residuals at extreme ends of all piping systems. After a chlorine residual of not less than 50 ppm has been achieved in all parts of the system, let the system stand for 24 hours. After this period, take further samples to ensure that there is still not less than 10 ppm of chlorine residual throughout the system.
 - .2 When chlorine residuals of 10 ppm have been maintained for a minimum of 24 hours, flush the system and refill to put the system into service.
 - .3 Submit copy of report as prepared by the testing laboratory as well as a certificate attesting to level of safety of water supply being in conformance with standards of Authority having jurisdiction.
- .9 After chlorination, the water from the line shall be flushed until it meets health department requirements.
- .10 Disposal of Disinfection Water:
 - .1 Disposal of disinfecting water shall be done in an approved manner.
 - .2 Disinfecting water should not be allowed to flow into a waterway without adequate dilution or other satisfactory method of reducing chlorine concentrations to a safe level.
- .6 When new systems are to be connected to existing systems
 - .1 Take samples of water in existing piping and submit to Chemical Treatment Subcontractor for water quality testing.

- .2 Should the water quality in the existing piping not be sufficient, include the existing piping in the above flushing and cleaning scope.
- .3 If flushing scope & cleaning is restricted to new piping only:
 - .1 Provide isolation valves as required to fully isolate new piping from existing piping during cleaning and flushing procedure.
 - .2 Create additional loops at the end of the system, as necessary to ensure no dead legs and that flushing only takes place in new piping.
 - .3 Complete one final water quality test for new piping prior to opening up to existing system.

3.26 PIPING SYSTEM TESTS

- .1 Do not insulate piping systems until completed, perfected, and proven tight.
- .2 Should leaks develop in any part of the piping system, remove and replace defective sections, fittings and equipment.
- .3 Test piping system in sections as required by the progress of work.
- .4 Test all piping hydraulically to a minimum pressure of 1100 kPa (150 psi) or 1.5 times the normal working pressure, whichever is the greater, and prove tight for a period of 8 hours. Testing with nitrogen is also acceptable provided a pressure of 1.25 times values specified previously is used. Test natural gas piping as required by codes and authorities.
- .5 All plumbing, heating and cooling mains and branches are to be flushed and cleaned without fixtures and appliances connected.
- .6 All tests must be recorded. Submit recorded data to the Consultant.

3.27 AIR AND WATER BALANCING AND TESTING

- .1 Costs to perform air and water balancing to be included in the Tender for the Work of Divisions 20, 23 and 25.
- .2 Provide the services of an independent firm specializing in air and water balancing, acceptable to the Consultant, to undertake this work as follows:
 - .1 Provide personnel to review the Drawings and Specifications, make site visits, prepare reports and take responsibility for measuring and adjusting all air supply, exhaust, return and transfer systems and water and other fluid pumping systems operate in accordance with specified requirements with tolerance of plus or minus five percent (5%).
 - .2 Review and check working drawings to ensure that modifications, if required, are implemented prior to execution of work.
 - .3 Provide inspections during the course of construction and issue reports making whatever recommendations are necessary in the interests of achieving specified performance.
 - .4 When the work is adequately completed, inspect, check and test all systems and equipment. Cooperate with the controls systems subcontractor to achieve required flow rates where modulating dampers, valves etc., are installed.
 - .5 Prepare and submit testing and balancing reports to the Consultant for review. All reports shall include instrument calibration certificates, a report summary and remarks section explaining the rationale for how the system was configured for testing, and a listing of any deficiencies.
 - .6 Provide assistance to the Consultant for on-site spot verification of the testing and balancing report.
- .3 Air Balancing

- .1 Perform air balancing in accordance with current NBCTA, NEBB or AACB procedural standards by adjusting fan speed. Use damper throttling only in systems where fan motor is less than 1 HP or where throttling results in no greater than one additional fan HP over a reduced RPM condition.
 - .2 Where ductwork is subject to static pressure in excess of 75mm (3 in.) WC, leak test 25% minimum of total installed duct area of all representative sections of the total system. All testing to conform to requirements of HVAC Duct Leakage Test Manual, 1985, Sections 5 and 6 and tested duct leakage class at a test pressure equal to the design duct pressure class rating to be equal to or less than leakage Class 6 as defined in 4.1 of Ref. 35.
 - .3 Where ductwork is subject to static pressure below 75mm (3 in.) WC, leak test all mains and major branches. All testing to conform to requirements of HVAC Duct Leakage Test Manual, 1985, Sections 5 and 6 and tested duct leakage class at a test pressure equal to the design duct pressure class rating to be equal to or less than leakage Class 6 as defined in 4.1 of Ref. 35.
 - .4 Provide Dial 1000 or Dial 2000 or acceptable alternative, duct pilot tube test opening enclosures for installation by the Section 23 31 13 Subtrade. Provide all required test opening locations and installation instructions to the Section 23 31 13 Subtrade.
 - .5 After inspection and tests, report all required replacement of sheaves and belts and all required adjustments and ductwork modifications to achieve system performance as specified.
 - .6 After deficient items have been rectified, retest and issue a final report and certificate covering the following:
 - .1 Specified and achieved total air quantities per system supported by curves for all fans over 150 l/s (300 cfm) capacity.
 - .2 Specified and achieved individual air quantities per outlet with supporting schematic diagrams showing test points.
 - .3 Nameplate and actual motor loading in amperes at actual voltage and installed overload heater size and manufacturer.
 - .4 Specified and actual fan total static pressures with breakdown showing inlet and discharge pressures with data shown on fan curves.
 - .5 Sheave and belt sizes and quantities per unit.
 - .7 Provide personnel, tools and materials to assist and work under the direction of the air balancing firm to perform the following:
 - .1 Removal and replacement of ceiling tiles.
 - .2 Installation of Pitot tube test opening enclosures.
 - .3 Installation of dampers and baffles as required for specified air balance and elimination of stratification.
 - .4 Provision of access openings and covers.
 - .5 Provision of ladders and scaffolds
 - .6 Removal and replacement of belt guards.
 - .7 Removal and replacement and provision of required sheaves and belts as directed, and other items as necessary for complete and acceptable air balancing procedures.
- .4 Water Balancing

- .1 Perform hydronic system balancing by minor throttling for pumps that are less than 7.45 kW (10 HP) provided this results in a power draw of no greater than 10% of that required if the impeller were trimmed. For pumps greater than 7.45 kW (10 HP), the same limit applies but in no case is it to exceed 2.23 kW (3 HP). In either case where these limits are exceeded by throttling, the impeller is to be trimmed or replaced.
- .2 Make adjustments to achieve specified temperature drops and flows across all chillers and coils. Also report all pump data such as suction, and discharge pressure, current draw at tested voltage and starter OL heater sizes and pump motor nameplate ratings.
- .3 Provide pump curves indicating the operating point with superimposed power draw, RPM, impeller size, etc.
- .4 Instruct piping system installers on proper locations of flow measurement ports.
- .5 Report any required pump impeller adjustments to achieve specified performance.
- .6 After adjustments, retest systems and issue final report confirming systems are operating in compliance with design.
- .7 Provide flow measurement ports as shown on detail drawings and piping schematics in locations as directed by the water balancing specialist. Provide balancing valves where required as directed by the water balancing specialist.
- .8 Provide any pump impeller modifications as recommended by the water balancing firm.
- .5 Acceptable Air and Water Balancing Contractors:
 - .1 Aerodynamics Inspecting Consultants Ltd.
 - .2 Dasstab Inc.
 - .3 Designtest & Balancing Co. Ltd.
 - .4 Dynamic Flow Balancing Ltd.
 - .5 VPG Associates Ltd.

END OF SECTION 20 05 10

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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Section 20 05 05 Mechanical Work General Instructions and Section 20 05 10 Basic Mechanical Materials and Methods.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Provide all vibration isolation and control equipment, properly selected to provide noise and vibration control for all motor driven equipment.

1.03 QUALITY ASSURANCE

- .1 Execute work of this section in accordance with the manufacturer's instructions by workman only experienced in the installation of vibration isolation systems and equipment.
- .2 Ensure isolators and restraining devices factory supplied with equipment meet the requirements of this Section.
- .3 Provide all equipment to control noise and vibration such that the average noise criteria curves for the conditioned occupied space, do not exceed the NC levels and vibration levels specified in the acoustic report or, in the absence of such report, the table below:

Room Types		Octave Band Analysis NC
Rooms with Intrusion from Outdoor Noise sources	Traffic Noise Aircraft flyovers	N/A N/A
Office Buildings	Executive and private offices	30
	Conference rooms	30
	Teleconference rooms	25
	Open-plan offices	40
	Corridors and lobbies	40
Libraries, Indoor Stadiums, Gymnasiums	Gymnasiums and natatoriums	45
	Large-seating-capacity spaces with speech amplification	50

- .4 Engage the vibration isolation equipment manufacturer to provide inspection and supervision services during construction to ensure all equipment is installed as required to achieve effective vibration isolation and noise control.
- .5 Finishes are to be ULC labelled and listed for flame spread rating of less than 25 and smoke development classification of less than 50.
- .6 Types of isolators, types of equipment bases, and applications for various types of equipment specified herein are based on ASHRAE Handbook HVAC Applications.
- .7 Coordinate with vibration isolation manufacturer and structural engineer of record to locate and size structural supports underneath vibration isolated equipment (e.g. roof curbs, cooling towers, chillers and other similar equipment).
- .8 Health and Safety:

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

1.04 SUBMITTALS

- .1 Submit shop drawings on all product/equipment specified in this Section. Include detailed dimension drawings, construction, performance and finishes in accordance with Section 20 01 05 – Shop Drawings, Product Data & Samples.
 - .1 Vibration Isolation Bases: Dimensional drawings including anchorage and attachments to structure and to supported equipment, if needed or required. Include auxiliary motor slides and rails, base weights, equipment static loads.
 - .2 Vibration Isolators: Vibration isolation selection must include quantities & layout of isolators for each equipment being isolated. Deflection calculations with rated & actual deflection and natural frequency under load as well as installation instructions for all isolators being supplied.
 - .3 Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
- .2 Provide certified test data or calculations as prepared by a registered Professional Engineer attesting to conformance with the requirements of this section.

1.05 DELIVERY, STORAGE AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

1.06 WARRANTY

- .1 Provide warranties as outlined in Section 20 05 05 - Mechanical Work General Instructions.

PART 2 - PRODUCTS

2.01 VIBRATION ISOLATION – GENERAL

- .1 All springs are to have a minimum additional travel to solid equal to 50% of the rated deflection. All springs, except internal nested springs, are to have an outside diameter not less than 0.8 of the compressed height of the spring. Ends of springs are to be square and ground for stability. Laterally stable springs are to have k_x/k_y ratios of at least 0.9. Spring elements are to be colour-coded.
- .2 Steel equipment bases are to be of welded construction with cross members to form an integral support platform. Design structural steel members to match supported equipment. Minimum clearance under steel equipment bases is 25 mm (1").
- .3 Concrete inertia bases are to be of welded steel construction with concrete in-fill supplied by the installing contractor on site, incorporate reinforcing bars, spaced 300 mm (12") maximum on centres each way, and of sufficient weight to lower the center of gravity to or below the isolator support plane. Minimum thicknesses as follows:
 - .1 Up to 30 HP: 150 mm (6");
 - .2 40 to 75 HP: 200 mm (8");
 - .3 100 HP and greater: 300 mm (12").
- .4 Ensure isolation systems have a natural frequency no higher than 10% to 15% of the lowest forcing frequency unless otherwise specified.
- .5 Provide weatherproof coating on springs and housings for all isolation equipment exposed to outdoors.

- .6 Isolators and seismic restraints to meet the requirements of the current Ontario Building Code. Use horizontal force factor SP-10 for mechanical equipment, and SP-15 for equipment containing toxic or explosive materials including steam (these requirements generally mean 0.8 g and 1.4 g respectively for maximum impact loads transmitted to the structure).
- .7 Acceptable manufacturers are: Vibro-Acoustics, Kinetics Noise Control, Mason Industries, Isotech Industries.

2.02 VIBRATION ISOLATORS – TYPES

- .1 Provide all vibration isolation equipment as manufactured by one approved supplier.
- .2 Provide isolators as follows:
 - .1 Type 1 - Pad Isolators:
 - .1 Neoprene elastomer in-shear pads, used in conjunction with steel shims where required. Pads are 50 durometer, designed for a maximum of 4.2 kg./sq.cm (60 psi) loading, and designed for a maximum deflection of approximately 20% of its unloaded thickness, 0.38 cm (0.15"). All pads shall be molded using 2500 psi minimum tensile strength. Several layers of pads can be stacked for additional deflection when steel separation shim stock is used. All layers shall be affixed together using appropriate glue or double sided tape to prevent delamination. The elastomer is oil and water resistant, offers a long-life expectancy consistent with neoprene compounds, and has been designed to operate within the safe stress limits of the material. Pads are to be able to be easily cut-to-fit as needed.
 - .2 Type 2 - Rubber Floor Isolators or Hangers:
 - .1 Rubber Floor Isolators: Captive, bridge bearing quality neoprene mount selected for a minimum 4 mm (0.15") static deflection unless otherwise specified, with an integral ductile iron housing and integral equipment anchor bolt.
 - .2 Neoprene Hanger Isolators: Neoprene double deflection rod isolators with steel housing and hanger rod bushing, selected for a minimum 4 mm (0.15") static deflection unless otherwise specified.
 - .3 Type 3 - Spring Floor Isolators or Hangers:
 - .1 Open Spring Mounts: Base mount free-standing assemblies, each complete with a stable steel spring welded in place, drilled mild steel mounting plate bonded to a ribbed rubber or neoprene acoustical pad, and an external 16 mm (5/8") diameter level adjustment bolt.
 - .2 Closed Spring Mounts: Base mount free-standing enclosed assemblies, each complete with stable spring(s), 2-piece cast housing, non-binding rubber horizontal stabilizers, a ribbed rubber or neoprene acoustical pad bonded to base of the closed housing, and an external level adjustment bolt.
 - .3 Spring Hangers: Welded steel plate housing with top and bottom rod mounting holes and spring retainer, neoprene double deflection isolation element, stable colour-coded spring, and heavy-duty rubber washers.
 - .4 Type 4 - Restrained Spring Isolators:
 - .1 Restrained Spring Isolator: Base mount free-standing enclosed and retained assemblies to limit both vertical and lateral movement of mounted equipment, each complete with stable spring(s), drilled welded steel housing and top plate, ribbed rubber or neoprene acoustical pad bonded to bottom of housing, vertical limit adjusting hardware, and a level adjustment bolt.
 - .5 Type 5 - Thrust Restraints:

- .1 High deflection, large diameter, laterally stable steel coil springs assembled into a threaded rod and angle bracket assembly complete with moulded neoprene end load plate assemblies for light capacities or stamped steel end cups for heavier capacities, threaded adjustment rod with zinc-plated hardware, polyester powder coated lateral spring stiffness greater than 1.0 times the rated vertical stiffness with a minimum of 50% overload deflection, and safe when temporarily loaded to solid capacity.

2.03 EQUIPMENT BASES – TYPES

- .1 Type A – No base, isolators attached directly to equipment:
 - .1 Direct Isolation: Used when equipment is unitary and rigid and does not require additional support.
- .2 Type B – Structural Steel Rails or Bases:
 - .1 Steel Equipment Base: Fully welded structural steel equipment and motor support bases, each complete with a wide flange steel frame, full depth cross members, brackets for spring mounts, and adjustable motor slide rails.
- .3 Type C – Concrete Inertia Base:
 - .1 Concrete Inertia Type Base: Welded steel bases, each complete with a structural black steel channel frame, concrete reinforcing rods, and brackets for spring mounts welded to frame.
 - .2 Combination Steel/Concrete Inertia Base: Welded steel bases with a structural black steel channel frame, concrete reinforcing rods, bottom sheet steel pan, brackets for spring mounts welded to frame and adjustable motor slide rails.
- .4 Type D – Curb-Mounted Base:
 - .1 Continuous Rail Type for Roof Mounted Equipment: Continuous rooftop isolation shipped completely assembled, consisting of:
 - .1 galvanized steel sections formed to fit roof curb and associated equipment with a flexible air and weather seal joining upper and lower rail sections;
 - .2 stable springs, cadmium plated and selected to provide minimum deflection with 50% additional travel to solid;
 - .3 neoprene cushioned and wind restraints allowing 6 mm (¼") movement before engaging and resisting wind loads in any lateral direction.
 - .2 Wind Rated Spring Isolation Roof Curbs: Full perimeter adjustable vibration isolation curbs with integral restrained spring isolators. Curbs shall be designed to attach directly to roof structure with provisions for accommodating roof slope and maintaining equipment level. Lower portion of curbs shall be constructed with minimum 16 ga (1.6 mm) galvanized steel with seams continuously welded and complete with full-perimeter factory-attached 2x4 (40 x 90 mm) wood nailers; minimum height to top of nailers shall be as required by local authority or 18" (3450 mm), whichever is greater. Curbs shall include all-directional limit stops with reinforced elastomeric components to eliminate metal-to-metal contact and with nominal ¼" (6 mm) clearance under normal operation. Curbs shall provide continuous support for equipment and shall withstand the wind and seismic forces applicable to the project. Curbs shall be provided with weather seal materials consisting of closed cell sponge tape for installation between the equipment and curbs and waterproof, flexible, reinforced EPDM strips for joining the outside perimeter of upper and lower members. Internal insulation and additional weather seals for return air plenums, solid top covers, acoustical barrier packages, galvanized steel duct supports, and flexible duct connections shall be provided as scheduled or required.

2.04 GENERAL VIBRATION ISOLATION SCHEDULES

- .1 Provide vibration isolation in accordance with the following schedule:

Equipment	Base Type	Isolator Type	Equipment Installation	Static Deflection, mm (in.)	Notes
Rooftop Units	A	1	Floor Mounted	2.5 (0.1)	2
Chillers	A	4	Floor Mounted	50 (2)	1,3
ERVs	A	3	Ceiling Suspended	25 (1)	
Boilers	A	1	Floor Mounted	2.5 (0.1)	
Heat Exchangers	A	1	Floor Mounted	2.5 (0.1)	
Expansion Tanks	A	1	Floor Mounted	2.5 (0.1)	
End Suction and Split Case Pumps	C	3	Floor Mounted	19 (0.75)	1
Vertical Inline Pumps	A	1	Floor Mounted	2.5 (0.1)	
	N/A	3	Ceiling Suspended	25 (1)	4
Heat Pumps	A	3	Floor Mounted	19 (0.75)	
Piping Suspended in Mechanical Rooms	A	3	Ceiling Suspended	25	
1. Contractor to provide structural base if equipment is not suitable for direct isolation. 2. Unit to be provided with internal isolation. 3. Wind load calculations/restraints must be included for equipment located outdoors. 4. Provide inline pump suspension bracket if equipment is suspended.					

- .2 Table above is for general reference only. Successful vibration isolation manufacturer is to review all equipment shop drawings and structural drawings in order to provide properly selected bases and isolators.

2.05 SPHERICAL TYPE FLEXIBLE CONNECTORS / EXPANSION JOINTS

- .1 Double sphere or "twin sphere" complete with peroxide cured EPDM throughout with either Kevlar or Nylon tire cord, a ductile iron external ring between the two spheres, and either ductile iron or steel flanges. Provide control rods where required.
- .2 Ensure materials are suitable for connecting piping and for service temperature and pressure.
- .3 Acceptable manufacturers are: Mason Ind., Kinetics Noise Control, Vibro-Acoustics.

2.06 BRAIDED FLEXIBLE CONNECTORS

- .1 Double wall, braided stainless steel flexible connectors for piping connections to vibration isolated equipment, each selected by manufacturer to suit the application. Shop drawings or product data sheets must indicate construction and performance requirements that suit the application.
- .2 Acceptable manufacturers are: Mason Ind., Kinetics Noise Control, Vibro-Acoustics.

PART 3 - EXECUTION

3.01 INSTALLATION OF VIBRATION ISOLATION

- .1 Obtain all relevant equipment information and provide shop and installation drawings for all vibration isolation elements and steel bases. Include details of attachment to both the equipment and the structure to meet the specified forces involved. Do not perform any work or order any materials or equipment prior to review of shop and installation drawings by the Consultant.
- .2 Refer to details on mechanical drawings for additional information.
- .3 For all equipment mounted on vibration isolators, provide a minimum clearance of 50 mm (2") to other structures, piping, equipment, etc.
- .4 Do not install any rigid connections between equipment and building structure that degrades the noise and vibration isolation system herein specified. Electrical conduit connections to isolated equipment are to be looped to allow free motion of isolated equipment. Coordinate with Electrical Contractor as required.
- .5 Ensure pipe, duct and electrical connections to isolated equipment do not reduce system flexibility. Ensure that pipe, conduit and duct passing through walls and floors do not transmit vibrations.
- .6 Space isolators under equipment so that the minimum distance between adjacent corner isolators is at least equal to the height of the centre of gravity of the equipment or specifically designed for increased forces on the supports. If improved supports are proposed, include design calculations with shop drawings, for approval.
- .7 Unless noted otherwise, provide flexible connectors for chillers, cooling towers and all pumps with motors higher than 3.7 kW (5 HP). Provide braided type for domestic water applications and for equipment located outdoors. Provide spherical type for all other equipment located indoors.
- .8 Isolate all floor or pier mounted equipment on Type 3 or Type 4 isolators unless otherwise specified.
- .9 Use the lowest RPM scheduled for 2-speed equipment.
- .10 Under equipment mounted on Type 3 mounts, provide neoprene/steel/neoprene (Type 1) pads, adjacent to the springs selected for the manufacturer's optimum loading, and shimmed to be just clear of the base of the equipment under operating conditions. Bolt these pads to the floor slab, maintaining the top of the bolt below the top of the pads. These pads are to minimizing rocking of the equipment in the event of an earthquake and can be deleted if other provision is designed into the isolator to control rocking.
- .11 For equipment mounted on slab on grade including chillers and pumps, mount on Type 1 neoprene/steel/neoprene sandwich pads unless otherwise specified.
- .12 Use Type 3 spring hangers for a minimum static deflection of 25 mm (1") for all ceiling hung fans, air handling units and emergency generator exhaust silencers.
- .13 Provide Type 3 resilient hangers on all piping connected to a vibrating source if the piping is supported from walls or ceiling slabs adjoining occupied spaces, and if the piping is in excess of 40 mm (1-1/2") diameter. Provide the hangers for a distance of 4 m (13 ft.) plus $0.03 \times (\text{pipe diameter mm})$ from the vibrating source - e.g. for 250 mm (10") pipe, required distance is 4 m (13 ft.) plus $0.03 \times 250 = 11.5 \text{ m (37.7 ft.)}$. Use Type 1 pads under pipe pedestals on slab on grade. Bolt down equipment mounted on neoprene pad isolators using neoprene grommets.
- .14 Provide thrust restraints (Type 5 isolators) for ceiling suspended or floor mounted units operating at 500 Pa (2" wc.) or more total static pressure.
- .15 To limit noise transmission to the structure, generator(s) should be mounted on spring isolators with neoprene pads in series and all exhaust piping up to and including the mufflers resiliently suspended using spring isolators with fibreglass or felt in series.

- .16 Vertical in-line pumps shall be supported by spring hangers having a static deflection of at least 32 mm (1-1/4") plus an additional neoprene mount in the isolator. In addition, these pumps shall include a twin-sphere flexible connector to reduce pipe and fluid-borne noise transmission near both the suction and discharge of these pumps. These flexible connectors should be located just beyond the first isolation hanger outside the pump drop-down piping. All condenser or chilled water piping penetrating walls on the mechanical level shall be clear at penetrations. Any penetrations that need to be fire-rated shall be sealed using an approved flexible fire-stopping system.
- .17 Cooling towers and/ or closed circuit fluid coolers are to be mounted on concrete piers extending above 1 m (3 ft.) above the slab and should be isolated from these piers using springs plus neoprene pads in series. Individual spring mounts with a minimum static deflection of 50 mm (2") plus double-layer ribbed or waffled neoprene pads below are preferred. If a manufacturer-supplied spring isolation rail is used in lieu of individual springs, double-layer rubber pads should be used between the I-beam that supports the rail and the top of each pier. Shop drawings for all noise and vibration control equipment shall be submitted for review and approval prior to installation.
- .18 All boilers, including hot water boilers, are to be supported on 25 mm (1") thick neoprene pads, properly selected for the weight involved. All in-line heating pumps and associated piping are to be isolated using spring and neoprene isolation hangers having at least 25 mm (1") of static deflection. This applies to all heating pipes over 50 mm (2") in diameter on the mechanical level. Pipes 50 mm (2") or smaller shall be isolated where clamped to shear walls using rubber or Armaflex sleeves.
- .19 Provide vibration isolation on all motor driven equipment with electric motors of 0.37 KW (0.5 H.P.) and greater power output and on piping and ductwork as specified herein. For equipment less than 0.37 KW, provide neoprene grommets at the support points.
- .20 Provide horizontal limit springs or snubbers on all spring isolated fans (except vertical discharge) in excess of 1 kPa (4" water gauge) static pressure, and on hanger supported horizontally mounted axial fans.
- .21 Provide, for equipment as designated in the Equipment Schedules and/or shown on the Drawings, concrete inertia bases or structural steel frames located between all vibrating equipment and vibration isolation elements. Structural steel frames will not be required if the equipment manufacturer certifies direct attachment capabilities. Provide inertia bases on centrifugal fans with static pressure in excess of 876 Pa (3.5") and/or motor in excess of 30 KW (40 HP) and on base mounted pumps over 8 KW (10 HP).
- .22 On fans, as designated in the Equipment Schedules and/or on the Drawings, provide stabilizing springs to eliminate movement at flexible connections to 25% of fabric width under steady state conditions and 40% at start up. Flexible duct connectors between all isolated fans and non-isolated ductwork are specified in Section 23 33 00 Air Duct Accessories.
- .23 Refer to Section 20 05 10 for the provision of housekeeping pads.

3.02 VIBRATION ISOLATION INSPECTION

- .1 Engage the services of the local representative of the vibration isolation materials manufacturer to conduct periodic inspections of the installation of materials herein specified, and report in writing to the Contractor of any deviations from good installation practice observed.
- .2 On completion of installation of all noise and vibration isolation devices herein specified, the local representative of the isolation materials manufacturer is to inspect the completed system and report in writing any installation errors, improperly selected isolation devices, or other fault in the system that could affect the performance of the system. Supplier shall provide conformance

3.03 CLEANING

- .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

END OF SECTION 20 05 20

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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Mechanical Work General Instructions Section 20 05 05 and Basic Mechanical Materials and Methods Section 20 05 10.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Supply and installation of piping, ductwork, and equipment insulation.

1.03 DEFINITIONS

- .1 For purposes of this section:
 - .1 "CONCEALED" - insulated mechanical services and equipment in suspended ceilings and non-accessible chases and furred-in spaces.
 - .2 "EXPOSED" - means "not concealed" as previously defined.
 - .3 Insulation systems - insulation material, fasteners, jackets and other accessories.

1.04 QUALITY ASSURANCE

- .1 Qualifications: Execute work of this section only by skilled tradesmen regularly employed in the application of insulation to piping, ductwork, plenums, tanks, pressure vessels, equipment casings and heating panels for building heating, cooling, ventilating and plumbing systems.
- .2 Insulation, self-adhesive tape, adhesives and any insulation finishes to be ULC labelled and listed for flame spread rating of less than 25 and smoke development classification of less than 50.
- .3 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Division 01, Health and Safety Requirements.
- .4 Acceptable Manufacturers:
 - .1 Insulation: Fiberglas Canada Inc., Knauf Fiber Glass, Manson, Roxul.
 - .2 Preformed flexible elastomeric insulation: ARMACELL – AP Armaflex SS Pipe Insulation, Johns Manville, Rubatex.
 - .3 Tape: Avery Dennison, Mactac, Tuck, Compac.
 - .4 Canvas: Fattal Thermocanvas, Alpa-Maritex 3451-RW, Clairmont Diplag 60.
 - .5 Lagging adhesive: Childers CP.50A-HV2, Fosters 30-36 asbestos free.

1.05 SUBMITTALS

- .1 Submit manufacturer's printed product literature and datasheets for insulation adhesives, coatings and finishes, include product characteristics, performance criteria, physical size, finish and limitations in accordance with Section 20 05 01 – Shop Drawings, Product Data & Samples.

1.06 DELIVERY, STORAGE AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

1.07 WARRANTY

- .1 Provide warranties as outlined in Section 20 05 05 - Mechanical Work General Instructions.

PART 2 - PRODUCTS

2.01 INSULATION

- .1 Preformed: ULC Listed sectional glass fibre pipe insulation in compliance with ASTM C335 in sections 900 mm (36") long, split and ready for application with a maximum Thermal Conductivity of 0.033 W/m°C at 24°C mean temperature and be capable of use on service from -40°C to 260°C and with factory applied vapour seal jacket of vinyl coated foil Kraft laminate with reinforcing of open mesh glass fibre.
- .2 Preformed Foam: ULC Listed sectional DOW Trymer 2000 XP Polyisocyanurate Foam pipe insulation in compliance with ASTM C335 in sections 900 mm (36") long, split and ready for application with a density of 32.8 kg/m³ (2.05 lb/ft³) according to ASTM D1622, R-value of 0.93 m² °C/W at 24°C mean temperature, water absorption of not more than 0.7% by volume according to ASTM C272, be capable of use on service from -183°C to 149°C and with factory applied vapour seal jacket.
- .3 Rigid board: 72 kg/m³ (4.5 lbs/ft³) density ULC listed glass fibre board with glass fibre reinforced aluminium foil vapour seal facing and maximum thermal conductivity of 0.035 W/m°C at 24°C mean temperature.
- .4 Blanket: 24 kg/m³ (1.5 lbs/ft³) ULC listed flexible glass fibre blanket with glass fibre reinforced aluminium foil vapour seal facing with thermal conductivity of 0.036 W/m°C.
- .5 High temperature (over 200°C): Preformed calcium silicate or Roxul 1200 mineral fibre piping insulation.
- .6 Low temperature: 20 mm fire retardant closed cell Armaflex in sheet form or preformed for piping.
- .7 Preformed flexible elastomeric closed cell insulation for installation on cold and dual temperature (hot and cold) system piping, valves and fittings: to ASTM C534. Thermal performance: 0.04 W/m°C @ 24°C (0.28 btu/hr/in/sq ft°F @ 75°F) established in accordance with ASTM C 177 or ASTM C 518 and CAN2-51.40-M80+Amendments. service temperature: -40°F to 203°F (-40°C to 95°C), tubular with self-sealing seams, noncombustible meeting 25/50 flame spread/smoke developed when tested to ASTM E84, a water vapour transmission rating of 0.08 in accordance with ASTM E96-90, Procedure A. Provide manufacturer specific sealer/adhesive.

2.02 FINISHES AND PROTECTIVE COVERINGS

- .1 Canvas: 170 g/m² with lagging adhesive, ULC labelled.
- .2 Protective covering (aluminium): .020 Childers corrugated aluminium preformed covering complete with strapping and seals.
- .3 For pipework, ductwork or equipment exposed to the elements, provide an external PVC jacket to the insulation which is to be a white UV resistant PVC jacket. Extra thick material is to be used on outdoor installations only. Normal thickness for indoor installation. 25/50 flame and smoke rated grade PVC shall be used.
 - .1 Finish is to be high gloss white.
 - .2 Minimum thickness to be 10mm
 - .3 Must be resistant to fungi and bacterial growth and comply with ASTM G 21 & G22.
 - .4 PVC must be in compliance with ASTM 1784 & CAN/CGSB 51.53.95.
 - .5 When installing PVC jacket, jacket must overlap a minimum of 50mm
- .4 Polyvinyl Chloride (PVC) (For use inside mechanical room only):
 - .1 ULC labelled One piece moulded type to CAN/CGSB 51.53 with pre formed shapes as required.
 - .2 Colours: [to match adjacent finish paint.
 - .3 Minimum service temperatures: 20°C.
 - .4 Maximum service temperature: 65°C.

- .5 Moisture vapour transmission: 0.02 perm.
- .6 Thickness: 6 mil.
- .7 Fastenings:
 - .1 Use solvent weld adhesive compatible with insulation to seal laps and joints.
 - .2 Tacks.
 - .3 Pressure sensitive vinyl tape of matching colour.
- .8 Special Requirements:
 - .1 Outdoor: UV rated material at least 0.5 mm thick.

PART 3 - EXECUTION

3.01 APPLICATION

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

3.02 PRE-INSTALLATION REQUIREMENTS

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

3.03 EQUIPMENT AND MISCELLANEOUS APPLICATIONS

- .1 Heat exchangers and tanks: shell and tube type [and hot water storage tanks:] 50mm (2") thick rigid board or preformed. Score and mitre to fit contours of equipment and secure with 12mm x 0.38mm (2" x 0.015") galvanized steel bands 600mm (24") OC. Point up all joints with insulating cement. Finish with specified canvas. Do not insulate over registration and nameplates.
- .2 Chiller vessels and refrigerant suction lines: 20mm fire retardant closed cell Armaflex on evaporator/condenser, suction/discharge piping, and chilled water headers. Apply Armaflex with suitable adhesive and seal all joints with suitable plastic tape. For chiller heads, provide one or two piece slip-on field fabricated and fitted sections held in place with metal bands with screwdriver operated tightening devices. Cover all Armaflex with specified canvas. Do not insulate over registration and nameplates.

3.04 AIR UNIT CASINGS (INTERNAL)

- .1 25mm (1") thick rigid board neoprene faced. Install insulation on weld pins and speed washers 300mm (12") OC. Cut pins flush with surface of insulation and cover all pins and joints with glass fab tape embedded in two coats of approved mastic compound. Use the first coat to embed the glass fab tape and the second coat as a finish. Refer to detail drawings.

3.05 DUCTWORK

- .1 Installation
 - .1 Exposed ductwork: rigid board Insulation
 - .1 Rectangular ductwork: Impale rigid board on weld pins and speed washers 300mm (12") OC with a minimum of two rows per side on any side greater than 300mm (12"). Cut pins flush with surface of insulation and cover with foil faced type. Cover all joints with foil faced self-adhesive tape. Finish with canvas.
 - .2 Round ductwork: Score and mitre rigid board to fit contours of duct and secure with 12mm x 0.38mm (2" x 0.015") galvanized steel bands 300mm (12") OC. Point up all joints with insulating cement and seal with foil faced self-adhesive tape. Finish with canvas.
 - .2 Concealed ductwork:

- .1 Blanket type insulation. Apply flexible blanket insulation with an approved adhesive brushed on in 100mm (4") wide strips 300mm (12") OC and at all joints. For rectangular ducts over 450mm (18"), blanket type insulation should be secured to the bottom side of the duct with mechanical fasteners spaced on 450mm (18") centres. Care should be taken to avoid over-compressing the insulation with the retaining washer. Seal all joints and perforations with foil-faced self-adhesive tape.
- .2 Ductwork over 1500mm (5') in width or ductwork located in vertical shaft: Use rigid board insulation.
- .3 Ductwork exposed to outdoors: Impale rigid board on weld pins and speed washers 300mm (12") OC with a minimum of two rows per side on any side greater than 300mm (12"). Cut pins flush with surface of insulation and cover pins and joints with foil-faced self-adhesive tape. Finish with two applications of weather protective coating trowelled smooth.
- .4 Where ductwork is symbolized as external acoustic: apply over rigid board two coats of hard plaster at 9.53mm thick each, trowel smooth and finish with canvas.
- .2 Application: Provide external ductwork insulation in thickness as listed below:
 - .1 All supply air ductwork from fan discharge or unit outlet of air handling systems delivering air at temperatures less than 18°C and greater than 30°C. This includes supply air ductwork connected to discharge side of fan coil units, heat pumps, reheat coils and VAV terminals and air handling systems with cooling and/or heating coils and direct or indirect fired burner sections.
 - .1 Provide 25mm (1") thick for systems with 18°C or less air supply temperature.
 - .2 Provide 40mm (1½") thick for systems with 30°C or greater air supply temperature.
 - .3 Outdoor intake ductwork, ductwork conveying mixed outdoor/return air and mixed air plenums: 50mm (2") thick.
 - .4 Supply and return air ductwork located outdoors: 75mm (3") thick.
 - .5 Exhaust ductwork located outdoors: 50mm (2") thick.
 - .6 Exhaust ductwork located indoors for a minimum of 3 m (10 ft.) back from the discharge point to outdoors: 25mm (1") thick.
 - .7 Exhaust ductwork located indoors from ERV or heat wheel to the discharge point: 25mm (1" thick), except for residential suites.
 - .8 Where specifically noted on drawings that could be an exception to the foregoing.
 - .2 Exceptions: external duct insulation is not required where:
 - .1 Supply air ductwork installed exposed within conditioned space.
 - .2 Note: Supply air ductwork installed concealed in ceiling spaces, whether ceiling space used as return air plenum or not, is to be totally insulated.
 - .3 Ductwork is internally insulated and located indoors.
 - .4 Collars to registers, grilles and diffusers are 900mm (3 ft.) or less in length.
 - .5 Acoustic type flexible ductwork is used.
 - .6 Duct silencers with acoustic media on all four sides are installed.
 - .3 Where a supply or return duct is not protected by an insulated exterior wall or where the duct is exposed to an unheated space, provide a minimum of 75mm (3") of rigid board insulation with a minimum RSI 2.1 (R-12) insulation value.

- .4 Where exhaust ducts containing air from heated space pass through or are adjacent to unheated spaces, provide a minimum of 75mm (3") of rigid board insulation with a minimum RSI 2.1 (R-12) insulation value.

3.06 PIPING APPLICATION SCHEDULE

Item	Conductivity Range W/m°C	Insulation Thickness & Type
Domestic hot water (Conditioned space)	0.032 – 0.041	25mm (1") pre-molded for pipe up to and including 31mm (1¼"). 40mm (1½") for 38mm (1½") pipe and greater. 50mm (2") for greater than water temperature higher than 60°C (140°F).
Domestic hot water (Non-conditioned space or outdoor)	0.032 – 0.041	40mm (1½") for runouts less than 50mm (2") pipe 65mm (1½") pre-molded for pipe up to and including 50mm (2"). 76mm (3") pre-molded for pipe from 65mm (2½") up to and including 100mm (4") 88mm (3½") for 125mm (5") pipe and greater.
Domestic hot water recirculation (Conditioned space)	0.032 – 0.041	25mm (1") pre-molded for pipe up to and including 31mm (1¼"). 40 mm (1½") for 40mm (1½") pipe and greater.
Domestic hot water recirculation (Non-conditioned space or outdoor)	0.032 – 0.041	40mm (1½") for runouts less than 50mm (2") pipe 65mm (2½") pre-molded for pipe up to and including 50mm (2").
Domestic cold water & Non-potable water	0.033	12mm (½") pre-molded 40mm (1½") pipe and below. 25mm (1") pre-molded for 50mm (2") pipe to 150mm (6") pipe. 31mm (1") pre-molded for 200mm (8") pipe and greater.
Heating system piping (Design operating temperature below 93 °C)	0.036 – 0.042	40mm (1½") pre-molded 31mm (1¼") pipe and below. 50mm (2") pre-molded for 40mm (1 ½") pipe and greater.
Heating system piping (Design operating temperature above 93 °C)	0.039 – 0.043	65mm (2½") pre-molded 75mm (3") pipe and below. 75mm (3") pre-molded for 100mm (4") pipe and greater.
Chilled water piping (Design operating temperature 5-13 °C)	0.030 – 0.039	25mm (1") pre-molded [50mm (2") pre-molded Foam for Cayman application]

Item	Conductivity Range W/m°C	Insulation Thickness & Type
Chilled water piping (Design operating temperature below 5 °C)	0.029 – 0.037	25mm (1") pre-molded for 19mm (¾") pipe and including 100mm (4"). 40mm (1½") pre-molded for pipe greater than 100mm (4").
Condensate Horizontal drains from fan coil units, heat pumps, and cooling coils, suspended horizontal drains receiving cooling coil condensate, suspended horizontal drains from urinals and water closets and roof drain receptors and horizontal rainwater leaders and fittings	0.033	25mm (1") pre-molded
Heat pump piping	0.033	Not required for standard water to air type. 50mm (2") for ground loop water to air and water to water type, to be applied as specified for chilled water piping. This applies to the heat sink (i.e. ground source) side. Supply side within the building to be insulated as specified for chilled water. Insulation for buried piping under floor slabs and outdoors is specified in Section 23 85 10
Refrigeration suction and hot gas lines	0.04	40mm (1.5") flexible elastomeric up to and including 25mm (1"). 45mm (1.75") flexible elastomeric for pipe between 32mm (1-1/4") to 50mm (2"). 50mm (2") flexible elastomeric for pipe between 65mm (2-1/2") to 100mm (4").

3.07 PIPING

- .1 Apply insulation at temperature of approximately 8°C over clean, dry surfaces. Butt adjoining sections of insulation firmly together with the longitudinal seam of the jacket located on the bottom half of the pipe.
- .2 Insulate and finish in the same manner and same thickness as piping, all valves, fittings and flanges on cold, hot and chilled water piping. Use PVC jacketed mitred sections of the specified pipe covering or preformed insulation to suit fitting. Insulate all fittings, valves, strainers, unions and flanges on domestic hot water service for health care facilities including old age homes and long term care buildings.
- .3 Seal longitudinal lap joints with a suitable vapour barrier adhesive for cold and chilled water piping and a suitable cement capable of withstanding service temperature on hot water piping. Cover circumferential butt joints with a strip of the same material as the jacket and cement as indicated above. Cover all joints with foil faced self-adhesive tape on chilled and cold water piping.
- .4 Concealed insulated items require no further finish than provided in factory applied jacket. Cover exposed insulation and all insulated equipment with canvas, field applied, adhered and lap sealed and finished off by a brush coat of approved sizing.

- .5 Insulated piping exposed to outdoors: Apply aluminium protective covering over all insulated pipe and fittings. Seal all joints with approved sealants.
- .6 Seal valves, fittings and flanges on cold and chilled water application in a manner as specified for circumferential joints. On strainers, insulate over blow-down valves and bushings or flanges required for strainer basket removal by providing a removable prefabricated Armaflex cover held in place with a stainless steel gear clamp. Do not insulate over blow-down valves and bushings or flanges for strainer basket removal on condenser water piping.
- .7 Seal end joints and perforation with 100mm (4") vapour barrier strips applied with the same adhesives and cements as previously specified for cold and chilled water.
- .8 On all domestic cold and chilled water piping:
 - .1 Where oversized hangers are used, protect insulation with a sheet metal saddle installed over the vapour barrier. For piping 40mm (1½") and larger provide a section of rigid insulation or non-compressible material under the vapour barrier the same length as the saddle - see detail drawing.
 - .2 Where oversized hangers are not used, apply 12 mm (½") insulation with vapour seal over hanger and support rod for a distance of two pipe diameters up the rod from the attachment point at the ring, clamp or clevis.
- .9 Apply blanket type insulation on piping using an approved adhesive and seal all longitudinal and transverse joints with foil faced tape. Insulate pipe hanger in similar manner for a distance of two pipe diameters up the rod beyond the attachment point at the ring, clamp or clevis.
- .10 Insulation on piping where Victaulic couplings are used:
 - .1 In concealed areas, provide insulation over couplings to same thickness as specified for piping.
 - .2 In exposed areas, (except mechanical and service rooms) increase insulation thickness and provide one-half specified thickness over couplings to achieve the appearance of uniform diameter of pipe and fittings.
 - .3 Where aluminium sheet cladding is required, increase insulation thickness as described in (2) above to achieve a standard and uniform diameter.
- .11 On water to water heat pump circuits utilizing 50mm (2") insulation: At all ball valves, use 1" insulation to allow space for valve handle operation.

3.08 FINISHES

- .1 PVC over insulated items where exposed indoors.
- .2 28 ga. aluminium over all insulated piping exposed to outdoors.
- .3 Weatherproof mastic, two coats trowelled smooth, over ductwork insulation where exposed outdoors.
- .4 Breeching Insulation: Apply 13mm (½") coat of hydraulic setting insulating cement trowelled smooth over metal mesh.

3.09 CLEANING

- .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

END OF SECTION 20 05 25

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- 3.01 INSTALLATION OF VARIABLE FREQUENCY DRIVES
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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Section 20 05 05, Mechanical work General Instructions and Section 20 05 10, mechanical Basic Mechanical Materials and Methods.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Supply and installation of Variable Frequency Drives.

1.03 QUALITY ASSURANCE

- .1 Qualifications: Execute work of this section only by skilled licensed tradesmen regularly employed in the installation of variable frequency drives.
- .2 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Division 01 to suit Health and Safety Requirements.
- .3 Acceptable manufacturers: ABB, AC Tech, Allen Bradley, Danfoss (Graham), Siemens, Nidec, Schneider Electric factory assembled units.

1.04 SUBMITTALS

- .1 Submit shop drawings on variable frequency controllers and starters in accordance with Section 20 05 01 – Shop Drawings, Product Data & Samples.

1.05 DELIVERY, STORAGE AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

1.06 WARRANTY

- .1 Provide warranties as outlined in Section 20 05 05.
- .2 Variable Frequency Drives will be accepted after start-up, a minimum of 10 hours of logged trouble-free operation, 10 hours of connected EMCS trouble-free operation, four hours of instruction to Owner's operating staff and submission of written verification attesting thereto by manufacturer's representative. The Consultant must also witness a portion of this procedure
- .3 Include verification of acceptance certificates with the maintenance and operating manuals in the appropriate sections.

PART 2 - PRODUCTS

2.01 VARIABLE FREQUENCY CONTROLLERS

- .1 General: Provide as indicated in the Equipment Schedules factory fabricated and tested pulse width modulating frequency controllers compatible with the motor horse powers listed for the variable volume air handling units, return air fans, pumps and/or cooling tower fans.
- .2 Application:
 - .1 The load characteristics of the application are:
 - .1 Variable torque (e.g. fans).
 - .2 Operating speed range from 180 to Normal Motor RPM (refer to FAN MOTOR DATA table in item .18).
- .3 Operating Conditions:
 - .1 Drive to accept power nominal AC voltage of 600V \pm 15%, three-phase, frequency 60 Hertz.

- .2 Operating ambient condition to have a temperature range of 0 to 40°C with a relative humidity of up to 95% (non-condensing).
- .3 Altitude: 0 - 215m (0 - 700 ft.) above sea level.
- .4 AC Adjustable Speed Drive Systems:
 - .1 Adjustable frequency AC drives to convert 600V \pm 15%, 3 phase, 60 Hertz utility input power to an adjustable AC frequency and voltage for controlling variable torque through speed of AC squirrel cage fan motors. Converters to be of the voltage source design with a pulse width modulated inverter section utilizing insulated gate bi-polar transistors (IGBT). The use of input/output transformers is not acceptable.

The drive controllers to be rated for 110% continuous of rated motor current and have capacity to provide speed control of motors throughout speed range specified.
 - .2 Controllers to include power conversion components, power control logic devices and regulator circuitry. Regulators to incorporate microprocessor technology for control of power semiconductors.
 - .3 Variable speed drive to be supplied in a NEMA 4 enclosure with drip hood if in sprinklered area and to be completely pre-wired and pre-piped for the specified control sequences, and require only field wiring from a power source to each motor and wiring of control points and safeties.
- .5 The drive to contain the following, all interconnected and factory-wired to an identified terminal strip:
 - .1 Variable frequency controllers (VFC).
 - .2 Motor control components such as overload relays, fused control circuit transformers, pushbuttons, pilot lights and other items required to perform the specified sequences of operation.
 - .3 Terminals to which specified remote devices like start/stop; etc. may be wired to the Building Management System. Field wiring for these control devices to be the responsibility of Division 25.

[If disconnect required]
 - .4 Through-the-door disconnect switch.
- .6 Operating Characteristics:
 - .1 The adjustable frequency drives to have the following features:
 - .1 \pm 1% frequency regulation.
 - .2 \pm 1% voltage regulation.
 - .3 0 to 66 Hertz operating frequency range.
 - .4 Active current limit function, adjustable 0 to 100% of controller rating.
 - .5 Maximum efficiency at full load and speed of 98%.
 - .6 Minimum incoming line power factor throughout the load speed range of 0.95.
- .7 Drive Diagnostics:
 - .1 Provide fault diagnostics to simplify troubleshooting. Each of the following points to be indicated by on LCD or LED screen:
 - .1 Lockout - (fault shutdown after three (3) restart attempts)
 - .2 Line Fault - (Line over/under voltage, phase loss/unbalance)
 - .3 Controller Overtemperature
 - .4 Motor I²t Thermal Protection

- .5 DC Bus Overvoltage
- .6 DC Bus Undervoltage
- .7 Auxiliary Power Supply Fault
- .8 Output Fault - Phase A
- .9 Output Fault - Phase B
- .10 Output Fault - Phase C
- .2 Provide keypad accessibility to a non-volatile Fault History Memory which is not operator erasable. This memory to store the following data for each of the thirty (30) most recent drive shutdowns and include date, time and elapsed time meter:
 - .1 The fault which caused the shutdown
 - .2 Output frequency at time of trip
 - .3 Output voltage at time of trip
 - .4 Output load (power) at time of trip
 - .5 Whether the load was accelerating or decelerating
- .8 Protective Functions:
 - .1 Active limiting of fundamental current by frequency fold back on acceleration loads and frequency hold on decelerating loads.
 - .2 Over current protection.
 - .3 Short circuit protection.
 - .4 Fast acting supply fuses.
 - .5 Supply voltage phase loss.
 - .6 DC intermediate bus under voltage.
 - .7 DC intermediate bus over voltage.
 - .8 Power section over temperature.
 - .9 Power section faults.
- .9 Adjustments:
 - .1 Active current limit 0-100%.
 - .2 Maximum frequency 40-100%.
 - .3 Minimum frequency 0-50%.
 - .4 Acceleration/Deceleration separately adjustable from 1 to 999 seconds.
 - .5 All adjustments shall be programmable from the front panel of VFD. Potentiometer or dip switch adjustments are not acceptable.
- .10 Auxiliary Contacts for Drive Logic Status:
 - .1 The following (NO, NC) contacts to be provided for the following logic conditions.
 - .2 Fault
 - .3 Start
 - .4 Motor contactor at the inverter output.
 - .5 Input card with auto/manual logic for isolation of analog input reference signals 4-20 mA.

- .11 Output card providing isolated 4-20 mA output for drive signals including output frequency, active or total output current.
- .12 Provide diagnostics for operator on-line status information. Each of the following status points shall be indicated on door mounted LCD screen:
 - .1 Power on
 - .2 Ready
 - .3 Run
 - .4 Jog
 - .5 Motor Accelerating
 - .6 Motor Decelerating
 - .7 Direction of rotation (forward or reverse) (if function enabled)
 - .8 Auto Mode (if function enabled)
 - .9 Manual Mode
 - .10 Stop
 - .11 Low Reference (missing or zero speed reference)
 - .12 External Trip (interlocks open)
 - .13 Current Limit
 - .14 Power Lost
 - .15 Fire Alarm Shut Down Contacts
- .13 Provide the following control functions on the door mounted keypad:
 - .1 Run
 - .2 Stop
 - .3 Jog (enabled in Stop Mode only)
 - .4 Auto/Manual (if Auto Mode is enabled)
 - .5 Forward/Reverse (if function enabled)
 - .6 Accelerate (Manual Mode)
 - .7 Decelerate (Manual Mode)
 - .8 Direct Speed Set (Manual Mode)
 - .9 Load meter to indicate active current
 - .10 Frequency meter
 - .11 Manual frequency reference potentiometer
- .14 Provide diagnostic to allow signal tracing of the logic and base or gate driver circuit boards plus additional fault diagnostics.
- .15 Provide terminals for interlocking of up to six (6) external interlocks e.g. Firestat, Freezestat, etc.
- .16 Provide the following to interface with the Energy Management Control System (EMCS):
 - .1 Software connection] from EMCS for run Command (Auto Mode).
 - .2 Isolated 4-20 mA (0-10 VDC, 0-5 VDC) signal from EMCS for speed control (Auto Mode).
 - .3 Dry contact [or software connection] (NO) output to EMCS to indicate:
 - .1 Inverter Ready

- .2 Inverter Fault
- .3 Inverter Running
- .4 Isolated 4-20 mA or isolated 0-10 VDC output to EMCS, proportional to 0-110% speed.
- .5 Isolated 4-20 mA or isolated 0-10 VDC output to EMCS, proportional to 0-110% load power.
- .6 Provide for logic card or built in interface to Modbus RTU (LonWorks, JC Metasys N2, Siemens P1, BACnet) systems. Provide for PC connection to download setup parameters.
- .17 Start-stop for manual operation of motor in by-pass starter mode.
- .18 Provide for Remote Shut Down of Inverter Circuitry

The variable frequency drive shall be fitted with a low voltage relay having normally closed contacts in the solid state electronic circuitry of the inverter to allow the power down of the inverter from a remote stop button mounted in a remote disconnected switch. This shall protect the inverter solid state electronic circuits prior to the line power being shut off at the remote disconnect switch.
- .19 AC Drive Quality Assurance:
 - .1 Power semiconductors (thyristors, diodes, etc.) to be tested for proper electrical characteristics (dv/dt, di/dt, etc.) on LEM testers.
 - .2 All chips (CMOS, TTL, LINEAR, etc.) to be given a 100% burn-in with applied voltage, and then functionally tested.
 - .3 All power capacitors active components to be functionally tested.
- .20 Provide guarantee that harmonics generated will not exceed 5% THD. If necessary provide line reactor or other filters to achieve this at no additional cost. External line reactors to be mounted in NEMA 4 enclosure.
- .21 Provide load reactor, if drive to be located more than 50 feet from motor. Co-ordinate with contractors of Divisions 20, 22, 23 and 26 for location of the motors and drives.
- .22 Provide call back within 30 minutes of receiving emergency call for service and provide on-site service within two (2) hours.
 - .1 All component parts must be maintained in a local based storage. Provide evidence of this in submission of shop drawings.
- .23 Start-Up Service:
 - .1 Provide on-site commissioning (start-up) of the adjustable frequency drives by a qualified technician. Allow a minimum of half a day per system. Also include an allowance for a second visit to site of one day duration to train operating personnel in the operation and maintenance of the drives.

PART 3 - EXECUTION

3.01 INSTALLATION OF VARIABLE FREQUENCY DRIVES

- .1 Install variable frequency drive units in locations shown on the contract drawings to provide the best possible connection arrangement and accessibility for service.

Provide clearances on all sides of the equipment as required by authorities having jurisdiction or manufacturers, whichever is greater.
- .2 Floor mounted units to be installed on a 100mm (4") thick concrete pad extending a minimum of 100mm (4") beyond foot print of drive unit. Pad to have all edges chamfered to avoid spalling.
- .3 Install drive units in accordance with the manufacturer's instructions and all applicable building and Canadian Electrical codes.
- .4 Co-ordinate the installation of variable frequency drives with the Division 26 Sub-Trade.

- .5 Co-ordinate the installation and commissioning of drive units with the Energy Management Control Contractor (Division 25 Sub-Trade) and Air & Water Balancing Contractor.
- .6 The Divisions 20, 21, 22, and 23 contractors shall notify the Division 26 contractor of the requirement to provide remote disconnects of all motors controlled through variable frequency drives to be fitted with a low voltage push button for inverter circuit isolation.
- .7 The Divisions 20, 21, 22 and 23 contractors shall provide warning labels at remote disconnects stating that:
"Before shutting off main power, isolate the VFD inverter by depressing the low voltage push button".
"Push button to be reset and disconnect closed prior to restart of variable frequency drive."

3.02 VARIABLE FREQUENCY CONTROLLER TEST

- .1 Follow manufacturer's instructions and have manufacturer's representative present to certify the installation.
- .2 Check each item of equipment to ensure proper electrical connections, etc., and to verify proper operation.
- .3 Upon completion of installation of equipment start-up, operate equipment to demonstrate capability and compliance with requirements. Field correct malfunctioning units, then retest to demonstrate compliance.
- .4 Start each piece of equipment controlled via frequency controller and by varying the control set point check that speed variation is linear throughout the full control range.
- .5 Check that annunciator panel and alarms are functioning in accordance with the specifications, and that all signals between the variable frequency drive and EMCS are accurate.

3.03 CLEANING

- .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

END OF SECTION 20 05 30

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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Section 20 05 05 Mechanical Work General Instructions.
- .3 Comply with requirements of Section 26 00 00 Electrical General Requirements.

1.02 WORK INCLUDED

- .1 Provide low voltage motor starters as specified herein and as shown on the contract drawings.
- .2 The motor starters shall be designed, manufactured and tested in accordance with the latest applicable standards of NEMA, ANSI and UL.

1.03 RELATED SECTIONS

- .1 Section 20 05 30 - Variable Frequency Drives
- .2 Section 25 01 01 - Building Automation System

1.04 SUBMITTALS

- .1 Submit shop drawings showing the following information:
 - .1 Master drawing index
 - .2 Dimensioned outline drawings
 - .3 Conduit entry/exit locations
 - .4 Cable terminal sizes
 - .5 Wiring diagrams
 - .6 Nameplate schedule
 - .7 Ratings including:
 - .1 Voltage
 - .2 Horsepower and/or continuous current
 - .8 Product data sheets
- .2 Submit for record purposes as part of O&M manuals:
 - .1 Final as-built drawings and information for items listed in Paragraph above, and shall incorporate all changes made during the manufacturing process.
 - .2 Wiring diagrams.
 - .3 Seismic certification and equipment anchorage as specified.

1.05 QUALIFICATIONS

- .1 The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.
- .2 For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.
- .3 The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Consultant, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- .4 Provide Seismic tested equipment as follows:

- .1 The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of the International Building Code (IBC) for zone 4 application. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, IBC: a peak of 2.45g's (3.2-11 Hz), and a ZPA of 0.98g's applied at the base of the equipment. The tests shall fully envelop this response spectrum for all equipment natural frequencies up to at least 35 Hz.

--OR --

- .2 The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of the California Building Code (CBC) through zone 4 application. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, CBC: a peak of 2.15g's, and a ZPA of 0.86g's applied at the base of the equipment. The tests shall fully envelop this response spectrum for all equipment natural frequencies up to at least 35 Hz.

--OR --

- .3 The manufacturer may certify the equipment based on a detailed computer analysis of the entire assembly structure and its components. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment
- .4 The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.
- .1 The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon approved shake table tests used to verify the seismic design of the equipment.
- .2 The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.
- .3 The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

1.06 DELIVERY, STORAGE AND HANDLING

- .1 Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.07 OPERATION AND MAINTENANCE MANUALS

- .1 Equipment operation and maintenance manuals shall be provided with each assembly shipped and shall include instruction leaflets, instruction bulletins and renewal parts lists where applicable, for the complete assembly and each major component.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- .1 For Motor Starters:

- .1 Eaton/Cutler-Hammer products
- .2 Schneider Electric
- .3 Siemens

The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Consultant ten (10) days prior to bid date.

2.02 MANUAL MOTOR CONTROL

.1 Single-Phase Manual Starters

- .1 Manual single-phase starters 1 hp or smaller shall be Cutler-Hammer type MS starters or approved equal. The starter shall have a quick-make/quick-break toggle mechanism. The overload shall have a field adjustment allowing up to +/- 10% variance in ratings of the nominal heater value
- .2 Manual single-phase starters above 1 hp shall be Cutler-Hammer type B100 or approved equal. The starter shall have quick-make/quick-break mechanism. The closure of the contacts shall be blocked while the line terminals are exposed. The operating handle or button shall clearly indicate whether the unit is ON, OFF or TRIPPED
- .3 The enclosure shall be [general purpose NEMA 1] [general purpose NEMA 1B – flush mounted] [watertight NEMA 3, 4, 5] [hazardous locations NEMA 7D: Class I, Group D] [hazardous locations NEMA 9E, F, G: Class II, Groups E, F, G] [as indicated on the contact drawings]

.2 Three-Phase Manual Starters

- .1 The starter shall have quick-make/quick-break operating mechanism.
- .2 The operating handle or button shall clearly indicate whether the unit is ON, OFF or TRIPPED.
- .3 The closure of the contacts shall be blocked while the line terminals are exposed
- .4 The enclosure shall be [general purpose NEMA 1] [general purpose NEMA 1B – flush mounted] [watertight NEMA 3, 4, 5] [hazardous locations NEMA 7D: Class I, Group D] [hazardous locations NEMA 9E, F, G: Class II, Groups E, F, G] [as indicated on the contract drawings]
- .5 Manual three-phase motor starters shall be Cutler-Hammer type B100 or equal

.3 Three-Phase Manual Motor Starter and Protector

- .1 The starter shall have an adjustable Class 10 ambient compensated integral overload relay and a fixed magnetic short-circuit trip mechanism designed to trip at twelve (12) times the maximum current rating of the starter
- .2 The starter shall be UL listed and CSA certified for group motor installations with 1200 ampere maximum fuse and circuit breaker ratings at 480 Vac
- .3 The starter shall have provisions for padlocking in the OFF position
- .4 The starter shall have accessories such as auxiliary contacts, trip alarm, undervoltage release, and shunt trip available for field installation
- .5 The enclosure shall be general purpose NEMA 1
- .6 Motor starter and protector shall be Cutler-Hammer type [A302], [A307], [A308], [A309] [or equal]

2.03 ELECTROMECHANICAL MOTOR CONTROL

.1 Non-Reversing Starters

- .1 Magnetic starters through NEMA Size 9 shall be equipped with double-break silver alloy contacts. The starter must have straight-through wiring. Each starter shall have one (1) NO auxiliary contact
- .2 Coils shall be permanently marked with voltage, frequency and part number
- .3 Overload relays shall be an ambient compensated bimetallic-type with interchangeable heaters, calibrated for 1.0 and 1.15 service factor motors. Electrically isolated NO and NC contacts shall be provided on the relay. Visual trip indication shall be standard. A test trip feature shall be provided for ease of troubleshooting and shall be conveniently operable without removing components or the motor starter. Overload to have (+/-) 24% adjustability, single-phase sensitivity, and isolated alarm contact, and manual or automatic reset

OR --

.4 Solid-State Overload Relay

- .1 Provide a solid-state overload relay for protection of the motors. The relay shall be Cutler-Hammer type CEP7 or approved equal.
- .2 The overload relay shall provide high accuracy through the use of state-of-the-art microelectronic packaging technology. The relay shall be suitable for application with NEMA Size 1 through Size 7 motor starters.
- .3 The overload relay shall be modular in design, be an integral part of a family of relays to provide a choice of levels of protection, be designed to directly replace existing electromechanical overload relays, and be listed under UL Standard 508.
- .4 The overload relay shall have the following features:
 - .1 Be self-powered
 - .2 Class 10 or 20 fixed tripping characteristics
 - .3 Manual or automatic reset
 - .4 Phase loss protection. The relay shall trip in 2 seconds or less under phase loss condition when applied to a fully loaded motor
 - .5 Visible trip indication
 - .6 One NO and one NC isolated auxiliary contact
 - .7 Test button that operates the normally closed contact
 - .8 Test trip function that trips both the NO and NC contacts
 - .9 A current adjustment range of 3.2:1 or greater
 - .10 Ambient temperature compensated
 - .11 Ground fault protection. Relay shall trip at 50% of full load ampere setting
 - .12 Jam/Stall protection. Relay shall trip at 400% of full load ampere setting, after inrush
- .5 NEMA Size 00 through 2 starters shall be suitable for the addition of at least six (6) external auxiliary contacts of any arrangement normally open or normally closed. Sizes 3 through 8 starters shall be suitable for the addition of up to eight (8) external auxiliary contacts of any arrangement normally open or normally closed
- .6 Motor starters shall be Cutler-Hammer Freedom Series or approved equal

.2 Reversing Starters

- .1 Reversing starters shall consist of two (2) contactors and a single overload relay assembled together. The contactors shall be mechanically and electrically interlocked to prevent line shorts and the energizing of both contactors simultaneously
- .2 Magnetic starters through NEMA Size 8 shall be equipped with double-break silver alloy contacts. The starter must have straight-through wiring
- .3 Coils shall be permanently marked with voltage, frequency and part number
- .4 Overload relays shall be an ambient compensated bimetallic-type with interchangeable heaters, calibrated for 1.0 and 1.15 service factor motors. Electrically isolated NO and NC contacts shall be provided on the relay. Visual trip indication shall be standard. A test trip feature shall be provided for ease of troubleshooting and shall be conveniently operable without removing components or the motor starter. Overload to have +/- 24% adjustability, single-phase sensitivity, and isolated alarm contact and manual or automatic reset
OR --
- .5 Solid-State Overload Relay
 - .1 Provide a solid-state overload relay for protection of the motors. The relay shall be Cutler-Hammer type CEP7 or approved equal. The overload relay shall provide high accuracy through the use of state-of-the-art microelectronic packaging technology. The relay shall be suitable for application with NEMA Size 1 through Size 7 motor starters.
 - .2 The overload relay shall be modular in design, be an integral part of a family of relays to provide a choice of levels of protection, be designed to directly replace existing electromechanical overload relays, and be listed under UL Standard 508.
 - .3 The overload relay shall have the following features:
 - .1 Be self-powered
 - .2 Class 10 or 20 fixed tripping characteristics
 - .3 Manual or automatic reset
 - .4 Phase loss protection. The relay shall trip in 2 seconds or less under phase loss condition when applied to a fully loaded motor
 - .5 Visible trip indication
 - .6 One NO and one NC isolated auxiliary contact
 - .7 Test button that operates the normally closed contact
 - .8 Test trip function that trips both the NO and NC contacts
 - .9 A current adjustment range of 3.2:1 or greater
 - .10 Ambient temperature compensated
 - .11 Ground fault protection. Relay shall trip at 50% of full load ampere setting
 - .12 Jam/Stall protection. Relay shall trip at 400% of full load ampere setting, after inrush
 - .4 NEMA Size 00 through 2 starters shall be suitable for the addition of at least six (6) external auxiliary contacts of any arrangement normally open or normally closed. Sizes 3 through 8 starters shall be suitable for the addition of up to eight (8) external auxiliary contacts of any arrangement normally open or normally closed
 - .5 Motor starters shall be Cutler-Hammer Freedom Series or approved equal
- .3 Two-Speed Starters

- .1 Magnetic starters through NEMA Size 6 shall be equipped with double-break silver alloy contacts. The starter must have straight-through wiring
- .2 Coils shall be permanently marked with voltage, frequency and part number
- .3 Overload relays shall be an ambient compensated bimetallic-type with interchangeable heaters, calibrated for 1.0 and 1.15 service factor motors. Electrically isolated NO and NC contacts shall be provided on the relay. Visual trip indication shall be standard. A test trip feature shall be provided for ease of troubleshooting and shall be conveniently operable without removing components or the motor starter. Overload to have +/- 24% adjustability, single-phase sensitivity, and isolated alarm contact and manual or automatic reset
- OR --**
- .4 Solid-State Overload Relay
 - .1 Provide a solid-state overload relay for protection of the motors. The relay shall be Cutler-Hammer type CEP7 or approved equal.
 - .2 The overload relay shall provide high accuracy through the use of state-of-the-art microelectronic packaging technology. The relay shall be suitable for application with NEMA Size 1 through Size 7 motor starters.
 - .3 The overload relay shall be modular in design, be an integral part of a family of relays to provide a choice of levels of protection, be designed to directly replace existing electromechanical overload relays, and be listed under UL Standard 508.
 - .4 The overload relay shall have the following features:
 - .1 Be self-powered
 - .2 Class 10 or 20 fixed tripping characteristics
 - .3 Manual or automatic reset
 - .4 Phase loss protection. The relay shall trip in 2 seconds or less under phase loss condition when applied to a fully loaded motor
 - .5 Visible trip indication
 - .6 One NO and one NC isolated auxiliary contact
 - .7 Test button that operates the normally closed contact
 - .8 Test trip function that trips both the NO and NC contacts
 - .9 A current adjustment range of 3.2:1 or greater
 - .10 Ambient temperature compensated
 - .11 Ground fault protection. Relay shall trip at 50% of full load ampere setting
 - .12 Jam/Stall protection. Relay shall trip at 400% of full load ampere setting, after inrush
 - .5 NEMA Size 00 through 2 starters shall be suitable for the addition of at least six (6) external auxiliary contacts of any combination of normally open or normally closed contacts. Sizes 3 through 6 starters shall be suitable for the addition of up to eight (8) external auxiliary contacts of any combination of normally open or normally closed contacts
 - .6 Two-speed magnetic starters for motors up to 400 hp, 600 volts shall be Cutler-Hammer Freedom Series type AN700 or approved equal
- .4 Vacuum Starters
 - .1 Vacuum starters shall incorporate "low-chop" interrupters and limit chop currents to less than 0.5 amperes. Contact material to be silver tungsten carbide

- .2 Interrupters shall have contact wear detection indicators
- .3 Vacuum starters shall have front removable coil and auxiliaries
- .4 The contactor coil shall utilize rectified ac current
- .5 Provide a "push-to-test" button for Sizes 5 and 6
- .6 Vacuum contactors shall be Cutler-Hammer Class V200 for non-reversing and Class V210 for reversing
- .7 Overload relays shall be an ambient compensated bimetallic-type with interchangeable heaters, calibrated for 1.0 and 1.15 service factor motors. Electrically isolated NO and NC contacts shall be provided on the relay. Visual trip indication shall be standard. A test trip feature shall be provided for ease of troubleshooting and shall be conveniently operable without removing components or the motor starter. Overload to have (+/-) 24% adjustability, single-phase sensitivity, and isolated alarm contact and manual or automatic reset

OR –

- .8 Solid-State Overload Relay
 - .1 Provide a solid-state overload relay for protection of the motors. The relay shall be Cutler-Hammer type CEP7 or approved equal.
 - .2 The overload relay shall provide high accuracy through the use of state-of-the-art microelectronic packaging technology. The relay shall be suitable for application with NEMA Size 1 through Size 7 motor starters.
 - .3 The overload relay shall be modular in design, be an integral part of a family of relays to provide a choice of levels of protection, be designed to directly replace existing electromechanical overload relays, and be listed under UL Standard 508.
 - .4 The overload relay shall have the following features:
 - .1 Be self-powered
 - .2 Class 10 or 20 fixed tripping characteristics
 - .3 Manual or automatic reset
 - .4 Phase loss protection. The relay shall trip in 2 seconds or less under phase loss condition when applied to a fully loaded motor
 - .5 Visible trip indication
 - .6 One NO and one NC isolated auxiliary contact
 - .7 Test button that operates the normally closed contact
 - .8 Test trip function that trips both the NO and NC contacts
 - .9 A current adjustment range of 3.2:1 or greater
 - .10 Ambient temperature compensated
 - .11 Ground fault protection. Relay shall trip at 50% of full load ampere setting
 - .12 Jam/Stall protection. Relay shall trip at 400% of full load ampere setting, after inrush

2.04 MICROPROCESSOR-BASED MOTOR CONTROL

- .1 Motor Starters – IT Design
 - .1 Provide electromechanical type motor starters with coil control and overload integrated into a single or dual microcontroller

- .2 The motor starter shall operate over a temperature range of -40 to 149°F (-40 to 65°C) and shall meet or exceed the following Standards and Certifications: UL, CSA, NEMA ICS1, ICS2, ICS5, IEC 60947-4-1, CE, and KEMA where applicable. Devices shall meet Electromagnetic Compatibility (EMC) Requirements per EMC IEC 61000-4
- .3 Provide one toroidal current sensor per phase accurate to 2% providing input to analog circuitry and software which yields a time-current curve paralleling actual motor heating. Motor FLA shall be set via a potentiometer for 1.0 or greater Service Factor settings
- .4 Provide user selectable overload Trip Class of 10, 20 and 30 on each Overload Relay. To adjust factory defaults, Trip Class shall be manually changed using the Test button and FLA dial
- .5 Provide phase loss and phase current unbalance protection. If the phase unbalance of any phase is greater than or less than approximately 50% of the average, the device trips. This feature is user enabled/disabled and manually changed using the Test button and FLA dial
- .6 Provide each motor starter with a lockable cover that prevents unwanted tampering of FLA dial settings once installed
- .7 Provide a microcontroller with the following features:
 - .1 Monitor the nominal 24 Vdc and adjust the Pulse Width Modulation (PWM) accordingly to minimize utilized power and maximize contact sealed force.
 - .2 Energizes coil at full voltage and then applies Pulse Width Modulation.
 - .3 Monitors user control inputs (i.e., permissive {stop}, forward, reverse, local reset, remote reset, test/test to trip. Control inputs shall be rated are 24 Vdc (3-5 mA) with a plug and unplug lockable control connector.
 - .4 Operates an LED indicator which displays a flash sequence for thermal capacities over 70%, test button depression, trip indication, class setting, phase enablement/disablement, and microcontroller reset condition.
 - .5 Monitors 3-phase current into a common node.
 - .6 Sweeps the current waveform to avoid synchronizing with the current waveform
 - .7 Provides Thermal Memory (in addition, Thermal Pile, Thermal Capacity) which shall be saved to non-volatile memory for safety purposes in the event of a power loss or removal and restore event.
 - .8 Controls an alarm output which is a solid-state open collector or emitter type output at 24 Vdc 250 mA.
 - .9 Shall solve a first order differential equation for an actual motor heating model to calculate trip points.
 - .10 Provides an "alarm only" or "alarm without trip" mode for critical must run applications.
 - .11 Provides built-in logic to provide either 2- or 3-wire control, eliminating the need to provide and wire auxiliary contacts to seal-in and interlock the contactor coil
 - .12 Starter can be easily networked with the appropriate SNAP device communicating to a factory bus.
- .8 Control Voltages:
 - .1 The starter voltage shall be nominal 24 Vdc from 20 to 28 Vdc
- .9 Motor starters shall have replaceable fixed and movable contacts, Size 1 through 5
- .10 Motor starters shall have no laminations, shading coils, or magnet noise

- .11 Accessories:
- .1 Motor starters shall accommodate auxiliary contacts per various maximum combinations of single and dual auxiliaries. Maximum number of circuits shall be six (6) for Size 1 through 4 and twelve (12) for Size 5 starters. Contacts shall be rated ten (10) amperes continuous, 7200 VA make, 720 VA break for 120 Vac, 3600 VA make, 360 VA break for 240 Vac, 1800 VA make, 180 VA break for 480 Vac, 1440 VA make, 144 VA break for 600 Vac, and 137.5 VA make and break for 125 through 250 Vdc. No seal-in auxiliary contacts are required.
 - .2 Provide mechanical interlock on reversing contactors of a pivot-type mechanism to prevent closing of one contactor when the other is closed. Coil controller energizes both forward and reverse contactors providing one control point for wiring.
 - .3 Provide control modules to perform the indicated input/output control functions shown on the drawings. Module shall incorporate faceplates having membrane type pushbuttons and LEDs. All pushbutton and LED functions shall be provided with clearly written identification. Modules shall be provided with the ability to replace conventional start, stop, hand, auto control functions, and overload reset function. Modules shall be provided with the ability to replace conventional indicating light status of run, off, selector switch pushbutton position, and overload trip and circuit breaker trip.
- .12 Microprocessor-based motor starters shall be Cutler-Hammer IT. Series or approved equal
- .13 All printed wiring boards shall be conformally coated to provide environmental robustness
- .14 Motor starters shall provide [Manual] [Remote Reset] [Auto Reset] capability
- .15 [Provide] [Make provisions for] a DeviceNet Starter Network Adapter addressable communication card capable of providing communication capability, control, and monitoring. All data, including trip data, shall be transmitted over the DeviceNet network. The adapter shall serve as a single node on the DeviceNet network. The adapter shall be designed for use with the same 24 Vdc power as the starter. A starter power sensing circuit shall indicate to the network that the starter does not have 24 Vdc power, signaling a fault or an emergency stop. The adapter MAC ID and baud rate shall be manually set. Configuration software shall not be required for normal operation. Configuration software shall be available for configuring advanced features. The adapter shall connect to the starter via an interconnection cable and terminal adapter. The following data shall be transmitted over the network:
- .1 RMS average current
 - .2 Percent of operating full load current
 - .3 Percent thermal memory
 - .4 Integral contact position detection
 - .5 Operating status and fault codes
 - .6 Start/Stop control
 - .7 Run/Forward-Reverse control
 - .8 Trip reset
 - .9 Fault log
 - .10 Current level warning (adjustable)
 - .11 Underload warning (adjustable).

-- OR --

- .16 [Provide] [Make provisions for] a QCPort Starter Network Adapter addressable communication card capable of providing communication capability, control and monitoring. All data, including trip data, shall be transmitted over the QCPort network. The adapter shall consume a single QCPort ID. The adapter shall be designed for use with the same 24 Vdc power as the starter. A starter power sensing circuit shall indicate to the network that the starter does not have 24 Vdc power, signaling a fault or an emergency stop. The adapter Group ID shall be manually set. Configuration software shall not be required for normal operation. Configuration software shall be available for configuring advanced features. The adapter shall connect to the starter via an interconnection cable and terminal adapter. The following data shall be transmitted over the network:
- .1 RMS average current
 - .2 Percent of operating full load current
 - .3 Percent thermal memory
 - .4 Integral contact position detection
 - .5 Operating status and fault codes
 - .6 Start/Stop control
 - .7 Run/Forward-Reverse control
 - .8 Trip reset
 - .9 Fault log
 - .10 Current level warning (adjustable)
 - .11 Underload warning (adjustable)

-- OR --

2.05 SOLID-STATE REDUCED-VOLTAGE MOTOR CONTROL

- .1 Reduced Voltage Motor Starter Type S801
- .1 Controller shall be Cutler-Hammer type S801
 - .2 The solid-state reduced-voltage starter shall be UL and CSA listed. The solid-state reduced-voltage starter shall be an integrated unit with power SCRs, logic board, paralleling bypass contactor, and electronic overload relay enclosed in a single molded housing
 - .3 The SCR-based power section shall consist of six (6) back-to-back SCRs and shall be rated for a minimum peak inverse voltage rating of 1500 volts PIV
 - .4 Units using triacs or SCR/diode combinations shall not be acceptable
 - .5 Resistor/capacitor snubber networks shall be used to prevent false firing of SCRs due to dV/dT effects
 - .6 The logic board shall be mounted for ease of testing, service and replacement. It shall have quick disconnect plug-in connectors for current transformer inputs, line and load voltage inputs and SCR gate firing output circuits
 - .7 The logic board shall be identical for all ampere ratings and voltage classes and shall be conformally coated to protect environmental concerns
 - .8 The paralleling run bypass contactor shall energize when the motor reaches 90 of full speed and close/open under one (1) times motor current
 - .9 The paralleling run bypass contactor shall utilize an intelligent coil controller to limit contact bounce and optimize coil voltage during varying system conditions

- .10 Starter shall be provided with electronic overload protection as standard and shall be based on inverse time-current algorithm. Overload protection shall be capable of being disabled during ramp start for long acceleration loads via a DIP switch setting on the device keypad
- .11 Overload protection shall be adjusted via the device keypad and shall have a motor full load ampere adjustment from 30 to 100% of the maximum continuous ampere rating of the starter
- .12 Starter shall have selectable overload class setting of 5, 10, 20 or 30 via a DIP switch setting on the device keypad
- .13 Starter shall be capable of either an electronic or mechanical reset after a fault
- .14 Units using bimetal overload relays are not acceptable
- .15 Overtemperature protection (on heat sink) shall be standard
- .16 Starters shall provide protection against improper line-side phase rotation as standard. Starter will shut down if a line-side phase rotation other than A-B-C exists. This feature can be disabled via a DIP switch on the device keypad
- .17 Starters shall provide protection against a phase loss or unbalance condition as standard. Starter will shut down if a 50% current differential between any two phases is encountered. This feature can be disabled via a DIP switch on the device keypad
- .18 Start shall provide protection against a motor stall condition as standard. This feature can be disabled via a DIP switch on the device keypad
- .19 Starter shall provide protection against a motor jam condition as standard. This feature can be disabled via a DIP switch on the device keypad
- .20 Starter shall be provided with a Form C normally open (NO), normally closed (NC) contact that shall change state when a fault condition exists. Contacts shall be rated 60 VA (resistive load) and 20 VA (inductive load). In addition, an LED display on the device keypad shall indicate type of fault (Overtemperature, Phase Loss, Jam, Stall, Phase Reversal and Overload)
- .21 The following control function adjustments on the device keypad are required:
 - .1 Selectable Torque Ramp Start or Current Limit Start
 - .2 Adjustable Kick Start Time: 0–2 seconds
 - .3 Adjustable Kick Start Torque: 0–85%
 - .4 Adjustable Ramp Start Time: 0.5–180 seconds
 - .5 Adjustable Initial Starting Ramp Torque: 0–85%
 - .6 Adjustable Smooth Stop Ramp Time: 0–60 seconds.
- .22 Units enclosed in motor control centers shall be of the same manufacturer as that of the circuit breaker and motor control center for coordination and design issues
- .23 Maximum continuous operation shall be at 115% of continuous ampere rating
- .24 Pump Control Option – Provide control algorithm for pump start-up and shut down sequences. Control algorithm shall reduce the potential for water hammer in a centrifugal pump system. Upon a start command, the speed of the motor is increased, under the control of the IT. Soft Starter microprocessor, to achieve a gentle start. After the speed has reached its nominal value, the bypass contactors close and the pump. Upon a stop command, the bypass contactors are opened and the motor speed is decreased in a tapered manner, to gradually slow the flow until the motor is brought to a stop. The start and stop ramp times are user adjustable and are to be set for the application requirements. The pump control option shall be factory installed.

-- OR --

- .2 Reduced Voltage Motor Starter Type S811
 - .1 Controller shall be Cutler-Hammer type S811
 - .2 The solid-state reduced-voltage starter shall be UL and CSA listed. The solid-state reduced-voltage starter shall be an integrated unit with power SCRs, logic board, paralleling bypass contactor, and electronic overload relay enclosed in a single molded housing
 - .3 The SCR-based power section shall consist of six (6) back-to-back SCRs and shall be rated for a minimum peak inverse voltage rating of 1500 volts PIV
 - .4 Units using triacs or SCR/diode combinations shall not be acceptable
 - .5 Resistor/capacitor snubber networks shall be used to prevent false firing of SCRs due to dV/dT effects
 - .6 The logic board shall be mounted for ease of testing, service and replacement. It shall have quick disconnect plug-in connectors for current transformer inputs, line and load voltage inputs and SCR gate firing output circuits
 - .7 The logic board shall be identical for all ampere ratings and voltage classes and shall be conformally coated to protect environmental concerns
 - .8 The paralleling run bypass contactor shall energize when the motor reaches 90 of full speed and close/open under one (1) times motor current
 - .9 The paralleling run bypass contactor shall utilize an intelligent coil controller to limit contact bounce and optimize coil voltage during varying system conditions
 - .10 Digital interface module mounted on the face of the S811 shall be used to program the soft starter. Display shall include six line LED readout. Monitoring parameters shall include line currents, pole currents, pole voltages, number of starts, and DC control voltage. Soft starter shall display motor status and the previous 5 fault conditions
 - .11 Starter shall be provided with electronic overload protection as standard and shall be based on inverse time-current algorithm. Overload protection shall be capable of being disabled during ramp start for long acceleration loads via digital interface module
 - .12 Overload protection shall be adjusted via the device keypad and shall have a motor full load ampere adjustment from 30 to 100% of the maximum continuous ampere rating of the starter
 - .13 Starter shall have selectable overload class setting of 5, 10, 20 or 30 via a DIP switch setting on the device keypad
 - .14 Starter shall be capable of either an electronic or mechanical reset after a fault
 - .15 Units using bimetal overload relays are not acceptable
 - .16 Overtemperature protection (on heat sink) shall be standard
 - .17 Starters shall provide protection against improper line-side phase rotation as standard. Starter will shut down if a line-side phase rotation other than A-B-C exists. This feature can be disabled via digital interface module
 - .18 Starters shall provide protection against a phase loss or unbalance condition as standard. Starter will shut down if a 50% current differential between any two phases is encountered. This feature can be disabled via digital interface module
 - .19 Start shall provide protection against a motor stall condition as standard. This feature can be disabled via digital interface module.
 - .20 Starter shall provide protection against a motor jam condition as standard. This feature can be disabled via digital interface module

- .21 Starter shall be provided with a Form C normally open (NO), normally closed (NC) contact that shall change state when a fault condition exists. Contacts shall be rated 60 VA (resistive load) and 20 VA (inductive load). In addition, an LED display on the device keypad shall indicate type of fault (Overtemperature, Phase Loss, Jam, Stall, Phase Reversal and Overload)
 - .22 The following control function adjustments from digital interface module are required:
 - .1 Selectable Torque Ramp Start or Current Limit Start
 - .2 Adjustable Kick Start Time: 0–2 seconds
 - .3 Adjustable Kick Start Torque: 0–85%
 - .4 Adjustable Ramp Start Time: 0.5–180 seconds
 - .5 Adjustable Initial Starting Ramp Torque: 0–85%
 - .6 Adjustable Smooth Stop Ramp Time: 0–60 seconds.
 - .23 Units enclosed in motor control centers shall be of the same manufacturer as that of the circuit breaker and motor control center for coordination and design issues
 - .24 Maximum continuous operation shall be at 115% of continuous ampere rating
 - .25 Pump Control Option – Provide control algorithm for pump start-up and shut down sequences. Control algorithm shall reduce the potential for water hammer in a centrifugal pump system. Upon a start command, the speed of the motor is increased, under the control of the IT. Soft Starter microprocessor, to achieve a gentle start. After the speed has reached its nominal value, the bypass contactors close and the pump. Upon a stop command, the bypass contactors are opened and the motor speed is decreased in a tapered manner, to gradually slow the flow until the motor is brought to a stop. The start and stop ramp times are user adjustable and are to be set for the application requirements. The pump control option shall be factory installed.
- 2.06 ELECTROMECHANICAL REDUCED VOLTAGE MOTOR CONTROL
- .1 Autotransformer Type
 - .1 The starter shall utilize an autotransformer for a reduced voltage start. The autotransformer shall have adjustable voltage taps at 50%, 65% and 80%
 - .2 The starter shall be [an open] [a closed] transition type
 - .3 The autotransformer shall use [electromechanical] [microprocessor-based] type starters
 - .2 Part-Winding Type
 - .1 The starter shall utilize a part winding connection for a reduced voltage start
 - .2 The part-winding starter shall use [electromechanical] [microprocessor-based] type starters
 - .3 Wye-Delta Type
 - .1 The starter shall utilize a wye-delta connection for a reduced voltage start
 - .2 The starter shall be [an open] [a closed] transition type
 - .3 The wye-delta starter shall use [electromechanical] [microprocessor-based] type starters
- 2.07 ENCLOSURES
- .1 The enclosure shall be [general purpose NEMA 1] [NEMA 3R] [NEMA 12] [NEMA 4X] [as indicated on the contract drawings].
 - .2 Starters shall have [an adjustable instantaneous motor circuit protector (HMCP) type] [a thermal-magnetic circuit breaker type] [a fusible type] [a non-fused type] disconnect device.
- 2.08 OPTIONS

- .1 Each starter shall be equipped with [a fused control power transformer (100 VA minimum)] [HOA selector switch] [start-stop pushbutton] [red "run" pilot light] [green "stop" pilot light] [2 NO/2 NC auxiliary contacts] [options as indicated on the contract drawings].

PART 3 - EXECUTION

3.01 FACTORY TESTING

- .1 Standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of UL and NEMA standards.
- .2 The manufacturer shall provide three (3) certified copies of factory test reports.

3.02 FIELD QUALITY CONTROL

- .1 Provide the services of a qualified factory-trained manufacturer's representative to assist the Contractor in installation and start-up of the equipment specified under this section. The manufacturer's representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained herein.
- .2 The following minimum work shall be performed by the Contractor under the technical direction of the manufacturer's service representative.
 - .1 Inspection and final adjustments
 - .2 Operational and functional checks of starters and spare parts.
- .3 The Contractor shall provide three (3) copies of the manufacturer's field startup report.

3.03 MANUFACTURER'S CERTIFICATION

- .1 A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations. Equipment shall be inspected prior to the generation of any reports.
- .2 The Contractor shall provide three (3) copies of the manufacturer's representative's certification.

3.04 EXAMINATION

- .1 Contractor shall fully inspect shipments for damage and report damage to manufacturer and file claim upon shipper, if necessary.

3.05 INSTALLATION

- .1 Contractor shall follow the installation instructions supplied by the manufacturer.
- .2 Control wiring shall be as shown on the contract drawings except as modified by the approval and submittal process. Interface all local and remote devices into the control wiring and operational system.

3.06 FIELD ADJUSTMENTS

- .1 The Contractor shall perform field adjustments of the short circuit and overload devices as required to place the equipment in final operating condition. The settings shall be in accordance with the approved short-circuit study, protective device evaluation study, protective device coordination study, manufacturer's instruction leaflets, and the contract documents.

END OF SECTION 20 05 35

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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Mechanical Work General Instructions Section 20 05 05 and Basic Mechanical Materials and Methods Section 20 05 10.

1.02 WORK PERFORMED BY THIS SECTION

- .1 This Section specifies requirements, criteria, methods and execution for mechanical demolition work that are common to one or more mechanical work Sections, and it is intended as a supplement to each Section and is to be read accordingly.

1.03 QUALITY ASSURANCE

- .1 Qualifications: Execute work of this section only by skilled tradesmen regularly employed in the demolition of mechanical piping, equipment, ductwork, etc.

1.04 ASBESTOS AND HAZARDOUS MATERIALS

- .1 If asbestos, PCBs or other hazardous materials are encountered in the course of the work, stop work in the vicinity of such materials and report their presence to the Owner and Consultant.

1.05 SUBMITTALS

- .1 Submit documentation to confirm reclaimed refrigerant has been properly removed and stored, recycled, or disposed of as applicable.

1.06 DELIVERY, STORAGE AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

PART 2 - PRODUCTS

2.01 MATERIALS

- .1 Materials used for patching and finishing shall be of the same quality and texture as the adjacent undisturbed areas. Refer to Section 20 05 10 – Basic Mechanical Materials and Methods for additional information regarding cutting and patching.

PART 3 - EXECUTION

3.01 DISCONNECTION AND REMOVAL OF EXISTING MECHANICAL WORK

- .1 Where indicated on drawings, disconnect and remove existing mechanical work, including hangers, supports, insulation, etc. Disconnect at point of supply, remove obsolete connecting services and make system safe. Cut back obsolete piping behind finishes and cap water-tight, unless otherwise specified.
- .2 Contractor shall remove all abandoned piping, ductwork, insulation, hangers, equipment within project limits whether shown on drawings or not. Existing ductwork and piping rendered abandoned after demolition of equipment shall be removed.
- .3 Drain down existing piping prior to demolition. Safely dispose of fluids within piping, unless specified otherwise.
- .4 Where existing mechanical services extend through, or are in an area to serve items which are to remain, maintain services in operation. Include for rerouting existing services concealed behind existing finishes and which become exposed during renovation work, so as to be concealed behind new or existing finishes.
- .5 Unless otherwise specified, remove from site and dispose of existing materials which have been removed and are not to be relocated or reused.

- .6 Unless otherwise specified, remove from site and dispose of existing materials which have been removed and are not to be relocated or reused, except for following which are to be handed over to Owner at site. Materials which are to be handed over to the Owner shall be transported by the contractor to a location within the project site designed by the Owner. The contractor shall be liable for damage to existing salvaged equipment during removal and transporting.
- .7 Where existing mechanical equipment, ductwork, piping, etc. penetrating walls is removed, leaving an opening in the wall, the wall shall be sealed and patched by the mechanical contractor. The opening shall be sealed commensurate with the rating of the rest of the wall.
- .8 Perform cutting and patching on fire rated surfaces to maintain the existing fire rating.
- .9 Contractor shall pay for all fees for disposal of equipment.
- .10 Remove existing piping, ductwork, equipment, etc. as far back and as close to walls as possible, to leave the maximum amount of space for new construction activities.
- .11 Removed materials shall not be reused in the new construction work unless specifically noted or approved.

3.02 EXAMINATION

- .1 Verify that abandoned or removed apparatus and equipment serve only abandoned facilities.

3.03 DEMOLITION AND EXTENSION OF EXISTING HVAC WORK

- .1 Remove, relocate and extend existing installation to accommodate new construction.
- .2 Remove abandoned piping and ductwork to source of supply.
- .3 Disconnect and remove existing apparatus and equipment where noted.
- .4 Extend existing installations using materials and methods compatible with existing HVAC installations, or as specified.

3.04 PIPING

- .1 All welded piping shall be cut off square at the locations indicated on the demolition drawings.
- .2 All threaded piping shall be disconnected at the location indicated on the demolition drawings.
- .3 All openings of an remaining valves, piping or fittings shall be closed off with weld caps or blind flanges to prevent debris from entering the existing systems.
- .4 All pipe hangers, supports and/or anchors shall be removed along with all piping shown to be removed.

3.05 INSULATION

- .1 Insulation shall be removed from all ductwork, piping, fittings, valves and equipment designated for demolition.
- .2 Comply with all safety precautions related to insulation removal.

3.06 HAZARDOUS WASTE

- .1 Be advised that items such as drainage sumps, catch basins, interceptors, and the like may contain unidentified hazardous waste and caution is to be taken when disconnecting and removing these items.
- .2 If hazardous waste not listed in Specification is found, notify Owner and Consultant immediately and await directions.

3.07 INTERRUPTION TO AND SHUT-DOWN OF MECHANICAL SERVICES AND SYSTEMS

- .1 Where disruptions of existing mechanical services are required, co-ordinate shut down with the Owner and do the work at a time and in a manner mutually acceptable.

- .2 Perform work associated with shut-downs and interruptions as continuous operations to minimize shut-down time and to reinstate systems as soon as possible, and, prior to any shut-down, ensure materials and labour required to complete the work for which shut-down is required are available at site.
- .3 Submit a written concise schedule of each disruption at least 72 (seventy two) hours in advance and obtain Owner's written consent prior to implementation. Do not shut-down or

3.08 PIPE FREEZING

- .1 Pipe freezing may be used to connect new piping to existing piping without draining existing piping. Pipe freeze equipment is to be equal to "NORDIC FREEZE" equipment supplied by Mag Tool Inc. or Rigid Tool Co. RIGID "SuperFreeze", or approved equal.
- .2 Mechanical Line Stopping may also be utilized as an alternative to pipe freezing.

3.09 DECOMMISSIONING OR ALTERATIONS TO EQUIPMENT CONTAINING HAZARDOUS WASTE

- .1 Remove and reclaim refrigerant, glycol and other hazardous waste materials from applicable equipment to be decommissioned and/or altered. Work is to be in accordance with Refrigerant Management Canada guidelines, and governing codes and regulations. Do not under any circumstances vent from existing equipment to atmosphere or drain into building drains.
- .2 Use proper recovery equipment designed specifically to reclaim and recycle specific hazardous waste materials, and use only skilled mechanics to perform reclaim and recycle work.
- .3 Provide approved, properly sized and sealable refrigerant containers for reclaimed hazardous waste.
- .4 Dispose of reclaimed hazardous waste by engaging services of a licensed firm specializing in recycling of reclaimed hazardous waste. Submit copies of license of company performing work. Submit documentation to confirm hazardous waste has been properly removed from site and recycled or properly disposed.

3.10 ROOFING WORK

- .1 Where roof revisions and/or replacements are part of project, include for disconnecting, lifting, or temporarily removing mechanical equipment on roof as required to permit completion of roofing work, and for re-installing equipment when roofing work is complete.

3.11 PROTECTIONS

- .1 Contractor shall coordinate with all trades for all work specified in this project and shall provide the necessary barricades and dust control to protect Owner's personnel, the general public, etc. from injury, provide them safe passage to and from occupied portions of the building, and protect floors, walls, ceilings, furnishings, and equipment from damage or exposure to dust or debris.

3.12 CLEANING

- .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

END OF SECTION 20 05 40

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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Mechanical Work General Instructions Section 20 05 05 and Basic Mechanical Materials and Methods Section 20 05 10.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Provision of all required equipment, piping, wiring, and chemicals for scale, corrosion, algae, and bacteriological control of chilled, heating, glycol, piping circuits. Provision of degreasing chemicals for degreasing of all heating, chilled, condenser, glycol water system piping and equipment.
- .2 Supervision of all degreasing procedures, initial fill/start-up, commissioning and monitoring of treated systems and training of Owner's staff in operating and maintenance procedures.
- .3 Provision of all temporary pipe, pumps, wiring, power, hoses, fittings, connections and ancillary devices to ensure complete cleaning, flushing and treatment off all piping systems and devices.
- .4 Submission of a report, on completion of the Work specified in this Section of the Specifications, for the following:
 - .1 Results of degreasing and initial fill of treated systems.
 - .2 Results of treatment procedures for each system treated.
 - .3 Details of instructions given to the Owner's staff and names of persons receiving instructions.

1.03 QUALITY ASSURANCE

- .1 Qualifications: Execute work of this section only by skilled tradesmen, technicians, and manufacturers regularly employed in the administration of water piping systems chemical treatment.
- .2 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Division 01 to suit Health and Safety Requirements.
- .3 Acceptable Manufacturers or Suppliers: Ashland, Drew Chemicals, Perolin-Bird Archer, GE-Betz, Klenzoid and Chem-Aqua.

1.04 SUBMITTALS

- .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 20 05 01 – Shop Drawings, Product Data & Samples. Include product characteristics, performance criteria, and limitations.
- .2 Certificates: Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .3 Provide written reports containing procedure of system cleaning and degreasing, giving times, dates, conditions of water and problems and actions encountered.
- .4 Site Visit Reports
 - .1 For all site visits, take samples, check the treatment, analyze and recommend treatment.
 - .2 Provide written reports to the Owner after each visit with a copy to the Consultant.

1.05 DELIVERY, STORAGE, AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

1.06 WARRANTY

- .1 Provide warranties as outlined in Section 20 05 05.

PART 2 - PRODUCTS

2.01 WATER TREATMENT

- .1 Provide a water conditioning system to control corrosion, scaling, algae and bacteria in chilled, heating, glycol and piping systems.
- .2 Provide a water conditioning program complete with all required chemicals for a period of one year commencing with the start-up of the equipment and systems.
- .3 Provide welding sockets where required or shown on the drawings and piping therefrom to equipment required for water treatment such as pumps, chemical storage tanks, and include all necessary piping, valves and accessories and control wiring.
- .4 Use only chemicals and methods complying with local health codes that do not have a detrimental effect on non-metallic materials such as rubber, neoprene and plastics used in the piping systems. Provide nitrite/borate type inhibitors.
- .5 Do not use chemical treatment containing tin or tin compounds in any cooling tower or any other evaporative process circuits.

2.02 CORROSION COUPON RACK

- .1 Provide suitable corrosion test coupons installed in appropriate piping arrangements for each treated closed loop system representing the metals in the circuit. Control corrosion rates in steel piping at maximum depth of Pitting of 0.127mm (0.005") of penetration per year and a maximum corrosion rate for copper tubing of 0.025mm (0.001") per year.

2.03 CHEMICAL POT FEEDER ASSEMBLY

- .1 Provide pot type feeders on all closed piping systems for injection of chemical treatment complete with corrosion coupon rack. Pot feeders are to be welded steel and have a maximum pressure rating of 1380 kPa (200 psi) and a maximum temperature rating of 94°C (200°F). In and connections are to be 19 mm (¾") FNPT.

2.04 BYPASS FILTER

- .1 Provide a low flow micron filter unit pipe line filter assembly with pressure gauge and an Arkon (ball type) flow indicator on the leaving side of each pot feeder.
- .2 Provide spare filter cartridges to be turned over to the Owner: 10 each of 10 micron retention, and 20 micron retention.

2.05 TEST EQUIPMENT

- .1 Provide one metal test cabinet [complete with light] to hold all test apparatus. Provide all required chemicals, comparator, titration equipment and test tubes to provide a complete testing facility for the systems treated.
- .2 Provide complete step-by-step instructions for testing procedures and include copy for Operating and Maintenance Manuals.
- .3 All test kits shall be provided with adequate chemicals and reagents for one year of testing. Following substantial performance.
- .4 Closed Systems
 - .1 Inhibitor Test Kit for measuring Sodium Molybdate or Sodium Nitrite.
 - .2 Glycol refractometer if applicable.
- .5 Condenser Water Systems
 - .1 Open loop system inhibitor Test Kit for measuring Phosphonate or Molybdate Tracer.
 - .2 Oakton Con 5, bench top conductivity meter.

- .3 CN-66 Free Available Halogen Test Kit.
- .4 Test kits for hardness and chlorides.
- .5 pH meter complete with three different calibration standard solutions.
- .6 Steam Boiler Systems
 - .1 Steam Boiler Scale/Corrosion Inhibitor Test Kit.
 - .2 Oakton Con 5, bench top conductivity meter.
 - .3 Test kits for hardness and chlorides.
 - .4 pH meter complete with three different calibration standard solutions.

2.06 GLYCOL FEED SYSTEM

- .1 Provide inhibited glycol solution using Dowfrost (propylene glycol) or Dowtherm SR-1 (ethylene glycol) as shown on drawings and schedules. Heat Transfer Fluid or acceptable alternative. All glycol solutions to be acceptable to Authorities having jurisdiction regarding environmental acceptability.
- .2 Provide an Axiom Industries packaged glycol feed system Model SF100 consisting of a 208 litre (55 gal.) polyethylene tank with cover; pump suction hose with inlet strainer; pressure pump with thermal cut-out; integral pressure switch; integral check valve; cord and plug; pre-charged accumulator tank with EPDM diaphragm; manual diverter valve for purging air and agitating contents of storage tank; pressure regulating valve adjustable (35– 380 KPa; 5 – 55 psig) complete with pressure gauge; built-in check valve; union connection; 12 mm (½") x 900mm (36") long flexible connection hose with check valve; low level pump cut-out. Pressure pump shall be capable of running dry without damage. Power supply 115/60/1 0.7 A. Unit shall be completely pre-assembled and certified by a recognized testing agency to CSA standard C22.2 No 68.
- .3 Operational Controls: low level switch and light, contact head water meter, system pressure switch, alarm bell with reset, hand-off-auto switch, motor rated switches for pump and mixer and SPST relay. Include RIA10-1-SAA – Low Level Alarm Panel c/w Remote Monitoring Dry Contacts and Selectable Audible Alarm.
- .4 The entire system to be factory prepiped and prewired with numbered terminal strip for wiring of remote items such as the pressure switch and the contact head meter.
- .5 System operation: pump to operate automatically or manually as selected by HOA switch and be interlocked with the tank low level switch. The contact head meter will initiate the alarm bell when a predetermined amount of make-up has been added. A separate alarm contact is provided to connect into a remote alarm device.

PART 3 - EXECUTION

3.01 MANUFACTURER'S INSTRUCTIONS

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

3.02 WATER TREATMENT

- .1 Provide equipment for complete system operations.
- .2 Provide chemical cleaners and corrosion inhibitors for systems as described. Chemical application rates are to be as required to maintain water quality guidelines in compliance with ASME and manufacturers' instructions (boiler, cooling tower etc.).
- .3 Provide all piping and valves for proper installation and operation of the chemical treatment programs.
- .4 Provide sufficient chemicals for cleaning and inhibiting.

- .5 Provide sufficient chemicals to treat and test the systems from the time of activation and acceptance of the building for the first year of operation by the Owner.
- .6 Install test equipment cabinet as directed by the Consultant or as shown on the drawings.
- .7 Field wire all required wiring between panels, valves, sensors and interlocks.
- .8 Submit a report outlining procedure and final quality of fluid for each system.

3.03 EQUIPMENT

- .1 Closed Loop Hydronic Systems
 - .1 Supply and install one chemical pot feeder assembly, bypass filter and corrosion coupon rack per system, installed across circulating pumps.
- .2 Condenser Water System
 - .1 Provide the following chemical treatment assembly for each cooling tower:
 - .1 Provide water softener assembly in make-up water supply.
 - .2 Provide separate chemical feed pump assembly and mixing tank assembly for injection of:
 - .1 Chemical for biological growth control
 - .2 Chemicals for scale and corrosion control.
 - .3 Inject chemical for biological growth control into cooling tower sump.
 - .4 Inject scale and corrosion control chemicals into condenser water return piping.
 - .5 Provide bleed line assembly.
 - .6 Provide cold make-up water meter complete with contacts.
 - .7 Meter to initiate chemical feed pump administering inhibitor control into piping system.
 - .8 Timer to open bleed line solenoid valve, conductivity probe to close valve when total dissolved solids reach acceptable level.
 - .9 Interlock chemical feed pump injecting biocide with the timer that operates bleed line solenoid.
 - .10 Interlock chemical feed pumps with condenser water pump.
 - .11 Provide condenser water control panel.
 - .12 Field wire connections between panel and:
 - .1 Meter
 - .2 Bleed line solenoid valve
 - .3 Conductivity probe
 - .4 Chemical feed pumps
 - .13 Provide corrosion coupon rack. Locate in condenser water supply line.

3.04 MONITORING AND INSTRUCTIONS

- .1 Advise Divisions 20, 21, 22 23 and 25 Subtrades where drains and fill points are required in the piping systems to facilitate proper drainage and fill/injection of fluids.
- .2 Carefully monitor the condition of all systems from initial fill to the point at which the systems are considered under stable operating conditions.

- .3 Provide oral and written instructions to operating personnel for the maintenance and control of the water conditioning program.
- .4 Submit a written report of system start-up showing water analysis and corrosion check test as part of documentation at the completion of the work.
- .5 For the first year of operation, provide service calls once every thirty days and provide written reports to operating personnel showing details of each service call.

3.05 CLEANING

- .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

END OF SECTION 20 05 70

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PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

- .1 Comply with requirements of the Division 01 General Requirements and all documents referred to therein.

1.02 SCOPE OF WORK

- .1 The Contractor shall provide all services, materials and labour required to fully Commission the Mechanical, and Electrical Systems as specified herein.
- .2 The Contractor shall provide all services, materials and labour required to successfully complete Functional Performance Testing of the Mechanical Systems as part of Commissioning the overall building systems as a holistic operation.
- .3 Integrated Systems Testing (IST):
 - .1 Provide all necessary labour and equipment required for the successful completion of the Integrated Systems Testing in accordance with the requirements of the CAN/ULC Standard S1001 "Integrated Systems Testing of Fire Protection and Life Safety Systems".
 - .2 Coordinate all requirements with the Contractor's designated Integrated Testing Coordinator.
- .4 Equipment Suppliers, Vendors and other Sub-Trades are expected to support the Contractor complete Mechanical Commissioning Specified in this Section. Support may come in the form of attendance on site to verify correct installation, performance, trouble shooting, training and final documentation at turn-over. The Contractor shall ensure Equipment Suppliers and Vendors provide the support necessary for successful Mechanical Commissioning.
- .5 Provide Commissioning oversight of Pre-construction Building Performance Benchmarking.

1.03 COORDINATION

- .1 Appoint a single person as Commissioning Coordinator who shall be responsible for advancing the commissioning activities of the Mechanical Division.

1.04 QUALITY ASSURANCE

- .1 The following Standards shall be used to guide the commissioning process:
 - .1 ASHRAE (American Society of Heating Refrigerating & Air Conditioning Engineers).
 - .1 ASHRAE Standard 202 "The Commissioning Process Requirements for New Buildings and New Systems"
 - .2 ASHRAE Standard 230 "Commissioning Process for Existing Buildings and Systems"
 - .3 ASHRAE Guideline 0 "The Commissioning Process"
 - .4 ASHRAE Guideline 0.2 "Commissioning Process for Existing Systems and Assemblies"
 - .5 ASHRAE Guideline 1.1 "HVAC&R Technical Requirements for The Commissioning Process"
 - .6 ASHRAE Guideline 1.2 "Technical Requirements for the Commissioning Process for Existing HVAC&R Systems and Assemblies"
 - .7 ASHRAE Guideline 1.3 "Building Operations and Maintenance Training for the HVAC&R Commissioning Process"
 - .8 ASHRAE Guideline 1.4 "Preparing Systems Manuals for Facilities"
 - .9 ASHRAE Guideline 1.5 "The Commissioning Process for Smoke Control Systems"
 - .10 ASHRAE Guideline 4 "Preparation of Operating and Maintenance Documentation for HVAC&R Systems"

- .11 ASHRAE Guideline 41 "Design, Installation , and Commissioning of Variable Refrigerant Flow (VRF) Systems"
- .2 Building Commissioning Association (BCA):
 - .1 BCA: "New Construction Building Commissioning Best Practice"
 - .2 BCA: "Best Practices in Commissioning Existing Buildings"
- .3 Canadian Standards Association (CSA):
 - .1 CSA Z320 "Building Commissioning"
- .4 National Environmental Balancing Bureau (NEBB):
 - .1 NEBB; "Procedural Standards for Whole Building Systems Technical Commissioning for New Construction"
 - .2 NEBB; "Procedural Standards for the Technical Retro-Commissioning of Existing Building Systems"
- .5 National Fire Prevention Association (NFPA):
 - .1 NFPA 3 "Standard for Commissioning of Fire Protection and Life Safety Systems"
 - .2 NFPA 4 "Standard for Integrated Fire Protection and Life Safety System Testing"
- .6 Public Works and Government Services Canada (PWGSC):
 - .1 CP.1 Commissioning Manual
 - .2 Commissioning Guidelines:
 - .1 CP.3 Guide to the development of the Commissioning Plan
 - .2 CP.4 Guide to the preparation of the Building Management Manuals
 - .3 CP.5 Guide to the preparation of Training Plans
 - .4 CP.7 Commissioning for Facilities Management and Operation
 - .5 CP.8 Guide to the preparation of Commissioning Reports
 - .6 CP.9 Guide to the development of Check Lists
 - .7 CP.10 Guide to the development of Report Forms and Schematics
 - .8 CP.11 Guide to the preparation of the Commissioning Brief
- .7 Underwriter Laboratories of Canada (ULC):
 - .1 CAN/ULC-S1001 "Integrated Systems Testing of Fire Protection and Life Safety Systems"
- .2 Hold and attend regular meetings during the commissioning process. Prepare detailed progress reports to coincide with regular commissioning meetings.
- .3 In addition to all tests listed under this section, the Mechanical Division shall complete its own tests and any additional tests required by the Owner's Commissioning Authority to ensure that all facility, in its entirety, operates as intended.

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

- .1 All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by Division contractor for equipment being tested. For example, Mechanical Trades shall ultimately be responsible for all standard testing equipment for HVAC system and controls system provided as part of the Mechanical Work, except for equipment specific to and used by TAB Trades in their Commissioning responsibilities.
- .2 Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be

included in base bid price to Contractor and left on site, except for stand-alone data-logging equipment that may be used by Commissioning Authority.

- .3 All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with tolerances specified in Specifications. If not otherwise noted, following minimum requirements apply:
 - .1 Temperature sensors and digital thermometers shall have a certified calibration within past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F.
 - .2 Pressure sensors shall have an accuracy of + or - 2.0% of value range being measured (not full range of meter) and have been calibrated within twelve (12) months of scheduled commissioning testing.
 - .3 All equipment shall be calibrated according to manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

PART 3 - EXECUTION

3.01 DESIGN AND PERFORMANCE REQUIREMENTS

- .1 Provide a schedule with regular updates for the completion of Mechanical Division equipment and systems.
- .2 Six (6) weeks prior to the target Substantial Performance date, submit a detailed and comprehensive installation completion/ start-up/ testing schedule. Update the schedule and resubmit for review, on a bi-weekly basis, during the course of Commissioning. Provide regular revisions and updates to the schedule to suit the updated construction schedule. This schedule shall include, but is not limited to, the following items:
 - .1 Installation and testing of piping systems
 - .2 Chemical clean out and treatment of pipe systems, including disinfection of domestic water piping;
 - .3 Duct cleaning;
 - .4 Control system wiring;
 - .5 Air and hydronic system balancing;
 - .6 Electrical service connections;
 - .7 Equipment suppliers prestart inspection, testing and results of the mechanical equipment installations, including controls;
 - .8 Start-up of various pieces of mechanical equipment and systems;
 - .9 Operational testing and results of mechanical system components;
 - .10 Performance testing and results of mechanical equipment and systems;
 - .11 Acceptance testing of mechanical equipment installations and systems including fire and sprinkler systems, by Authorities Having Jurisdiction ("AHJs") and the Owner's insurance company;
 - .12 Troubleshooting: determination and reiteration of performance issues documenting cause, effect, revisions, and re-test results.
 - .13 Calibration of controls and point-to-point testing results;
 - .14 Control software setup inspection, testing and results including seasonal and response of operating sequences, including Proportional Integral Derivative ("PID") loop optimization
 - .15 Emergency system inspection, testing and results;
 - .16 Fire alarm and control system interfacing results;
 - .17 Submittal of completed mechanical equipment and systems test record sheets;

- .18 Demonstration of mechanical systems and equipment;
- .19 Operating and Maintenance ("O&M") manual preparation and submittal;
- .20 Operator training program
- .21 Record documentation submittal

3.02 RECORD DOCUMENTATION

- .1 Prepare record documentation for each equipment installation covering:
 - .1 Equipment identification and supplier
 - .2 Shop Drawing submittal, review, production release, and delivery dates
 - .3 Dates for completion of all work required to prepare for equipment installation
 - .4 Dates for equipment installation, supplier prestart checkout and system availability for start-up
 - .5 Dates for equipment start-up, performance testing, proposal for temporary use, acceptance testing, demonstration, turnover and warranty start/finish
 - .6 List all specialist personnel and equipment required for the test and ensure that these are available by the test date.
 - .7 Provide documentation of the commissioning process for inclusion into the maintenance manuals. These are to include checkout sheets, equipment data sheets, start-up certificates from suppliers involved in start-up, documentation concerning demonstration to the Owner. Include all records and result sheets from commissioning tests.
 - .8 Maintain a log of key operating parameters, problems encountered, solutions employed and verification of effectiveness of solutions. Include log in maintenance manuals.

3.03 START-UP

- .1 Coordinate and supervise the start-up of the various pieces of equipment and systems. Utilize the start-up services of the manufacturer's representative. Ensure that the equipment is operating in a satisfactory manner. Check the following items:
 - .1 Direction of rotation
 - .2 Grease and lubricants
 - .3 Noise, if deemed to be a problem
 - .4 Seals
 - .5 Alignment of base mounted pumps, fan drives and turbine drives by a Millwright
 - .6 Piping connections and safeties
 - .7 Electrical amp draw, starting inrush current and trip/heater settings
- .2 Prior to the equipment start-up, arrange to have the Manufacturer of all major equipment inspect the installation to ensure their equipment has been installed in accordance with their recommendations.
- .3 Functional testing is intended to begin upon successful completion of start-up. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the Owner and the Owner's Commissioning Consultant. Beginning system functional testing prior to full completion does not relieve the Mechanical Division from fully completing the system, including all start-up checklists.

3.04 TROUBLESHOOTING

- .1 Resolve inter-Division coordination problems.
- .2 Where problems become apparent during the commissioning process, identify and resolve these problems. The basic functions of troubleshooting include:

- .1 Identify and define the problems
- .2 Determine and evaluate the causes
- .3 Determine the time available to resolve the problem
- .4 Involve the designing authority in the review of the problem and proposed resolution
- .5 Coordinate remedial action with the appropriate parties
- .6 Evaluate the effectiveness of the remedial action
- .7 Record the problem, cause, remedial action and result

3.05 OPERATIONAL TESTING

- .1 Test the operation of the individual components and systems. Go through each step of the sequence of operation and verify that each component operates correctly. Direct and ensure that all trades involved make the required changes and adjustments to effect the proper operation of all components and systems. Meet commissioning test requirements.
- .2 Document the operation and testing.
- .3 Ensure operational tests are completed for heating, cooling and intermediate seasons.
- .4 For any systems and assemblies where some testing has been deferred, coordinate seasonal commissioning for those systems that have been functionally tested and handed over in seasons where retesting and commissioning will be required during the opposite season.

3.06 DEMONSTRATION AND TRAINING

- .1 Demonstrate to the operating staff the proper operation of all mechanical equipment and systems. Demonstrations shall occur only after the operation and testing has been successfully completed. Ensure that all affected Mechanical Division Trade Contractor(s) and equipment suppliers participate in the demonstrations as required.
- .2 Thoroughly instruct the operating staff in the safe and efficient operation and maintenance of all systems and equipment.
- .3 Provide designated operating personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of mechanical equipment including, but not limited to, pumps, boilers, chillers, heat rejection equipment, air conditioning units, air handling units, fans, terminal units, controls and water treatment systems, fuel systems and other mechanical systems.
- .4 Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including start-up, shutdown, fire/smoke alarm, power failure, and other similar modes of operation.
- .5 During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
- .6 The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer's representative.
- .7 Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment is required. More than one party may be required to execute the training.
- .8 The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.
- .9 The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
- .10 Training shall include:

- .1 Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
- .2 A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
- .3 Discussion of relevant health and safety issues and concerns.
- .4 Discussion of warranties and guarantees.
- .5 Common troubleshooting problems and solutions.
- .6 Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
- .7 Discussion of any peculiarities of equipment installation or operation.
- .8 Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate.
- .9 Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.
- .10 The mechanical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
- .11 During any demonstration or hands-on training, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
- .12 There shall be three controls training sessions:
 - .1 Training I. Control System. This training will be held on-site. Upon completion, each trainee, using appropriate documentation, should be able to perform elementary operations and describe general hardware architecture and functionality of the system.
 - .2 Training II. Building Systems. The second session shall be held on-site and shall include hands-on training after the completion of system commissioning. The session shall include instruction on:
 - .1 Specific hardware configuration of installed systems in this building and specific instruction for operating the installed system, including HVAC systems and any interface with other communication systems.
 - .2 Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing setpoints and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.
 - .3 All trending and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends.
 - .4 Trainees will actually set-up trends in the presence of the trainer.
 - .5 Every screen shall be completely discussed, allowing time for questions.
 - .6 Use of keypad or plug-in laptop computer at the zone level.
 - .7 Use of remote access to the system via phone lines or networks.

- .8 Setting up and changing an air terminal unit controller.
 - .9 Graphics generation.
 - .10 Point database entry and modifications.
 - .11 Understanding DDC field panel operating programming (when applicable).
 - .12 Trend log set-up and exporting.
 - .3 Training III. The third training shall be conducted on-site six months after occupancy. The session will be structured to address specific topics that trainees need to discuss and to answer questions concerning operation of the system.
- 3.07 OPERATING AND MAINTENANCE MANUALS
 - .1 Ensure that O&M Manuals are complete in accordance with the requirements of Section 01 10 10 Administrative Procedures, and Section 20 05 05 Mechanical Work General Instructions.
- 3.08 "AS-CONSTRUCTED" DRAWINGS
 - .1 Ensure that Mechanical Division Trade(s) "As-constructed" drawings have been produced and that they accurately reflect the completed mechanical systems.
- 3.09 COMPLETION
 - .1 Confirm successful completion of all Mechanical Work, including, but not limited to:
 - .1 Removal of all debris from inside mechanical systems and equipment.
 - .2 Compliance with manufacturer's written instructions regarding bearing lubrication
 - .3 Alignment of all drives to manufacturer's acceptable tolerances.
 - .4 Adjustment of belts for proper tension.
 - .5 Alignment of all pumps to manufacturer's acceptable tolerances.
 - .6 Removal of all temporary protection and covers.
 - .7 Removal of oil and grease from equipment and bases.
 - .8 Cleaning of all fixtures and equipment. Polishing of all plated surfaces.
 - .9 Replacement of all air and water filters.
 - .10 Removal, cleaning and reinstallation of pipeline strainer screens.
- 3.10 COMMISSIONING TESTS
 - .1 Verify readings, calibration and set-up of sensors and equipment, including:
 - .1 Vibration analysis on fan and pump motors;
 - .2 Temperature sensors
 - .3 Humidity sensors
 - .4 Pressure sensors
 - .5 Flow sensors
 - .6 Freeze protection devices
 - .7 Pressure switches
 - .8 Flow switches
 - .9 Status switches
 - .10 Temperature and pressure gauges and gauge connection utilization
 - .11 Control damper positioning, including tightness when closed and full open/balance position
 - .12 Alarm contacts

- .2 Verify correct sensors are reporting accurately to the distributed field panels and operator workstation.
- .3 Verify operation of building storm and sanitary drainage and vent systems, including ancillary support systems:
 - .1 Drainage and vent piping test results;
 - .1 Pressure testing results;
 - .2 Ball test results;
 - .2 Backwater valve operation;
 - .3 Trap seal primer operation;
- .4 Verify operation of plumbing pumping, heating and distribution piping systems, including ancillary support systems:
 - .1 Piping system test results;
 - .1 Pressure testing results;
 - .2 Flushing and cleaning test results
 - .2 Domestic water backflow preventers;
 - .3 Service water heating systems;
 - .4 Pressure boost and recirculation systems;
 - .5 Water supply pressure maintenance and stability;
 - .6 Water supply temperature including time taken for domestic hot water supply at fixture outlet from opening;
- .5 Verify operation of hydronic heating and cooling systems and distribution piping systems, including ancillary support systems:
 - .1 Heating water boilers, heating water pumping systems
 - .2 Boiler venting systems
 - .3 Air-source heat pump chillers, chilled water and condenser water pumping systems
 - .4 Heat exchangers, heat pump control valves, and makeup water
 - .5 Full checkout by manufacturer's startup representative
 - .6 Heat exchanger operation
 - .7 System pressure and temperature control maintenance and stability
 - .8 Strainer performance
 - .9 Pumping system performance
 - .10 Piping system pressure test results;
- .6 Verify operation of air distribution and fan systems, including ancillary support systems:
 - .1 Supply, return, exhaust fan performance;
 - .2 Heating and cooling coil temperature control performance;
 - .3 Control damper performance;
 - .4 Full checkout by manufacturer's startup representative;
 - .5 System pressure and temperature control maintenance and stability;
 - .6 Filter performance;
 - .7 Duct pressure test results.
- .7 Verify systems pipe cleaning and chemical treatment condition for all systems.

- .8 Verify that all cooling coil drain pans and condensate piping operate.
- .9 Verify backflow preventer operation.
- .10 Participate in Integrated Systems Testing of Fire Protection and Life Safety Systems in accordance with CAN/ULC-S1001 with all affected Trades. Provide documentation in a form satisfactory to the Authority Having Jurisdiction (AHJ) that testing has been successfully completed.
- .11 Demonstrate access to all valves, equipment and components for servicing.
- .12 Verify the response and operation of all Variable Frequency Drives ("VFD's") and Electronically Commutated Motors ("ECM's") to inputs provided;
- .13 Access to Building Automation System ("BAS") from remote workstations;
- .14 BAS system set-up, operation and alarm sequencing;
- .15 BAS Preventative Maintenance (PM) program access and read/ write revision procedures.
- .16 Verify the operation of all other mechanical equipment in accordance with its intended function;
- .17 Demonstrate equipment access for servicing and replacement at end of useful-life-expectancy.
- .18 Verify that interfacing to the work of other Divisions results in complete and operational systems.

3.11 POST OCCUPANCY EVALUATION

- .1 The post-occupancy evaluation period shall run for one full year following Substantial Performance of the facility. The Commissioning Coordinator shall meet regularly with the operating staff throughout this period to review the operation of all mechanical systems and equipment. The Commissioning Coordinator shall provide written advice regarding questions and concerns raised by the operating staff.
- .2 Resolutions of operational problems shall, where appropriate, be used to modify the Operation and Maintenance Instructions for the equipment and systems involved.
- .3 Identify areas that may come under warranty and conduct a review of condition and operation. Seek remedy under warranty for any outstanding issues and problems before end of warranty period.

END OF SECTION 20 08 10

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PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

- .1 Comply with Division 1 - General Conditions and all documents referred to therein.
- .2 Comply with requirements of Section 20 05 05 Mechanical Work General Instructions, and all documents referred to therein.
- .3 Comply with requirements of Section 20 05 10 Basic Mechanical Materials and Methods, and all documents referred to therein

1.02 WORK INCLUDED

- .1 Provide all parts of the plumbing system, including all required venting, in accordance with the Ontario Building Code, Part 7, and as indicated in the Specifications, Drawings and other referenced Contract Documents.
- .2 Install all fixtures, drains, cleanouts, brass and specialties to manufacturer's requirements.

1.03 SUBMITTALS

- .1 Except for piping, submit shop drawings for all products specified.

1.04 POOL SYSTEM SCHEMATIC DIAGRAMS

- .1 In addition to required operation and maintenance data specified elsewhere, provide for each pool mechanical circulating system, a minimum 550 mm x 860 mm (22" x 34") coloured schematic piping, power and control wiring diagram of the system, glazed with plexi-glass and framed with a non-corrosive metal frame suitable for wall mounting.
- .2 Each schematic is to clearly indicate entire pool circulating system including filtering equipment, heaters, chemical treatment and monitoring, fittings, piping and pipe sizes, valves with tag numbers, emergency alarm and pump shut-down equipment, and power and control wiring.
- .3 Wall mount schematic diagrams where directed, and include a copy in each operation and maintenance manual.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

- .1 Corrosion Prevention
 - .1 Provide V line insulating couplings from Watts, or accepted alternative, lead-free dielectric couplings, for prevention of galvanic corrosion at specific points where connections are required between copper, brass or bronze and stainless steel piping.
 - .2 Acceptable Manufacturers:
 - .1 Watts,
 - .2 EPCO,
- .2 All fittings 50mm (2") and below connecting to equipment: Use unions, extra heavy-duty pattern, having ground joints, brass seats and diagonal screws.
- .3 Connections to equipment 65mm (2½") and above: Flanged, standard weight provided with ring gaskets.

2.02 POTABLE (DRINKING) WATER PIPE AND FITTINGS

- .1 Domestic Water:
 - .1 System pressure rated for 1380 kPa (150psi).
 - .2 Code and Standards:
 - .1 ASTM B88 Standard Specification for Seamless Copper Water Tube.

- .2 ASME B16.15 Cast Bronze Threaded Fittings, Class 150 and 250
- .3 ASME B16.18 Cast Copper Alloy Solder Joint Pressure Fittings
- .4 ASME B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
- .5 ASME B16.24 Cast Copper Alloy Pipe Flanges and Flanged fittings Class 150, 300, 400 and 600.
- .6 CSA B242 Groove and Shouldered Type Mechanical Couplings
- .7 AWS A5.8 Brazing Filler Material
- .8 ASTM B32 Specification for Solder Metal
- .9 ASTM B-312 Standard Specification for Stainless Steel Piping.
- .3 When providing copper piping, all products serving the domestic water service shall be provided with copper and/or bronze fittings and components. When providing stainless steel piping, stainless steel fittings and components shall be used.
- .4 Above Grade:
 - .1 Type L copper, hard drawn, marked certified for compliance with ASTM B88 Standard, with 95/5 soldered, wrought copper or cast bronze pressure solder fittings to ANSI B16.22 and ANSI B16.18 respectively.
 - .2 Stainless Steel:
 - .1 304L stainless steel, Schedule 10 marked certified for compliance with ASTM A312/ASME SA-312 Standard for pipe sizes 75mm (3") and larger.
 - .2 Fittings: 304L stainless steel fittings to ASTM A-774 and A-403.
 - .3 Brass or bronze threaded fittings to ASME B16.15. Brass or bronze flanges or flanged fittings to ASME B16.24. Flanged joints to AWWA C111 and bolts to ASTM A307 and nuts to ASTM 563. Silver brazing alloy to AWS Classification BCuP-5.
 - .4 Method of joint connection:
 - .1 Soldered for pipes up to 65mm (2 ½").
 - .2 Brazed for pipes 75mm (3") or higher
 - .3 Grooved fittings may be used for exposed area.
 - .5 For pipe sizes 100mm (4") and smaller:
 - .1 Press fittings by Viega Model Pro Press and MegaPress is acceptable for use in copper and stainless steel domestic water piping distribution systems.
 - .1 Copper Press-Connect Fittings:
 - .1 Viega ProPress Bronze, or copper shall conform to ASTM F3226, ICC LC 1002, ASME B16.51, IAPMO PS 117, NSF 61, and NSF 61-G or NSF 372. . ProPress fittings ½-inch thru 4-inch for use with ASTM B88 copper tube type L and ½-inch up to include 1-1/4-inch annealed copper tube.
 - .2 ProPress fittings shall only be used for system pressure up to 2068 kPa (300 psi).
 - .3 Press fittings shall have a valid Ontario Building Material Evaluation Commission Authorization (BMEC).
 - .4 Press Connect Fitting shall carry CRN numbers.

- .5 Cast copper alloy fittings Alloy: Copper alloy - UNS C12200 Zero Lead silicon bronze alloy - C87710 (cast) or C87700 (machined) Shall not be bismuth bronze or yellow brass.
- .6 EPDM elastomeric sealing element shall be peroxide cured for resistance to chloramines
- .7 Press Connect fitting shall have Viega Smart Connect technology to detect unpressed fittings shall be integrated into the body of the fitting
- .8 2-1/2 inch thru 4 inch fittings shall have stainless-steel grip ring with bidirectional teeth, PBT separator ring, and EPDM sealing element at each press connection.
- .9 The manufacturer's installation instructions shall be strictly adhered to.
- .10 Special attention shall be given to the required two step pressure test. Initial test for unpressed fitting detection per manufacturer's installation manual. Full pressure test in accordance with code requirements.
- .11 Installers shall be field trained by Viega factory representative.
- .12 Approved manufacturer: Viega (no exceptions).
- .2 Stainless Steel Press-Connect Fittings:
 - .1 Viega LLC; MegaPress Stainless 316
 - .2 Viega MegaPress Stainless 316 shall conform to ASTM F3226, ICC LC 1002, IAPMO PS 117, ASME B31.1, B31.3, or B31.9, NSF 61, and NSF 61-G or NSF 372. MegaPress Stainless 316 fittings 1/2-inch thru 2-inch for use with schedule 5 thru 40 ASTM A 312 stainless steel pipe. MegaPress Stainless 316 fittings 2 1/2-inch thru 4-inch for use with schedule 10 thru 40 ASTM A 312 stainless steel pipe ProPress fittings shall only be used for system pressure up to 2068 kPa (300 psi).
 - .3 Press Connect Fitting shall carry CRN numbers.
 - .4 EPDM elastomeric sealing element shall be peroxide cured for resistance to chloramines
 - .5 Press Connect fitting shall have Viega Smart Connect technology to detect unpressed fittings shall be integrated into the body of the fitting
 - .6 1/2 inch thru 2-inch fittings shall have stainless-steel grip ring with bidirectional teeth, 304 stainless separator ring, and EPDM sealing element at each press connection. 2-1/2 inch thru 4 inch shall have stainless-steel grip ring with bidirectional teeth, PBT separator ring, and EPDM sealing element at each press connection
 - .7 The manufacturer's installation instructions shall be strictly adhered to.
 - .8 Special attention shall be given to the required two step pressure test. Initial test for unpressed fitting detection per manufacturer's installation manual. Full pressure test in accordance with code requirements.
 - .9 Installers shall be field trained by Viega factory representative.

.10 Approved manufacturer: Viega (no exceptions).

.5 Buried piping:

.1 Soft temper type K with soldered fittings to the previously mentioned standards.

.6 Victaulic products for domestic water services (hot and cold), to be rated for operating conditions of -34°C to +120°C (-29.2°F to 250°F) and 2067 kPa (300 psi).

.1 Couplings: ductile iron coated with copper alkyd enamel to ASTM A - 536. Flanges to be copper alkyd enamel coated to ANSI class 125 for cast iron and class 150 for steel. Couplings shall be "Installation Ready" stab-on couplings designed with angle bolt pads to provide a rigid joint, complete with EPDM gasket. Victaulic Style 607.

.2 Fittings: grooved copper to ASTM B-75 and grooved bronze castings to ASTM B-584 with copper tube dimensioned grooved ends (flaring of tube and fitting ends to IPS dimensions is not permitted).

.3 Gaskets: grade EHP EPDM to ASTM D-2000 (UL/ULC classified in accordance with ANSI/NSF-61 for hot (82°C) and cold (30°C) domestic water service).

.4 Acceptable Alternative: Gruvlok (Entire system by one manufacturer).

2.03 STORM AND SANITARY DRAINAGE PIPING

.1 Internal Suspended:

.1 Cast iron pipe and fittings to CSA B70

.2 DWV copper to ASTM B306 with 50-50 soldered cast brass drainage fittings to CSA B158.1 or wrought copper fittings to ANSI B16-29.

.2 Below Grade:

.1 Cast iron pipe and fittings to CSA B70, or PVC pipe and fittings.

.2 Provide all trenching and backfilling required for Mechanical Trades work.

.3 Run storm and sanitary drainage piping to main sewers with uniform grade, minimum 2% unless noted otherwise.

.4 Extend condensate drains from air conditioning equipment terminating over floor drains or service sink.

.5 Verification of Inverts:

.1 Existing drain locations and invert elevations shall be verified on site prior to commencement of work.

.2 On projects with existing drainage piping that will be utilized, provided snaking of pipework and camera drain inspections as necessary to ensure a functional system.

2.04 VENT PIPING

.1 DWV Grade copper to ASTM B306 with 50-50 soldered cast brass or wrought copper drainage fittings to CSA B158.1 and ANSI B16-29 respectively or cast iron pipe and fittings to CSA B70.

2.05 SWIMMING POOL PIPING, FITTINGS AND JOINTS

.1 Above Grade

.1 Equal to IPEX Inc. "XIRTEC" CPVC Schedule 80 pipes shall conforming to ASTM F441/F441M and be third-party certified to NSF 14. All CPVC Schedule Schedule 80 pipes from 1/2" to 8" shall be made with Corzan CPVC compound with a minimum cell classification of 24448. Socket dimensions of belled end pipe comply with ASTM D2672.

.2 Below Grade

- .1 Equal to IPEX Inc. "XIRTEC" CPVC Schedule 40 pipes shall conforming to ASTM F441/F441M and be third-party certified to NSF 14. All CPVC Schedule 40 pipes from 1/2" to 8" shall be made with Corzan CPVC compound with a minimum cell classification of 24448. Socket dimensions of belled end pipe comply with ASTM D2672.
- .3 Fittings:
 - .1 CPVC Schedule 80 socket fittings shall conform to ASTM F439 and Schedule 80 threaded fittings shall conform to ASTM F437. All fittings must be third-party certified to NSF 14. All CPVC Schedule 40 and 80 pipe and fittings shall be made from a 4000psi HDB PPI rated compound. Only CPVC Schedule 80 pipe shall be threaded; pressure rating shall be reduced by 50% as a result of threading procedure.
 - .2 CPVC fittings shall be molded or fabricated from a CPVC compound and shall be compatible with the pipe material. All pipe, fittings, and valves shall be compatible, produced using Corzan compound, and manufactured by same manufacturer as CPVC piping supplied.

2.06 SWIMMING POOL VALVES

- .1 Shut-Off Valves
 - .1 Ball Type up to 1/2" (12mm) to 2 1/2" (65mm):
 - .1 Equal to IPEX "VKD" CPVC in accordance with the following.
 - .2 Material: The valve body, stem, ball and unions shall be made of Corzan CPVC compound which shall meet or exceed the requirements of 23447 according to ASTM D1784.
 - .3 Seats: The ball seats shall be made of Teflon® (PTFE)
 - .4 Seals: The o-ring seals shall be made of EPDM.
 - .5 Connections:
 - .1 Socket style: The IPS socket CPVC end connectors shall conform to the dimensional standard ASTM F439.
 - .2 Threaded style: The female NPT threaded CPVC end connectors shall conform to the dimensional standards ASTM F437, ASTM F1498, and ANSI B1.20.1.
 - .6 Ball valves shall be double blocking with union ends.
 - .7 Ball valves shall be full port and shall allow for bi-directional flow.
 - .8 The valve body shall be single end entry with a threaded carrier (ball seat support). Threaded carrier shall be adjustable with the valve installed.
 - .9 Ball valve body shall have an expansion and contraction compensating groove on the molded end.
 - .10 Ball valve body, union nuts, and carrier shall have deep square style threads.
 - .11 Ball valve seats shall have O-ring backing cushions to compensate for wear and prevent seizure of the ball.
 - .12 Ball valve stem shall be complete with double O-ring seals and a safety shear point above the O-rings.
 - .13 Ball valves shall have integrally molded mounting feature to all for actuation.
 - .14 Ball valves shall have integrally molded support bracketing for anchoring.
 - .15 2 1/2" to 4" (65mm to 100mm) valves handle shall incorporate a transparent PVC plug and tag holder for valve identification.

- .16 Pressure Test:
 - .1 Ball valves shall be pressure tested in both the open and closed positions.
 - .2 Pressure Rating: CPVC ball valves shall be rated at 232 PSI at 73°F.
- .17 Markings: Ball valves shall be marked to indicate size, material designation, and manufacturers name or trade mark.
- .18 Colour Coding: All CPVC valves shall be color-coded light gray.
- .19 NSF Listings:
 - .1 CPVC ball valves shall be listed with NSF to Standard 61 for potable water applications.
 - .2 CPVC valves shall be listed with NSF to Standard 372 for lead content requirements.
- .2 Butterfly Type 3" (75mm) and larger
 - .1 Butterfly valves shall be provided compatible with ANSI 125# and 150# flanges, with a cast iron body, aluminum bronze disc, 416 stainless steel shaft, and CL-1 Buna N seat.
 - .2 NSF Listings:
 - .1 Butterfly valves shall be listed with NSF to Standard 61 for potable water applications.
 - .2 Butterfly valves shall be listed with NSF to Standard 372 for lead content requirements.
 - .3 For 3-way valve applications provide a Unilever operator of linked valve type shall be provided complete with double operator arms of aluminum which shall be heat treated to a T6 temper for strength and durability. Steel couplings and jam nuts shall be provided to facilitate adjustment of linkage. Aluminum connecting rods and high strength shear pins shall also be provided. Valves shall be set to move concurrently with one valve opening with the other valve closing.
 - .4 Provide flanged adaptor equal to IPEX "Xirtec" CPVC meeting ASTM F1970 requirements with pressure ratings of 400 psi at 73°F and 100 at 180°F.
- .2 Check Valves:
 - .1 Thermoplastic ball type check valve up to ½" (12mm) to 2 ½" (65mm):
 - .1 Ball type check valves shall be "Xirtec" Corzan model "VB" by IPEX or approved equal.
 - .2 All valves shall be marked to indicate size, material designation, and manufacturers name or trade mark.
 - .3 Check valve body, ball, end connectors, and unions shall be made of Corzan CPVC compound which shall meet or exceed the requirements of 23447 according to ASTM D1784. Compounds shall comply with standards that are equivalent to NSF Standard 61 for potable water.
 - .4 Seals: O-ring seals shall be made of Viton (FPM) which shall comply with standards that are equivalent to NSF Standard 61 for potable water.
 - .5 All other wetted and non-wetted parts of the valves shall comply with standards that are equivalent to NSF Standard 61 for potable water.
 - .6 Connections:

- .1 Socket style: The IPS socket CPVC end connectors shall conform to the dimensional standard ASTM F439.
 - .2 Threaded style: The female NPT threaded CPVC end connectors shall conform to the dimensional standards ASTM F437, ASTM F1498, and ANSI B1.20.1.
 - .3 Flanged style: The ANSI 150 flanged CPVC end connectors shall conform to the dimensional standard ANSI B16.5.
- .7 The valve shall have union ends.
- .8 The valve cavity shall feature full body guide ribs.
- .9 The valve body and union nuts shall have deep square style threads.
- .10 Pressure Rating: All valves shall be rated at 150 psi at 73°F.
- .11 Color Coding: All CPVC valves shall be color-coded light gray.
- .2 Bronze type check valve 3" (75mm) and larger:
 - .1 Provide wafer type check valve compatible with ANSI 125# and 150# flanges, with a cast iron body, aluminum bronze disc, stainless steel spring and stem, and EPDM seat.
 - .2 NSF Listings:
 - .1 Bronze type valves shall be listed with NSF to Standard 61 for potable water applications.
 - .2 Bronze type valves shall be listed with NSF to Standard 372 for lead content requirements.
 - .3 Provide flanged adaptor equal to IPEX "Xirtec" CPVC meeting ASTM F1970 requirements with pressure ratings of 400 psi at 73°F and 100 at 180°F.
- .3 Diaphragm Valves:
 - .1 IPEC Xirtec" Corzan model "DK", or equal, manual diaphragm valves, size ½" (12mm) to 2½" (65mm) as follows.
 - .2 All valves shall be marked to indicate size, material designation, and manufacturers name or trade mark.
 - .3 Valve body, including end connectors and unions, shall be made of Corzan CPVC compound which shall meet or exceed the requirements of cell classification 23447 according to ASTM D1784.
 - .4 The valve bonnet assembly shall be made of high temperature, high strength, glass-filled polypropylene (GFPP).
 - .5 Diaphragm: The diaphragm shall be made of PTFE (backed with EPDM).
 - .6 Connections:
 - .1 Spigot Style: The IPS spigot CPVC end connectors shall conform to the dimensional standard ASTM F441.
 - .2 Socket Style: The IPS socket CPVC end connectors shall conform to the dimensional standard ASTM F439.
 - .3 Threaded Style: The female NPT threaded CPVC end connectors shall conform to the dimensional standards ASTM F437, ASTM F1498, and ANSI B1.20.1.
 - .4 Flanged Style: The ANSI 150 flanged CPVC end connectors shall conform to the dimensional standard ANSI B16.5.

- .5 All valves shall be weir-style for throttling applications.
- .6 All valves shall have a manual handwheel that can be adjusted and locked in over 300 positions.
- .7 The manual handwheel shall be made of high strength glass-filled polypropylene (GFPP).
- .8 All valves shall have a graduated optical position indicator to allow for a visual check of the valve position.
- .9 All valves shall have a custom labelling plate housed in a transparent cap.
- .10 All through bolts shall be made of stainless steel.
- .11 The valve shall incorporate a feature that allows an identification tag to be easily affixed to the valve body.
- .12 Bodies of CPVC valves shall have brass mounting inserts.
- .13 Pressure Rating: All valves shall be rated at 150 psi at 73°F.
- .14 Colour Coding: All CPVC valves shall be colour-coded light gray.
- .4 Balancing Valves:
 - .1 Provide flanged adaptor equal to IPEX "Xirtec" CPVC meeting ASTM F1970 requirements with pressure ratings of 400 psi at 73°F and 100 at 180°F.
 - .2 Balancing Eccentric Plug Valves 3" (75mm) and larger:
 - .1 Provide eccentric plug valves DeZurik Model PEF, or approved equal, suitable for use in potable water applications for sizes 3" (75mm) and larger, in accordance with requirements as follows.
 - .2 Plugs shall be solid one piece, Cast Iron ASTM A126 Class B (applications up to 125 psi operation) or Ductile Iron ASTM A536 Grade 65-45-12 (applications up to 250 psi operation).
 - .3 The plug shall have a cylindrical seating surface eccentrically offset from the center of the shaft.
 - .4 Plug shall not contact the seat until at least 90% closed. Resilient plug facing shall be Chloroprene (CR).
 - .5 Bodies and covers shall be Cast Iron ASTM A126 Class B (applications up to 125 psi operation) or Ductile Iron ASTM A536 Grade 65-45-12 (applications up to 250 psi operation).
 - .6 The valve port area shall meet or exceed standard pipe area per ASME/ANSI B36.10M.
 - .7 Bearings shall be sleeve type and made of sintered, oil impregnated permanently lubricated type 316 stainless steel for sizes 3-18" (75-450mm) and ASTM A743 Grade CF8M for sizes 20-36" (500-900mm). For valve sizes larger than 36" (900mm), the upper and lower plug journals shall be fitted with ASTM A240 type 316 stainless sleeves with body bearings of ASTM B30, Alloy C95400 aluminum bronze.
 - .8 Seats shall be 1/8" thick welded overlay of not less than 95% pure nickel. Seat shall be at least 1/2" wide, 1/8" thick through entire width and raised. The raised surface shall be completely covered with nickel to ensure that the resilient plug face contacts only the nickel seat.

- .9 Adjustable packing shall be Acrylonitrile-Butadiene (NBR) multiple V-ring type, with a packing gland follower. Packing gland shall permit inspection, adjustment or complete replacement of packing without disturbing any part of the valve or actuator assembly, except the gland follower.
- .10 Pressure ratings shall be 175 psi (1210 kPa) on valve sizes through 12" (300mm) and 150 psi (1035 kPa) for 14" (350mm) and larger. Every valve shall have a factory certified hydrostatic shell test and seat test, with test reports being available upon request.
- .11 All valves larger than 6" (150mm) shall be installed with worm gear actuators. All gearing shall be enclosed in a cast iron housing, with outboard seals to protect the bearings and other internal components. The actuator shaft and gear quadrant shall be supported on permanently lubricated bronze bearings.
- .12 End connections shall meet or exceed the latest revisions of AWWA C517 and other applicable standards. End Connections shall be Flanged drilled per ASME B16.1 and/or Grooved End per AWWA C111.
- .13 Eccentric plug valve shall generally have the following flow performance characteristics when partially open:

DeZurik PEF Cv Values for Partially Open Valves										
Valve Size	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
3"	880	781	644	515	392	288	205	139	79	29
4"	1160	1030	849	679	517	380	270	183	104	38
5 & 6"	1960	1740	1435	1147	874	642	457	309	175	64
8"	3100	2752	2269	1814	1382	1016	722	488	277	101
10"	4540	4031	3323	2656	2024	1488	1058	715	406	147
12"	6300	5593	4611	3686	2808	2064	1468	992	563	205
14"	7560	6712	5533	4423	3370	2477	1761	1190	676	246
16"	9840	8736	7202	5757	4386	3224	2293	1549	879	320
18"	12500	11098	9149	7314	5572	4096	2912	1968	1117	406
20"	15400	13673	11272	9011	6864	5046	3588	2425	1376	500
24"	41400	34840	27289	20480	14446	10086	6871	4448	2554	1013
30"	65500	55122	43175	32402	22855	15957	10870	7038	4041	1603
36"	95100	80032	62685	47044	33184	23168	15783	10218	5868	2327

- .14 Provide the following options:
 - .1 Two (2), 1/4" (6mm) pipe taps, downstream & upstream suitable for flow measurement and/or balancing
 - .2 Dial positioning indicator
- .15 Certifications:
 - .1 ASTM A126 Class B "Gray Iron Castings for Valves, Flanges and Pipe Fittings"
 - .2 ASME B16.1 "Pipe Flanges and Flanged Fittings"
 - .3 AWWA C517 "Resilient-Seated Cast-Iron Eccentric Plug Valves"

- .4 AWWA C111 "Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings"
- .5 NSF/ANSI 61 "Drinking Water System Components - Health Effects"
- .6 NSF/ANSI 372 "Drinking Water System Components - Lead Content"
- .16 Acceptable Manufacturers:
 - .1 DeZurik
 - .2 VSI Waterworks
 - .3 Val-Matic
 - .4 J&S Valve
 - .5 Consultant approved equal
- .5 Built-up Balancing Butterfly Valves 3" (75mm) and larger:
 - .1 General:
 - .1 For potable water service provide concentric cast butterfly valves, Series BFI as manufactured by Valve Solutions, Inc. (VSI), or Consultant approved equal, size 3" (75 mm) to 42" (1050mm).
 - .2 Valve sizes 3" (75mm) to 24" (600mm) shall be rated for service pressure up to 250 psig (1725 kPa); valve sizes 30" (750mm) to 42" (1050mm) shall be rated for service pressure up to 150 psig (1035 kPa).
 - .3 Butterfly valves shall be resilient seated and of the quarter turn, concentric, bonded seal in body type.
 - .4 All butterfly valves shall be in full conformance with the design, manufacturing, and testing standards set forth by the American Water Works Association (AWWA) in Standard ANSI/AWWA C504.
 - .5 Series BFI valves shall be ANSI/NSF-61 Listed for drinking water, and ANSI/NSF-372 certified lead-free.
 - .6 All valves shall be warranted by manufacturer for a period of 12 months.
 - .2 End Connections:
 - .1 Flanged valves shall conform to all standards of ANSI B16.1, Class 125 or Class 250.
 - .2 Flanged valves' lay length shall conform to AWWA C504 Table 1, Short Body.
 - .3 Mechanical joint valves shall conform to all standards of ANSI/AWWA C111/A21.11.
 - .3 Markings:
 - .1 Each valve shall be marked with the manufacturer's name, valve size, body material, and pressure rating cast into the body of the valve. Lettering shall be a minimum of 1/2 inch tall and project 1/10 inch from body.
 - .2 All butterfly valves, except buried or submerged valves, shall be equipped with a type 304 or 316 stainless steel tag identifying body, disc, resilient seat, and stem material in addition to manufacturer's name, pressure rating, size, date of manufacturer, and date of testing.
 - .4 Construction
 - .1 Valves shall provide a bubble-tight shutoff bi-directionally at rated working pressure.

- .2 Valves shall be equipped with either a seat directly bonded to a machined finished surface on valve disc or an entirely corrosion resistant disc with machined seat.
- .3 Valve shall have a permanently installed seal bonded to the body of the valve. The seal-to-body bond shall comply with ASTM D429 pull test.
- .4 Valve shall be equipped with a set of V-type stem packing. Valve stem packing shall be replaceable without removing the valve from the line and be adjustable by means of shims.
- .5 Radial shaft bushings shall be provided in the upper and lower bearing journals.
- .6 The valves shall be equipped with a mounting area for operators conforming to Manufacturers Standard Society (MMS) 101 or International Organization of Standardization (ISO) 5211. Provide sufficient clearance to directly mount standardized operators with accessible fasteners.
- .7 Stem diameter shall be the preferred dimension stated in ISO 5211 Table 4.
- .8 Drive keys shall comply with ISO R773, unless specifically stated otherwise. Preferred tolerance is D10, however, tolerance of Js9 is acceptable for motor operated valves.
- .5 Materials:
 - .1 The valve body and bonnet if equipped shall be constructed of ASTM A536 Ductile Iron.
 - .2 The valve disc shall be 316 stainless steel for sizes 3" (75mm) to 6" (200mm), and ASTM A536 Ductile Iron for sizes 8" (200mm) and larger.
 - .3 For valve sizes 3" (75mm) to 6" (150mm) the seat shall be machined into the stainless-steel discs edge. For valve sizes 8" (200mm) and larger the seat shall be applied to the ductile iron disc in the form of a minimum of 95% nickel, type 316 stainless steel.
 - .4 The valve seal shall be made from resilient EPDM.
 - .5 Radial bearings shall be made of permanently lubricated RTFE.
 - .6 All coatings shall be ANSI/NSF-61 Listed for drinking water.
 - .7 All wetted hardware should be of corrosion resistant type 316 stainless steel.
 - .8 All valves shall have type 304 stainless steel exterior hardware.
- .6 Operators:
 - .1 Operator shall be designed to hold the valve in any intermediate position without creeping or fluttering.
 - .2 All manually operated valves 3" (75mm) and larger shall be equipped with a gear actuator with position indicator.
 - .3 All actuators shall be permanently sealed and suitable for buried service.
 - .4 All 2" (50mm) square operating nuts and exposed hardware shall be made of stainless steel.
 - .5 All actuators equipped with handwheels shall have a maximum rim pull of 80 lbs plus 5%.
- .7 Performance Characteristics:

VSI Series BFI Butterfly Valve Cv Values for Partially Open Valves										
Valve Size	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
3"	228	194	130	80	51	34	20	9	4	---
4"	463	394	263	163	104	69	41	19	9	---
6"	1069	909	608	376	241	160	96	44	21	---
8"	2372	2018	1348	834	534	355	212	98	46	---
10"	4380	3726	2490	1540	986	655	392	180	85	---
12"	6515	5543	3703	2291	1466	974	583	268	126	---
14"	9574	8145	5442	3366	2155	1432	856	394	185	---
16"	13356	11363	7592	4696	3006	1997	1195	549	259	---
18"	16898	14376	9605	5941	3804	2527	1512	695	327	---
20"	21421	18225	12176	7532	4822	3204	1916	881	415	---
24"	27889	23727	15852	9806	6278	4171	2495	1147	540	---
30"	39450	33563	22423	13871	8880	5900	3529	1622	764	---
36"	59520	50638	33831	20927	13397	8901	5325	2447	1152	---
42"	85740	72946	48735	30146	19299	12822	7670	3525	1660	---

.8 Accessories:

.1 Bleed-ring

- .1 Bleed rings, supplied by Optco Ltd., or Consultant approved equal, shall be 316 stainless steel bleed rings to be installed upstream and downstream of balancing butterfly valves, facilitating pressure taps and instrumentation connections.
- .2 Bleed rings shall be fabricated from ASTM A240/A182 Type 316 stainless steel, providing superior corrosion resistance in process environments.
- .3 Bleed rings shall conform to ASME B16.5 flange standards, matching the flange size, and pressure class (150#), of the adjoining butterfly valves. Rings shall be designed to fit within the bolt circle of the flanges, similar to a standard ring gasket, with bolt hole clearance maintained for proper alignment and sealing.
- .4 Each bleed ring shall include one (1) NPT female tap, sized 1/2" (25mm) nominal, oriented radially and centered on the ring's OD for instrument or pressure gauge connection. Threads shall comply with ASME B1.20.1.
- .5 Gasket contact surfaces shall be machined to a 125–250 µ-in. Ra finish to ensure effective sealing. Dimensional tolerances shall comply with ASME B16.5.
- .6 All rings shall undergo 100% visual inspection and material verification prior to installation.

2.07 POTABLE (DRINKING) WATER PLATE HEAT EXCHANGERS

.1 General:

- .1 Provide plate heat exchangers suitable for use in potable water applications with performance in accordance with the Drawings and/or Equipment Schedules.

- .2 The plate and frame heat exchanger manufacturer shall be a certified member of NSF 61 - Drinking Water System Components - Health Effects.
- .2 Construction:
 - .1 The manufacturer shall provide NSF 61 certified unit for use in potable water applications.
 - .2 The units shall be designed, constructed, tested, and "U" stamped in accordance with Section VIII, Division 1 of the ASME Pressure Code. A U-1 form and picture of the nameplate shall be furnished.
 - .3 The manufacturer shall hydro-test the unit to 1.3 times the design pressure in accordance with ASME Pressure Code requirements.
- .3 Frame:
 - .1 The frame plate and pressure plate shall be carbon steel SA 516 grade 70.
 - .2 The frame and pressure plate shall be of sufficient thickness to meet the ASME design pressure without the use of stiffeners or support brackets.
 - .3 Carbon steel frame components shall be painted with epoxy paint.
 - .4 Units with 4" (100mm) or larger connections shall be alloy lined studed ports to mate with raised face or flat faced ANSI flanges that meet NFS 61 certification requirements.
 - .5 Units with 2" (50mm) or smaller connections shall have male NPT connections where an alloy material is required to meet NFS 61 certification requirements.
 - .6 Units with 2½" (65mm) or 3" (75mm) connections shall be either studed ports or NPT as described above.
 - .7 The frame design shall allow the thermal plates to be supported by the carry bar, top bar. The guide bar, bottom bar, shall only help properly align the plates.
 - .8 A roller assembly from the carry bar shall support the pressure plate for units taller than 50" (1270mm).
 - .9 Tightening bolts shall be zinc plated carbon steel SA193 B7.
- .4 Plates:
 - .1 Plates for all NSF 61 certified units designed for domestic water application are to be constructed of 316L Stainless Steel double wall pressed in a once-step stamping process.
 - .2 Plates shall be pressed with a herringbone corrugation to optimize heat transfer.
 - .3 Plates shall use an integral rolled edge hanging system to provide a rigid hanger device between the plate and carry bar and guide bar without the use of welded on hanging brackets or stiffeners.
 - .4 Plates shall be permanently marked to indicate plate material and thickness.
- .5 Gaskets:
 - .1 Gaskets for all NSF 61 certified units designed for domestic water application are to be made of NBR or EPDM with an FDA approved material.
 - .2 The gaskets shall be a one-piece construction with a double gasket barrier at the port region.
 - .3 The area isolated by the double gasket shall be vented to the atmosphere, so that a gasket failure is detected by leakage to the exterior prior to any possible cross contamination.
 - .4 Gaskets are to be "mechanically fixed" in place; adhesives are not acceptable.
- .6 Acceptable Manufacturers:
 - .1 Alfa Laval,

- .2 S.A. Armstrong,
- .3 Xylem (Bell & Gossett)
- .4 Kelvion, Inc.,
- .5 Tranter,
- .6 Consultant approved equal.

2.08 TRAP SEAL PRIMERS

- .1 Equal to Precision Plumbing Products (PPP) model PTS electronic trap seal trap priming assembly shall automatically maintains a constant water seal in floor drain traps configured to accommodate 4 to 30 connections. Electronic trap seal primer assembly shall be as follows:
 - .1 Surface mounted NEMA-1 metal cabinet with cover plate: 12" x 12" x 4" deep (305mm x 305mm x 102mm deep)
 - .2 Domestic water inlet: ¾" (20mm) shut-off valve with female threaded connection to ANSI/ASME BI.20.1.
 - .3 Outlet: ½" (12mm) compression fitting(s) to SAEJ512.
 - .4 Manifold: ¾" (20mm) Type "L" copper tubing to ASTM B88.
 - .5 Soldered joints: 95-5 lead free containing lead not in excess of 0.2%.
 - .6 Electrical components: 2 Amp circuit breaker, manual over-ride switch/test button, timer, solenoid valve marked as UL listed.
 - .7 Backflow prevention: Anti-Siphon atmospheric vacuum breaker meets American Society of Sanitary Engineering (ASSE) Standard 1001 and CSA.
 - .8 Temperature rating: 32°F to 125°F (0°C to 51.7°C)
 - .9 Pressure rating: 20 psi to 150 psi (140 kPa to 1035 kPa).
 - .10 Electrical Specifications: 120V/1ph/60Hz; Watts: 6; Holding: 16 VA; In-rush: 34 VA
- .2 Install unit plumb and true with suitable access above finished floor.
- .3 Allow 1 ft. (300mm) of elevation for every 20 ft. (6m) of distance ran for floor drain make up line.

2.09 WATER HAMMER ARRESTORS

- .1 Equal to Precision Plumbing Products (PPP) model HPC lead free threaded water hammer arrestors, NSF/ANSI 61 Certified, and designed to operate on all domestic water systems as follows:
 - .1 Operating pressure: 35 psi to 500 psi; maximum spike pressure: 2000 psi;
 - .2 Temperature range: 32°F to 212°F (0°C to 100°C);
 - .3 Construction: Barrel-fabricated of type "K" copper;
 - .4 Cap: Brass with ground seat filler valve at the top of the arrestor;
 - .5 Piston: Brass;
 - .6 Seals: High pressure "O" rings.
- .2 Size water hammer arrestors in accordance with manufacturer's water fixture unit loading based on groups of fixtures served.
- .3 Locate water hammer arrestors in all new and modified potable water distribution systems in accordance with manufacturer's recommend installation practices using standard pipe tee fittings.

2.10 PLUMBING FIXTURES

- .1 All plumbing fixtures, where indicated on plan, shall be provided by Mechanical Trades unless otherwise indicated on the drawings.
- .2 Fixtures shall be piped with all necessary appurtenances (i.e. vents, sanitary, domestic hot and cold water connections). Install all components in strict accordance with the manufacturer's recommendations.
- .3 Connect fixtures, complete with supplies and drains, separately trapped, supported level and square. Provide chrome plated piping for all exposed water supply, waste and vent connections complete with chrome plated escutcheons.
- .4 Obtain Architects acceptance of mounting heights of all wall mounted fixtures.
- .5 Fixtures mounted on glazed tile surfaces: Provide ground faces to finished surfaces.
- .6 Install water hammer arrestors for each fixture or group of fixtures.

2.11 FLOOR DRAINS

- .1 Provide with trap primers connected to nearest cold water flush valve, or to automatic trap seal primer. Prime all floor drain traps and sump pump pits.
- .2 Finished Area Round Floor Drain (FD-1): Equal to Watts "FD-200-B" on-grade epoxy coated cast iron floor drain with anchor flange, weepholes, adjustable round heel proof heavy duty nickel bronze strainer, and no hub (standard) outlet.
- .3 Finished Area Square Floor Drain (FD-2): Equal to Watts "FD-200-L" on-grade epoxy coated cast iron floor drain with anchor flange, weepholes, adjustable square heel proof heavy duty nickel bronze strainer, and no hub (standard) outlet.
- .4 Service Area Round Floor Drain (FD-4): Equal to Watts "FD-320" epoxy coated cast iron area drain with anchor flange, body collar with weepholes, 8 in.(203mm) diameter adjustable top with heel proof ductile iron grate, and no hub (standard) outlet.
- .5 Service Area Square Floor Drain (FD-5): Equal to Watts "FD-330-Y" epoxy coated cast iron area drain with anchor flange, weepholes, 8 in. x 8 in. (203 x 203mm) square fixed top with heel proof ductile iron grate, and no hub (standard) outlet.
- .6 Service Area Funnel and Floor Drain (FD-6): Equal to Watts "FD-320-G-50" epoxy coated cast iron area drain with anchor flange, body collar with weepholes, 8 in.(203mm) diameter adjustable top with heel proof ductile iron grate, 4" x 9" cast iron oval funnel, and no hub (standard) outlet.

2.12 CLEANOUTS

- .1 Floor Cleanouts:
 - .1 Finished Areas Round Cleanout (CO-1): Equal to Watts model CO-200-R epoxy coated cast iron floor cleanout with 5-1/8" (130mm) round adjustable nickel bronze (standard) top and no hub (MJ) connection.
 - .2 Finished Areas Square Cleanout: (CO-2): Equal to Watts model CO-200-S epoxy coated cast iron floor cleanout with 5-1/8" (130mm) square adjustable nickel bronze (standard) top, and no hub (MJ) connection.
 - .3 Finished Areas Square Cleanout with Tile Recess: (CO-3): Equal to Watts model CO-200-TS epoxy coated cast iron floor cleanout with 5-1/8"(130) square adjustable nickel bronze standard top with tile recess and no hub (MJ) connection.
 - .4 Finished Areas Square Cleanout with Terrazzo Recess: (CO-4): Equal to Watts model CO-200-US epoxy coated cast iron floor cleanout with 5" x 5" (127mm x 127mm) square adjustable gasketed nickel bronze top with terrazzo recess, removable gas tight gasketed brass cleanout plug and no hub (standard) outlet.
 - .5 Service Area Round Cleanout (CO-5): Equal to Watts model WHDCO-NH extra heavy duty cleanout, epoxy coated cast iron body and 6¼" (159mm) diameter round cover.

- .2 Stack Cleanouts:
 - .1 Finished Areas Stack Cleanout (CO-6): Equal to Watts model CO-460 cast iron stack cleanout with gasketed brass countersunk plug, stainless steel access cover, vandal proof stainless steel screw, and no hub connection.
 - .2 Recessed Stack Cleanout (CO-7): Equal to Watts CO-460 cast iron stack cleanout with gasketed brass countersunk plug, and no hub connection.
- .3 Install cleanouts in accessible locations at traps, or behind access doors, and where required.

2.13 SHUT-OFF VALVES AND DRAIN VALVES

- .1 Drain Valves:
 - .1 Install $\frac{3}{4}$ " (20 mm) drain valves with hose thread end cap and chain in water services adjacent to and downstream of shut-off valves and at all system low points. Slope water piping to drain points.
- .2 Provide ball or butterfly valves for all shut-off requirements.
 - .1 Ball Valves:
 - .2 Ball valves shall be 2-piece full port design constructed using lead free forged copper silicon alloy brass body and end adapter.
 - .3 Free valves shall be NSF certified for use in potable (drinking) water systems requiring reduced lead content.
 - .4 Seats and stem packing shall be virgin PTFE. Stem shall be bottom loaded, blowout proof design with fluorocarbon elastomer O-ring to prevent stem leaks. Valve shall have chrome plated lead free brass ball and adjustable packing gland.
 - .5 Soldered end valves $\frac{1}{2}$ " to 2" (12mm to 50mm) to be UL listed FM approved, and certified to NSF/ANSI standard 61/8. Valve sizes $\frac{1}{4}$ " to 2" (6mm to 50mm) shall be rated to 600psi (41 bar) WOG non-shock and 150psi (10.3 bar) WSP.
 - .3 Butterfly Valves:
 - .1 NSF Certified for potable (drinking) water use, resilient seated butterfly valves sizes 2" to 12" (50mm to 300mm), wafer or lug body design.
 - .2 200psi (13.8 bar) pressure rating constructed of a ductile iron body, an aluminum bronze, and a 316 stainless steel shaft, and EPDM seat material. Mounting pad is designed to accommodate 10 position lever handles; provide gear operators where indicated. Butterfly valves shall be designed and manufactured for use with ANSI 125 or 150 Class flanges and to comply with API 609 and MSS-SP-67.

2.14 REDUCED PRESSURE ZONE (RPZ) BACKFLOW PREVENTER ASSEMBLIES

- .1 Sizes $\frac{1}{4}$ " to 2" (6mm to 50mm): NSF Certified for potable (drinking) water use, the assembly shall incorporate two poppet style check valves, replaceable check seats, with an intermediate relief valve. The check valve poppet assembly shall be guided via the use of a corrosion resistant plastic guide. The check valve and relief valve seats shall be push-in type. The relief valve cover shall be bronze construction secured with stainless steel bolts and shall utilize a quarter-turn locking joint to capture the spring load of the relief valve. The relief valve shall have an internal sensing line to sense the inlet water supply. All rubber elastomers shall be of chloramine resistant material. The assembly shall also include two resilient seated isolation valves, four top-mounted resilient seated test cocks and an air gap drain fitting.
 - .1 Body: Bronze
 - .2 Discs: Silicone rubber
 - .3 Check Seats: Replaceable polymer

- .4 Cover Bolts: Stainless steel
- .5 Temperature Range: 33°F to 180°F (0.5°C to 82°C)
- .6 Maximum Working Pressure: 175psi (12.1 bar)
- .2 Sizes 2½" to 10" (65mm to 250mm): NSF Certified for potable (drinking) water use, the assembly shall consist of a pressure differential relief valve located in a zone between two positive seating check valves and captured springs. Back siphon protection shall include provision to admit air directly into the reduced pressure zone via a separate channel from the water discharge channel. The assembly shall include two tightly closing shutoff valves before and after the valve and test cocks.
- .3 The assembly shall include a sensor on the relief valve for flood detection.
 - .1 Check Valve Body: FDA approved electrochemical corrosion inhibitor and microbial inhibitor coated cast iron
 - .2 Seat: Stainless steel
 - .3 Trim: Stainless steel
 - .4 Relief Valve Body: 2½" to 3" (65mm to 75mm) lead free cast copper silicon alloy; 4" to 10" (100mm to 250mm) FDA approved electrochemical corrosion inhibitor and microbial inhibitor coated cast iron
 - .5 Test Cock: lead free copper silicon alloy
 - .6 Temperature Range: 33°F to 110°F (0.5°C to 43°C) continuous, 140°F (60°C) intermittent
 - .7 Maximum Working Pressure: 175 psi (12.06 bar)

2.15 STRAINERS

- .1 Sizes ¼" to 2" (6mm to 50mm): NSF Certified for potable (drinking) water, wye-pattern lead free cast copper silicon alloy strainer shall have a solid retainer cap with gasket. Strainer shall be rated to 400psi (27.6 bar) WOG @ 210°F (99°C); 125psi (8.6 bar) WSP @ 353°F (178°F)
 - .1 Body: lead free cast copper silicon alloy
 - .2 Retainer Cap: ¼" to 2" (6mm to 50mm): Lead Free copper silicon alloy
 - .3 Cap Seal: ¼" to 2" (6mm to 50mm): EPDM O-Ring;
 - .4 Standard Screen: ½" to 2" (12mm to 50mm): 304 stainless steel #20 mesh;
- .2 Sizes 2½" to 12" (50mm to 300mm): NSF Certified for potable (drinking) water, wye pattern, cast iron strainer with a double coated, heat fused, FDA approved epoxy coating on the interior and exterior surfaces for FDA sanitary applications. Flanges to conform to ANSI B16.1 Class 125,
 - .1 304 stainless steel perforated screens, and a drain/blowoff connection furnished with a closure plug.
 - .2 Maximum Operating Pressure: 200psi (13.8 bar) WOG, non-shock, @ 210°F (99°C), 125psi (8.6 bar) WSP @ 353°F (178°C)

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

- .1 Install Plumbing and Drainage systems in accordance with the Building Code requirements, Manufacturer's requirements, and the requirements of the Authorities Having Jurisdiction (AHJs).
- .2 Provide all required labour necessary for the installation of control components and devices supplied by Controls Trades. Include all additional labour necessary for the successful completion of point-to-point verification of devices, and performance verification of devices and systems as part of the project commissioning requirements.

- .3 Locate equipment as shown on the drawings to provide connection arrangement and accessibility for servicing.
- .4 Provide clearances on all sides of equipment as required by the Manufacturer's Installation Instructions.
- .5 Install items of equipment with due regard to Architectural treatment, and ensure all items are level and finished in keeping with good workmanship.
- .6 Provide chemical treatment by-pass connections at heat exchangers as directed by chemical treatment supplier.
- .7 Provide branch take-offs from mains with shut off valves.
- .8 Install and connect remote components and other similar ancillary devices specified or supplied loose with the equipment. Install in serviceable locations as shown on the equipment Manufacturer's installation details, and where shown on the Drawings.

3.02 PIPE INSTALLATION:

- .1 Copper Fittings in Potable Water Systems:
 - .1 Provide lead, antimony, cadmium and zinc free solders composed of tin/copper/silver or nickel components that are acceptable to Authorities having jurisdiction.
 - .2 Clean ends of pipes or tubing and recesses of fittings to be brazed or soldered. Assemble joints without binding.
 - .3 Use nontoxic lubricant or teflon tape applied to male thread.
- .2 Copper Fittings in Drainage Systems:
 - .1 Drainage grade copper tubing with copper drainage fittings with 50-50 solder.
- .3 Run water piping from service connection to fixtures and equipment. At lavatories install supplies as high as possible. Install brass and copper pipe and tubing free from surface damage. Replace damaged pipe or tubing.
- .4 Lay copper tubing so that it is not in contact with dissimilar metal and will not be kinked or collapsed.
- .5 Provide washroom groups and branch take-offs from mains with isolating valves. Install stop valve in each fixture supply.
- .6 Install straight, parallel and close to walls and ceilings, with specified pitch. Use standard fittings for direction changes.
- .7 Install groups of piping parallel to each other on trapeze hangers; Space piping to permit application of insulation, identification and service access.
- .8 Install eccentric reducers in horizontal piping to permit drainage and eliminate air pockets.
- .9 Where pipe sizes differ from connection sizes of equipment, install reducing fittings close to equipment. Reducing bushings are not permitted.

3.03 INSTALLATION OF PLATE HEAT EXCHANGERS

- .1 Provide package type plate and frame heat exchangers where shown and/or required.
- .2 Provide package type shell and tube heat exchangers where shown and/or required.
- .3 Provide a line size strainer or pump suction diffuser at the primary side inlet connection to each plate and frame heat exchanger.
- .4 Secure each heat exchanger in place on a prime coat painted welded structural steel stand to a concrete housekeeping pad.

END OF SECTION 22 05 10

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- 1.02 WORK PERFORMED BY THIS SECTION
- 1.03 QUALITY ASSURANCE
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- 1.05 MAINTENANCE
- 1.06 DELIVERY, STORAGE, AND HANDLING

PART 2 - PRODUCTS

- 2.01 NIL

PART 3 - EXECUTION

- 3.01 EQUIPMENT AND TERMINALS
- 3.02 EQUIPMENT STARTUP

PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Mechanical Work General Instructions Section 20 05 05 and Basic Mechanical Materials and Methods Section 20 05 10.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Heating and Cooling
 - .1 Heating, cooling, refrigeration piping systems.
 - .2 Supply and installation of boilers, pumps, convectors, chillers, cooling towers, condenser, tanks, coils, unit heaters, air handling units, heat exchangers, rooftop HVAC units and other heating/cooling systems piped components.
- .2 Air Distribution
 - .1 Provide a complete installation of ventilation systems as shown of the Drawings and Detail Drawings including ductwork, grilles, and diffusers, fans, VAV terminals, dampers, hoods and provision of personnel and materials to assist in air balancing.
 - .2 Install all automatic dampers supplied by Division 25 Building Automation System.

1.03 QUALITY ASSURANCE

- .1 Qualifications: execute work of this section only by skilled tradesmen regularly employed in the installation of pressure piping systems and heating and cooling equipment.
- .2 All filters to be ULC labelled and listed for flame spread rating of less than 25 and smoke classification of less than 50.
- .3 Chillers to meet the energy efficiency requirement of CSA C743-02 Standard (latest edition). Other HVAC equipment to meet the performance standards of the Model National Energy Code of Canada for Buildings (latest edition) or ASHRAE 90.1-2010 whichever is more stringent. Comply with the requirements of Ontario Building Code Supplementary Standard SB-10.
- .4 Large air conditioners, heat pumps and condensing units to meet the Energy Efficiency Performance Standard of CAN/CSA-C746 (current version).

1.04 SUBMITTALS

- .1 Submit shop drawings in accordance with Section 20 05 01 – Shop Drawings, Product Data & Samples.
- .2 Closeout Submittals:
 - .1 Provide operation and maintenance data for incorporation into manual specified in Division 01 closeout submittals and as outlined in Section 20 05 05.
 - .2 Site records and Record Drawings: Refer to Section 20 05 05:
 - .3 Provide co-ordination/interference drawings, as required per Section 20 05 05, Co-ordination Drawings.

1.05 MAINTENANCE

- .1 Furnish spare parts in accordance with Division 01, to suit Close-out Submittals and in accordance with Section 20 05 05, 20 05 01 and 20 05 10, as follows:
 - .1 One set of packing for each pump.
 - .2 One casing joint gasket for each size pump.
 - .3 One head gasket set for each heat exchanger.

- .4 One glass for each gauge glass.
- .5 One filter cartridge or set of filter media for each filter or filter bank in addition to final operating set.
- .2 Provide one set of special tools required to service equipment as recommended by manufacturers and in accordance with Division 01, to suit Close-out Submittals.
- .3 Furnish one commercial quality grease gun, grease and adapters to suit different types of grease and grease fittings.

1.06 DELIVERY, STORAGE, AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

PART 2 - PRODUCTS

2.01 NIL

PART 3 - EXECUTION

3.01 EQUIPMENT AND TERMINALS

- .1 Deliver equipment to the Site of the Work and store in area as designated by the [Contractor]. Set equipment on temporary bases to avoid contact with the ground. Protect equipment from damage.
- .2 Comply with manufacturer's requirements for the installation of all specified equipment.
- .3 Locate equipment as shown on the drawings to provide best possible connection arrangement and accessibility for servicing. Provide clearances on all sides of equipment as required by Authorities having jurisdiction or manufacturer, whichever is greater.
- .4 Install items of equipment such as convectors with due regard to Architectural treatment, and ensure all items are level and finished in keeping with good workmanship. Grade all convector elements upward in direction of flow refer to detail drawings.
- .5 Provide drains to nearest floor drain on all back flow preventors.
- .6 Provide chemical treatment connections on chilled, heating circuits as directed by chemical treatment supplier.
- .7 Pitch coils for air handling systems 18mm/m (3"/ft) toward access end of unit.
- .8 Provide branch take-offs from mains of heating and cooling pipes with shut off valves.
- .9 Install and connect remote components such as thermostats, humidistats, control panels, level controllers, etc., that are supplied with the equipment. Install in locations as shown on the drawings.
- .10 Install rooftop HVAC and H&V equipment on bases per Manufacturer's instructions and in locations as shown on the Drawings. Provide PVC condensate drains to roof for HVAC units. Provide condensate drains with deep traps equivalent to 25 mm (1") deeper than air pressure in the unit with the top of the trap 50 mm (2") minimum below the unit condensate outlet. Condensate must be effectively trapped to avoid condensate hang-up in the unit and to prevent air flowing into the unit through the trap.
- .11 Install Infra-red heaters in locations and elevations as shown on the Drawings. Take care to ensure a neat installation to provide the best possible appearance. Install exposed items such as piping, vent tubing or wiring parallel with wall and ceiling surfaces.

3.02 EQUIPMENT STARTUP

- .1 Follow manufacturer's instructions and have manufacturer's representative present to certify the installation.
- .2 Check each item of equipment to ensure proper electrical connections, etc., and to verify proper operation.

END OF SECTION 23 05 00

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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Mechanical Work General Instructions Section 20 05 05, Basic Mechanical Materials and Methods Section 20 05 10.
- .3 Comply with the requirements of Section 23 05 00 Common Work Results for HVAC.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Provide all hydronic pumps for HVAC systems.
- .2 Section Includes:
 - .1 Materials and installation for hydronic pumps.
 - .2 Sustainable requirements for construction and verification.

1.03 REFERENCES

- .1 American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE)
 - .1 Standard 90.1, Energy Standard for Buildings except Low-Rise Residential Buildings.
- .2 Electrical Equipment Manufacturers Advisory Council (EEMAC)
- .3 Canadian Standards Association (CSA International)
 - .1 CSA-B214, Installation Code for Hydronic Heating Systems.
- .4 National Electrical Manufacturers' Association (NEMA)
 - .1 NEMA MG 1, Motors and Generators.

1.04 QUALITY ASSURANCE

- .1 Materials in accordance with Section 20 05 05 and 20 05 10.
- .2 Size and select components to: CSA-B214
- .3 Acceptable manufacturers: Bell & Gossett, S.A. Armstrong, PACO, Grundfos, TACO, Hydromatic, Patterson, Wilo

1.05 SUBMITTALS

- .1 Provide manufacturer's printed product literature and datasheets for pump, circulator and equipment and include product characteristics, performance criteria, physical size, finish and limitations indicate point of operation and final location in field assembly in accordance with Section 20 05 01 – Shop Drawings, Product Data & Samples.
- .2 Submit manufacturer's detailed composite wiring diagrams for control systems showing factory installed wiring and equipment on packaged equipment or required for controlling devices or ancillaries, accessories and controllers.

1.06 DELIVERY, STORAGE, AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

1.07 WARRANTY

- .1 Provide warranties as outlined in Section 20 05 05.

PART 2 - PRODUCTS

2.01 ALL PUMPS

- .1 All pumps: equipped with mechanical seals, non-overloading (not including motor service factor) over entire performance curve except where pumps are fitted with integrated VFD with non-overloading logic and bronze fitted except where noted. Provide split coupling for pumps having a motor equal to or higher than 5.6 kw (7½ HP). All vertical inline pumps to be complete with equally sized suction and discharge flanged connections, tapping for gauge, drain and flush line connections. Base mounted pumps: complete with coupling guards. All vertical inline and base mounted pumps with mechanical seals to be equipped with factory installed Micro-Wynd II Cuno filters and Arkon flow indicators. Provide an additional set of filters to replace original filters after system is cleaned and treated.
- .2 Each pump shall be hydrostatically tested 1.5 times the maximum rated working pressure and name-plated before shipment.
- .3 Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Motors through 1 HP shall be resilient mounted, motors over 1.5 HP shall be rigid mounted. Motors shall have permanently lubricated ball bearings and must be completely maintenance free. Larger motors requiring lubrication maintenance must be fitted with grease points (zerks). Motors shall be non-overloading at any point on the pump curve except where pumps are fitted with integral VFD with non-overloading logic and shall meet NEMA specifications. Efficiency of motors above 1.0 HP shall be NEMA Premium as standard.

2.02 IN LINE CIRCULATOR

- .1 The pump shall be of the horizontal system lubricated type specifically designed and guaranteed for quiet operation.
- .2 Pump to be suitable for 225° F (107° C) operation at 150 PSIG (10 Bar) working pressure or as indicated in schedule.
- .3 Pump volute shall be of a cast iron, lead free bronze or stainless steel design.
- .4 The pumps shall have a ceramic or steel shaft supported by carbon or steel bearings.
- .5 The pumps are to be equipped with a water-tight seal to prevent leakage.
- .6 Bearings are to be lubricated by the circulating fluid.
- .7 The motor shall be drip-proof, sealed precision ball bearing, quiet operating construction. The permanent split capacitor motor shall be equipped with thermal overload protection.
- .8 Motor stator for wet rotor type circulator to be isolated from circulating fluid through use of stainless steel can. Rotor to be sheathed in stainless steel.
- .9 Motors shall be non-overloading at any point on the pump curve. Motors to have built-in impedance protection.

2.03 SPLIT COUPLED VERTICAL IN-LINE PUMPS

- .1 Provide Vertical In-Line pumps, single stage, single suction type, with pump characteristics which provide rising heads to shut off. Refer to pump schedule for pump flows and heads and motor speed, enclosure, efficiency and power requirements and other system conditions.
- .2 Pump Construction: Pump Casing - Cast Iron with 125 psig ANSI/PN16 flanges for working pressure below 175 psig (12 bar) at 250°F (121°C) and Ductile Iron with 250 psig ANSI/PN25 flanges for working pressures to 250 psig (17 bar) at 250°F (121°C). Suction and discharge connections shall be flanged and the same size and shall be drilled and tapped for seal flush and gauge connections.
- .3 Pump shaft shall connect to a stainless steel or bronze impeller. Impeller shall be hydraulically and dynamically balanced to Hydraulic Institute Standards ANSI/HI 9.6.4.5-2000. The allowable residual imbalance conforms to ANSI grade 6.3, keyed to the shaft and secured by a stainless steel locking capscREW or nut.

- .4 The pumps shall have a 416 stainless steel shaft that is guided by a carbon graphite lower throttle bushing.
- .5 Coupling - Rigid spacer type of high tensile aluminum alloy. Coupling to be designed to be easily removed on site to reveal a space between the pump and motor shafts sufficient to remove all mechanical seal components for servicing and to be replaced without disturbing the pump or motor. Coupling shall incorporate tapered washer shaft jacking design.
- .6 Pump shall be equipped with a Unitized inside mechanical seal assembly with flush line. The seal assembly shall have an EPR elastomer bellows and a positive metal-to-metal drive system to reduce torsional stress on the bellows. The bellows will be pressure supported without creases or folds for long life. The mechanical seal shall have a rotating carbon face against a stationary ceramic face. (As an option, an outside mechanical seal may be used in lieu of the inside mechanical seal design. The outside seal materials shall be EPR elastomer with carbon-sintered silicon carbide faces.)
- .7 All split coupled pumps shall be provided with a lower seal chamber throttle bushing to ensure seals maintain positively cooling and lubrication.
- .8 Seal flush line accessories, if required to improve seal chamber cleanliness: Supply in the flush line to the mechanical seal a 50 micron cartridge filter and sight flow indicator, to suit the working pressure encountered.
- .9 Alternately, a maintenance-free accessory needing pump differential pressures exceeding 70 ft./30 psig/200 kPa for effective operation: Supply in the flush line to the mechanical seal a maintenance-free sediment separator, with sight flow indicator.

2.04 CLOSE COUPLED VERTICAL IN-LINE PUMPS

- .1 Pump casing shall be cast iron or ductile iron,
- .2 Suitable standard operations at 225F and 175 PSIG (1206kpa) working pressure, extended operations up to 250°F 250 PSIG (1724 kPa) working pressures and 300psi (2068 kPa) working pressures. Working pressure shall not be de-rated at temperatures up to 250°F.
- .3 Pump should be designed to allow for true back pull-out access to the pump's working components for ease of maintenance.
- .4 The casing suction and discharge connections shall be the same size and shall be provided with drilled and tapped seal vent and pressure gauge connections.
- .5 Pump impeller shall be stainless steel or bronze, fully enclosed type. Impeller shall be hydraulically and dynamically balanced.
- .6 A non-ferrous shaft sleeve, extending the full length of the mechanical seal area, shall be provided.
- .7 Seal assembly shall have a stainless steel housing, Buna bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face. Seal vent line shall be factory installed and shall be piped from the seal area to the pump suction connection.
- .8 Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Motors shall have heavy-duty grease lubricated ball bearings to offset the additional bearing loads associated with the closed-coupled pump design. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications.

PART 3 - EXECUTION

3.01 APPLICATION

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

3.02 INSTALLATION

- .1 Install hydronic pumps to: CSA-B214
- .2 In line circulators: Install as indicated by flow arrows.
 - .1 Support at inlet and outlet flanges or unions.
 - .2 Install with bearing lubrication points accessible.
- .3 Base mounted type: Supply templates for anchor bolt placement.
 - .1 Include anchor bolts with sleeves. Place level, shim unit and grout.
 - .2 Align coupling in accordance with manufacturer's recommended tolerance.
 - .3 Check oil level and lubricate. After run-in, tighten glands.
- .4 Ensure that pump body does not support piping or equipment.
 - .1 Provide stanchions or hangers for this purpose.
 - .2 Refer to manufacturer's installation instructions for details.
- .5 Pipe drain tapping to floor drain.
- .6 Install volute venting pet cock in accessible location.
- .7 Check rotation prior to start-up.
- .8 Install pressure gauge test cocks.

3.03 EQUIPMENT INSTALLATION

- .1 Pumps: Install pumps as shown on detail drawings. Mount all vertical in line pumps over 3.73 KW (5 HP) at floor level as shown on the detail drawings. Provide a minimum of 1.83 m (6' 0") of pipe on pump suction one size larger than pump inlet complete with strainer and valve.
- .2 Provide 12mm (½") drain lines with ball valves from Cuno filters to nearest floor drain.

3.04 START-UP

- .1 General:
 - .1 In accordance with Division 01 and Sections 20 05 05 and 20 05 10 - General Commissioning (Cx) Requirements; supplemented as specified herein.
 - .2 In accordance with manufacturer's recommendations.
- .2 Procedures:
 - .1 Before starting pump, check that cooling water system over-temperature and other protective devices are installed and operative.
 - .2 After starting pump, check for proper, safe operation.
 - .3 Check installation, operation of mechanical seals, packing gland type seals. Adjust as necessary.
 - .4 Check base for free-floating, no obstructions under base.
 - .5 Run-in pumps for 12 continuous hours minimum.
 - .6 Verify operation of over-temperature and other protective devices under low- and no-flow condition.
 - .7 Eliminate air from scroll casing.
 - .8 Adjust water flow rate through water-cooled bearings.
 - .9 Adjust flow rate from pump shaft stuffing boxes to manufacturer's recommendation.
 - .10 Adjust alignment of piping and conduit to ensure true flexibility.
 - .11 Eliminate cavitation, flashing and air entrainment.

- .12 Adjust pump shaft seals, stuffing boxes, glands.
- .13 Measure pressure drop across strainer when clean and with flow rates as finally set.
- .14 Replace seals if pump used to degrease system or if pump used for temporary heat.
- .15 Verify lubricating oil levels.

3.05 PERFORMANCE VERIFICATION (PV)

- .1 General:
 - .1 Verify performance in accordance with Division and Sections 20 05 05 and 20 05 10 - General Commissioning (Cx) Requirements, supplemented as specified herein.
- .2 Verify that manufacturer's performance curves are accurate.
- .3 Ensure valves on pump suction and discharge provide tight shut-off.
- .4 Net Positive Suction Head (NPSH):
 - .1 Application: Measure NPSH for pumps which operate on open systems and with water at elevated temperatures.
 - .2 Measure using procedures prescribed in Division 01 and Sections 20 05 05 and 20 05 10 - General Commissioning (Cx) Requirements Where procedures do not exist, discontinue PV, report to the Consultant and await instructions.
- .5 Multiple Pump Installations - Series and Parallel:
 - .1 Repeat PV procedures specified above for pump performance and pump BHP for combinations of pump operations.
- .6 Mark points of design and actual performance at design conditions as finally set upon completion of TAB.
- .7 Commissioning Reports: In accordance with Division 01 and Sections 20 05 05 and 20 05 10 - General Commissioning (Cx) Requirements. Reports to include:
 - .1 Record of point(s) of actual performance at maximum and minimum conditions and for single and parallel operation as finally set at completion of commissioning on pump curves.
 - .2 Use Report Forms specified in Division 01, to suit General Commissioning (Cx) Requirements: Report Forms and Schematics.
 - .3 Pump performance curves (family of curves).

3.06 OPERATION REQUIREMENTS

- .1 Filters shall be changed, by the installing contractor, after system is flushed and on a regular basis until turned over to the owner.
- .2 Operational requirements in accordance with Division 01, to suit Sustainable Requirements and include:
 - .1 Repair and maintenance materials and instructions.

3.07 CLEANING

- .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

END OF SECTION 23 21 23

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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Section 20 05 05 Mechanical Work General Instructions and Section 20 05 10 Basic Mechanical Materials and Methods.
- .3 Comply with the requirements of Section 23 05 00 Common Work Results for HVAC.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Materials and installation for ductwork including plenums and casings.
- .2 Materials and installation of metallic flexible ductwork.
- .3 Sustainable requirements for construction and verification.

1.03 REFERENCES

- .1 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE).
- .2 Health Canada/Workplace Hazardous Materials Information System (WHMIS).
 - .1 Material Safety Data Sheets (MSDS).
- .3 National Fire Protection Association (NFPA).
 - .1 NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
 - .2 NFPA 90B, Standard for Installation of Warm Air Heating and Air-Conditioning Systems.
 - .3 NFPA 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
- .4 Sheet Metal and Air-Conditioning Contractors' National Association (SMACNA).
 - .1 SMACNA HVAC Duct Construction Standards - Metal and Flexible.
 - .2 SMACNA IAQ Guideline for Occupied Buildings under Construction, 1st Edition.
- .5 Underwriters' Laboratories Inc. (UL).
 - .1 UL 181, Standard for Factory-Made Air Ducts and Air Connectors.
- .6 Underwriters' Laboratories of Canada (ULC).
 - .1 CAN/ULC S110, Fire Tests for Air Ducts.
- .7 American Society for Testing and Materials.
 - .1 ASTM A621 & A621M - 1998 Specification for Forming Steel (FS), sheet and Strip, Carbon, Hot Rolled.
 - .2 ASTM A653M Specification for Steel Sheet, Zinc Coated Galvanized or Zinc Alloy Coated (Galvannealed) by the Hot Dip Process

1.04 QUALITY ASSURANCE

- .1 Materials in accordance with Section 20 05 05 and 20 05 10.
- .2 Manufacture in accordance with SMACNA HVAC Duct Construction Standards.
- .3 Flexible Ducts:
 - .1 Factory fabricated to CAN/ULC S110.
 - .2 Pressure drop coefficients listed below are based on relative sheet metal duct pressure drop coefficient of 1.00.
 - .3 Flame spread rating not to exceed 25. Smoke developed rating not to exceed 50.

- .4 Develop and implement an Indoor Air Quality (IAQ) Management Plan in accordance with Division 01, for construction and preoccupancy phases of building.
- .5 Qualifications: execute work of this section only by skilled tradesmen regularly employed in the construction and installation of air distribution equipment and related ancillaries.
- .6 During construction meet or exceed the requirements of SMACNA IAQ Guideline for Occupied Buildings under Construction.
- .7 Pre-Installation Meetings:
 - .1 Convene pre-installation meeting one week prior to beginning work of this Section and on-site installations in accordance with Division 01, to suit Construction Progress Schedules.
 - .1 Verify project requirements.
 - .2 Review installation and substrate conditions.
 - .3 Co-ordination with other building subtrades.
 - .4 Review manufacturer's installation instructions and warranty requirements.
- .8 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Division 01, to suit Health and Safety Requirements.
- .9 Construction requirements: In accordance with Division 01, to suit Sustainable Requirements.
- .10 Verification: Contractor's verification in accordance with Division 01, to suit Sustainable Requirements.

1.05 SUBMITTALS

- .1 Submit shop drawings/product data sheets indicating flexible connections, thermal properties, friction loss, acoustical loss, leakage, fire rating, smoke development in accordance with Section 20 05 01.
- .2 With shop drawing/product data sheet submission, supply evidence that fire rated duct manufacturer is ULC listed to size requirements shows on drawings.
- .3 Test Reports: Submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.
 - .1 Certification of ratings: Catalogue or published ratings to be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.
- .4 Manufacturer's Field Reports: Manufacturer's field inspection reports specified.
- .5 Submit duct leakage test data prior to ductwork being covered from view.

1.06 DELIVERY, STORAGE AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

1.07 WARRANTY

- .1 Provide warranties as outlined in Section 20 05 05.

PART 2 - PRODUCTS

2.01 DUCTWORK - GENERAL

- .1 Provide rectangular and round ductwork constructed of ASTM A653 hot dip galvanized steel sheets in arrangements as shown on the Drawings complete with reinforcement, hanging methods, joints, seams and fittings as specified in Chapters I through 6 as well as all appendices in the SMACNA HVAC Duct Construction Standards - Metal and Flexible latest version.
 - .1 For exhaust, return and air supply systems where system static pressure does not exceed 0.124 kPa (½" wg), positive or negative, provide reinforced ductwork in metal gages and reinforcement requirements as specified in SMACNA Table 2-1M (2-1).
 - .2 For exhaust, return and air supply systems where system static pressure does not exceed 0.248 kPa (1" wg), positive or negative, provide reinforced ductwork in metal gages and reinforcement requirements as specified in SMACNA Table 2-2M (2-2).
 - .3 For exhaust, return and air supply systems where system static pressure does not exceed 0.496 kPa (2" wg), positive or negative, provide reinforced ductwork in metal gages and reinforcement requirements as specified in SMACNA Table 2-3M (2-3).
 - .4 For exhaust, return and air supply systems where system static pressure does not exceed 0.744 kPa (3" wg), positive or negative, provide reinforced ductwork in metal gages and reinforcement requirements as specified in SMACNA Table 2-4M (2-4).
 - .5 For exhaust, return and air supply systems where system static pressure does not exceed 1.0 kPa (4" wg), positive or negative, provide reinforced ductwork in metal gages and reinforcement requirements as specified in SMACNA Table 2-5M (2-5).
 - .6 For exhaust, return and air supply systems where system static pressure does not exceed 1.5 kPa (6" wg), positive or negative, provide reinforced ductwork in metal gages and reinforcement requirements as specified in SMACNA Table 2-6M (2-6).
- .2 Factory fabricated rectangular and round sheetmetal ductwork shall be as per SMACNA.
- .3 Button lock longitudinal seam may be used on systems up to 0.125 kPa (½" w.g.) positive or negative static pressure provided seam is sealed or caulked with high velocity duct sealer.
- .4 Spin-on type connections from main trunk to VAV terminals may be used. Provide balancing dampers at all connections to diffusers.
- .5 In place of duct joints previously specified, "Nexus" or "Ductmate" gasketed flanges, installed to manufacturer's instructions, may be used provided gasketing meets approval of ULC and installation is to SMACNA Standards.

2.02 GALVANIZED STEEL DUCTWORK

- .1 Rectangular
 - .1 Lock forming grade hot dip galvanized steel, ASTM A653, shop fabricated, minimum #26 gauge.
- .2 Round
 - .1 Factory machine fabricated, spiral, mechanically locked flat seam, single wall duct, fittings and couplings.
- .3 Flat Oval
 - .1 Factory machine fabricated, single wall, 4-ply spiral lock seam duct, fittings and couplings.
- .4 Galvanized steel sheet is to be hot dipped in accordance with requirements of ASTM A653. Provide G60 galvanizing for bare uncovered duct and with finish paint. Provide G90 galvanizing for other galvanizing.
- .5 Minimum yield strength for steel sheet and reinforcements shall be 30,000 psi (207 kPa).
- .6 Fittings: To SMACNA.

2.03 BURIED DUCTWORK

- .1 Provide spiral round 304 stainless steel ductwork as specified above and as shown and detailed on the Drawings in one gauge heavier than metal gauges as specified in the latest version of SMACNA HVAC Duct Construction Standards for the listed positive/negative pressure.
- .2 Seal and make waterproof all joints by using DT 5300 Hardcast tape and FTA-20 Hardcast sealer.

2.04 METALLIC – FLEXIBLE DUCTWORK

- .1 Spirally wound, semi-rigid, self-supporting corrugated aluminum duct with continuous triple lock seams, ULC S110 listed and labelled as a Class 1 Air Duct, constructed of dead soft aluminum strip, and supplied in 3 m (10') lengths. Equal to Flexmaster model T/L, T/L-VT and T/L-A for bare, insulated and acoustic flexible ducts. Flexible duct to be capable of delivering air without leakage up to positive pressures of 3.0 kPa (12" w.g.) and negative pressure of 0.25 kPa (1" w.g.).
- .2 Bare metallic flexible ductwork is to be in accordance with SMACNA Form "M-UN".
- .3 Insulated metallic flexible ductwork is to be in accordance with SMACNA Form "M-I". Insulated flexible duct is to be factory covered with 40 mm (1-1/2") thick, 12 kg/m³ (0.75 lb/ft³) density fibreglass insulation with a vinyl jacket meeting 25/50 flame spread and smoke developed requirements tested in accordance with CAN/ULC S102.
- .4 Acceptable manufacturers are: Flexmaster, Thermaflex.

2.05 PLENUMS AND CASINGS

- .1 All apparatus sheet metal connections, plenum chambers and casings above 400mm (16") in any dimension, or air handling unit casings: 20 gauge galvanized steel sheet as shown on the Detail Drawings, reinforced with 40mm x 40mm x 5mm (12" x 12" x 3/16") galvanized steel angles. Galvanized fluted 0.76mm (.03") thick roof decking with a 38mm (12") deep and 142mm (5.6") wide ribs spaced at a 203mm (8") oc may also be used.
- .2 Plenums for kitchen exhaust systems to be of same type of material as the system ductwork. Refer to kitchen exhaust duct section for material and installation requirements.
- .3 Internal Insulation of insulated air handling casings is specified in Section 23 33 53.
- .4 Refer to detail drawings regarding air handling unit plenum access doors, drip trays and coil mounting, construction details.
- .5 Special prefabricated enclosures: Provide, in the configurations and dimensions shown on the drawings, built-up system enclosures constructed of prefabricated acoustic panels complete with access doors.
 - .1 Side and top Panels: 100mm (4") nominal thickness consisting of 72 kg/m³ (4.5 lbs/ft³) density insulation packed between 18 ga. galvanized steel outer shell and 22 ga. galvanized perforated steel inner shell, reinforced by 10 ga. galvanized steel channels spot welded or riveted in place. Panel joints: Interlocking tongue and groove design. Trim angles: 16 ga. galvanized steel.
 - .2 Doors: 600mm x 1500mm (24" x 60") located as shown on the drawings constructed in the same manner as the panels except with solid sheets both sides, and complete with two butt hinges, two camlocking latches operable from inside and outside with single air seal gasket. Door action: To swing open against plenum pressure.
 - .3 Acceptable Manufacturers: Kinetics Noise Control, Vibro Acoustics.
 - .4 Submit shop drawings for all field or shop fabricated plenums, casings and enclosures.

2.06 SEALANTS

- .1 Duct Sealants

- .1 Provide water based duct sealant, Unimastic 181 as manufactured by United McGill Corporation, conforming to NFPA 90A, 90B and ASTM E 84 requirements and with UL classification of 0 flame spread and smoke development based on a .0028 mm (0.011 inch) thick application and UL test methods.
- .2 Sealant to comply with ASHRAE 90.1 and SMACNA leakage requirements and be unyielding up to 10 times operating stress and permanently flexible when cured.
- .3 Sealant odour to be mild and non-irritating when wet and be odourless when dry.
- .2 Internal Insulation Sealants
 - .1 Provide Superseal joint and edge sealants on internal duct insulation as manufactured by Shuller.
 - .2 Sealant to be acrylic polymer conforming to ASHRAE 62 as well as ASTM G-21 and G-22 for prevention of fungus and bacterial growth.

2.07 HANGERS AND SUPPORTS:

- .1 Provide hangers for rectangular and round ductwork as specified in the SMACNA HVAC Duct Construction Standards - Metal and Flexible. Support hardware constructed of same material as duct for metal duct, and, unless otherwise specified, type 316 stainless steel for non-metal duct. Where ductwork is externally insulated, ensure hangers are sized to suit and will not damage the insulation.
- .2 Strap hangers shall be of same material as the duct material but shall be to the next sheet metal thickness heavier than the duct.
- .3 Hanger configuration shall be to SMACNA. Maximum size duct supported by strap hanger shall be 19" (500 mm).
- .4 Hangers: Galvanized steel angle with galvanized steel rods shall be in accordance with SMACNA.
- .5 Upper Hanger Attachments:
 - .1 Concrete: after concrete pour:
 - .1 expanded concrete anchors shall be made of steel;
 - .2 powder actuated fasteners shall not be utilized;
 - .3 holes for expanding fasteners shall be drilled either by a carbide bit or by the teeth on the fastener itself. Expansion shield shall be "set" by driving it into the hole and expanding it with a conical plug.
 - .2 Steel Joist: manufactured joist clamp or steel plate washer:
 - .1 clamp or washer shall be mounted to top chord of steel truss only.
 - .2 Acceptable Manufacturer: Joist Clamps: Grinnell: Fig. 61 or 86, Hunt or approved equal.
 - .3 Steel Beams: Manufactured beam clamps:
 - .1 Acceptable Manufacturer (as listed or equal): Grinnell: Fig. 60, Hunt or equal.

PART 3 - EXECUTION

3.01 MANUFACTURER'S INSTRUCTIONS

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

3.02 DUCT INSTALLATION - GENERAL

- .1 Install all ductwork and fittings using crossbreaking, joining, attachment and hanging methods as specified in the SMACNA HVAC Duct Construction Standards - Metal and Flexible.

- .2 Confirm routing of all ductwork at site and site measure ductwork prior to fabrication. Duct dimensions may be revised to suit site routing and building element requirements, if dimension revisions are reviewed with and approved by Consultant. Duct routing and/or dimension revisions to suit conditions at site are not grounds for a claim for an extra cost.
- .3 Refer to structural drawings. Where ductwork is to be run within or through open web steel joists, ductwork shown on mechanical drawings is schematic only and is to be altered as required to suit steel joist configuration, spacing, panel points, and cross-bridging at no additional cost.
- .4 Wherever ductwork is required at locations where sprayed fireproofing is applied to building construction, install ductwork only after fireproofing work is complete and do not compromise fire rating of sprayed fireproofing.
- .5 Ground across flexible connectors with No. 2/0 braided copper strap.
- .6 Install balancing dampers at branch ducts and where indicated on the Drawings.
- .7 Sealing of ductwork and plenums:
 - .1 Apply sealant on all seams and joints on all air supply, return and exhaust ducts and all plenums in accordance with ASHRAE 90.1 and as described in the SMACNA HVAC Duct Construction Standards (latest version). In case of conflicts between the standards or codes, the stringent requirement takes precedence. Apply sealants on all seams and joints on built-up air handling unit casings.
 - .2 Refer to article 6.4.4.2 of ASHRAE 90.1. Ductwork and all plenums are to be constructed to seal class A. Openings for rotating shafts to be sealed with bushings or other devices that seal off air leakage. Pressure sensitive tape is not to be used as the primary sealant unless it has been certified to comply with UL-181A or UL-181B by an independent laboratory and the tape is used in accordance with that certification. All connections, including but not limited to, spin-ins, taps, branch connections, access doors, access panels and duct connection to equipment are to be sealed. Sealing that would void product listings is not required. Spiral lock seams need not be sealed.
 - .3 Refer to SMACNA HVAC Duct Construction Standards Table 1-2 for Pressure Classification For Ductwork.
- .8 Where interior of duct is visible through grilles, registers or diffusers, paint interior of duct with flat black Tremco paint formulated for galvanized surfaces.
- .9 Apply full coverage of adhesive (all internal surfaces) for internal insulation.
- .10 Apply internal insulation edge, joint and pin sealant to manufacturer's instructions. Thoroughly seal all exposed edges, perforations and joints on internal duct lining.
- .11 Ductwork installed outdoors (not externally insulated): Seal all joints with paintable Silicon caulking compound.
- .12 Apply sealants by brush or gun to cleaned metal surfaces. Where bare ductwork is exposed apply neat uniform lines of sealant. Randomly brushed, sloppy looking sealant applications will be rejected and must be repaired or replaced with a neat application of sealant.
- .13 Provide spin on connections with dampers at each boot or plenum supplying integrated ceiling air supply outlets.
- .14 Where flanged duct joints are used, do not locate joints in wall or slab openings, or immediately at wall or slab openings. Do not use flanged joints for exposed uninsulated ducts in finished areas.
- .15 Where watertight horizontal ductwork is required, construct ducts without bottom longitudinal seams. Solder or weld joints of bottom and side sheets. Seal all other joints with duct sealer. Slope horizontal duct to hoods, risers, or drain points. Provide drain points. Provide watertight ductwork for:
 - .1 ductwork outside building or otherwise exposed to the elements;

- .2 dishwasher exhaust;
- .3 shower exhaust ducts from grilles to duct main or riser;
- .4 minimum of 3 m (10') upstream and downstream of duct mounted humidifiers or humidifier manifolds;
- .5 fresh air intakes;
- .6 wherever else shown, noted or indicated on drawings.
- .16 Where dissimilar metal ducts are to be connected, isolate ducts by means of flexible duct connection material.
- .17 During installation of ductwork, protect open ends of ducts to prevent entry of debris and dust.
- .18 Place ductwork as close as possible to partitions where shown on the Drawings in such locations.
- .19 Ventilation ducts for refrigeration exhaust systems of chiller rooms to be extended to 300mm (12") above finished floor.
- .20 All outdoor air intake and exhaust systems are to be equipped with motorized dampers. Unless noted otherwise, backdraft gravity dampers are acceptable with a design capacity of 141 l/s (300 cfm) or less.

3.03 INSTALLATION OF GALVANIZED STEEL DUCTWORK

- .1 Provide required ductwork, rectangular, round and/or flat oval. Where rectangular ductwork is shown, round or flat oval ductwork of equivalent cross-sectional area is acceptable.
- .2 Variable air volume ductwork from supply fans to boxes is as above but rectangular duct take-offs are double side straight taper type with a take-off length equal to 0.5 times the branch duct width but minimum 150 mm (6") length, and double taper side is to have an included angle of minimum 60°.

3.04 INSTALLATION OF BURIED DUCTWORK

- .1 Install buried ductwork [encased in concrete] [embedded in (pea gravel) (sand)] to SMACNA [Fig. 3-11] [Fig. 3-12] as detailed and in locations as shown on the Drawings.
- .2 Install buried ductwork 300 mm (12") minimum above normal water table.

3.05 FLEXIBLE DUCTWORK INSTALLATION

- .1 Install in accordance with: CAN/ULC-S110, UL-181, NFPA 90A, NFPA 90B and SMACNA.
- .2 Install all ductwork and fittings using crossbreaking, joining, attachment and hanging methods as specified in the SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- .3 Provide hangers for rectangular and round ductwork as specified in SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- .4 Maximum installed length: One continuous length at 1600 mm (5' 0").
- .5 Do not install flexible ductwork through walls, even if shown on drawings.
- .6 Do not penetrate fire barriers with flexible duct.
- .7 Use standard sheetmetal elbows at drop points to outlets.
- .8 Do not bend flexible ductwork any greater than 1.5 X diameter.

3.06 INSTALLATION OF CASINGS AND PLENUMS

- .1 Provide required shop or site fabricated casings and plenums. Unless otherwise specified or shown, construct casings and plenums of same material as connecting duct system.

- .2 Construct and install casings and plenums in accordance with Chapter 9 of ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible to suit systems' pressure classification. Ensure plenums and casings secured to building structure are gasketed air-tight and equipped with angle reinforcing.
- .3 Provide drain pans with accessible trapped drains for fresh air intake plenums, and wherever else shown.
- .4 Provide access doors into all site or shop fabricated casings and plenums requiring access, and wherever shown. Construct access doors to open in or out to suit positive and negative pressures of system. Provide pitot tube openings in access doors where required for system air quantity balancing purposes. Provide suitably sized, engraved, red-white laminated Lamacoid warning nameplates on access doors into casings and plenums where equipment is located, i.e. fans.

3.07 LEAKAGE TESTING

- .1 Ductwork leakage is not to exceed following:
 - .1 ductwork to 2" W.C. Class, 1% of total air quantity handled by respective fans;
 - .2 ductwork exceeding 2" W.C. Class, 2% of total air quantity handled by respective fans.
- .2 Leakage testing is to be performed by the Testing, Adjusting and Balancing (TAB) agency in accordance with SMACNA HVAC Air Duct Leakage Test Manual and is to be witnessed by Consultant.
- .3 Be responsible for following:
 - .1 preparing duct systems for leakage testing prior to installation of external insulation including capping duct runouts and provision of final tap-in for test equipment;
 - .2 schedule testing with TAB agency in advance, be present for all testing and ensure notice is given to Consultant so they may witness testing;
 - .3 resealing and/or replacement of defective ductwork;
 - .4 bearing all costs associated with retesting ductwork which has failed to pass leakage testing.

3.08 FIELD QUALITY CONTROL

- .1 Manufacturer's Field Services:
 - .1 Have manufacturer of products, supplied under this Section, review Work involved in the handling, installation/application, protection and cleaning, of its products and submit written reports, in acceptable format, to verify compliance of Work with Contract.
 - .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
 - .3 Schedule site visits, to review Work, at stages listed:
 - .1 After delivery and storage of products and when preparatory Work, or other Work, on which the Work of this Section depends, is complete but before installation begins.
 - .2 Twice during progress of Work at 25% and 60% complete.
 - .3 Upon completion of the Work, after cleaning is carried out.
 - .4 Obtain reports, within 3 days of review and submit, immediately, to the Consultant
- .2 Verification requirements in accordance with Division 01 and include:
 - .1 Materials and resources.
 - .2 Storage and collection of recyclables.

- .3 Construction waste management.
- .4 Resource re-use.
- .5 Recycled content.
- .6 Local/regional materials.
- .7 Certified Wood.
- .8 Low-emitting materials.

3.09 DUCT SYSTEM PROTECTION, CLEANING AND START-UP

- .1 Temporarily cover all open ends of ducts during construction.
- .2 Remove all dirt and foreign matter from entire duct systems and clean duct system terminals and interior of air handling units prior to operating fans.
- .3 Prior to starting any supply air handling system provide 50 mm (2") thick glass fibre construction filters at fan equipment in place of permanent filters.
- .4 Provide cheesecloth over duct system inlets and outlets and run system for 24 hours, after which remove cheesecloth and construction filters, and install new permanent filters.

3.10 AIR BALANCING

- .1 Air balancing is specified in Section 20 05 10 Basic Materials and Methods.
- .2 Provide personnel, tools and materials to assist and work under the direction of the air balancing firm to perform the following:
 - .1 Removal and replacement of ceiling tiles.
 - .2 Installation of pitot tube test opening enclosures.
 - .3 Installation of dampers and baffles as required for specified air balance and elimination of stratification.
 - .4 Provision of access openings and covers.
 - .5 Provision of ladders and scaffolds.
 - .6 Removal and replacement of belt guards.
 - .7 Removal and replacement and provision of required sheaves and belts as directed, and other items as necessary for complete and acceptable air balancing procedures.
- .3 Perform corrective work as required as a result of the testing, adjusting and balancing work.

3.11 VIBRATION AND OBJECTIONABLE NOISE

- .1 Install ductwork free from pulsation, chatter, vibration or objectionable noises. Should any of these defects appear after the system is in operation, correct same by either removing and replacing or reinforcing the work as directed by the Consultant.

3.12 FLASHING

- .1 Provide flashings to suit installation.
- .2 Follow detail Drawings for vents and pipes penetrating roofs.

3.13 CLEANING

- .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

END OF SECTION 23 31 13

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PART 2 - PRODUCTS

- 2.01 FLEXIBLE CONNECTIONS
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PART 3 - EXECUTION

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- 3.02 INSTALLATION
- 3.03 CLEANING

PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Mechanical Work General Instructions Section 20 05 05 and Basic Mechanical Materials and Methods Section 20 05 10.
- .3 Comply with the requirements of Section 23 05 00 Common Work Results for HVAC.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Section includes:
 - .1 Materials and installation for duct accessories including flexible connections, access doors, vanes and collars, balancing dampers, fire and smoke dampers.
 - .2 Sustainable requirements for construction and verification.
- .2 Related Sections:
 - .1 Division 01
 - .2 Division 02

1.03 REFERENCES

- .1 Health Canada/Workplace Hazardous Materials Information System (WHMIS).
 - .1 Material Safety Data Sheets (MSDS).
- .2 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).
 - .1 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

1.04 QUALITY ASSURANCE

- .1 Materials in accordance with Section 20 05 05 and 20 05 10.
- .2 Manufacture in accordance with SMACNA HVAC Duct Construction Standards.
- .3 Develop and implement an Indoor Air Quality (IAQ) Management Plan in accordance with Division 01, for construction and preoccupancy phases of building.
- .4 During construction meet or exceed the requirements of SMACNA IAQ Guideline for Occupied Buildings under Construction.
- .5 Pre-Installation Meetings:
 - .1 Convene pre-installation meeting one week prior to beginning work of this Section and on-site installations in accordance with Division 01, to suit Construction Progress Schedules.
 - .1 Verify project requirements.
 - .2 Review installation and substrate conditions.
 - .3 Co-ordination with other building subtrades.
 - .4 Review manufacturer's installation instructions and warranty requirements.
- .6 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Division 01, to suit Health and Safety Requirements.
- .7 Construction requirements: In accordance with Division 01, to suit Sustainable Requirements.
- .8 Verification: Contractor's verification in accordance with Division 01, to suit Sustainable Requirements.

1.05 SUBMITTALS

- .1 Submit manufacturer's printed product literature, specifications and data sheet. Indicate flexible connections, duct access doors, turning vanes, instrument test ports in accordance with Section 20 05 01.
- .2 Test Reports: Submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.
 - .1 Certification of ratings: Catalogue or published ratings to be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.
- .3 Manufacturer's Field Reports: Manufacturer's field reports specified.

1.06 DELIVERY, STORAGE AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

1.07 WARRANTY

- .1 Provide warranties as outlined in Section 20 05 05.

PART 2 - PRODUCTS

2.01 FLEXIBLE CONNECTIONS

- .1 Frame: Galvanized sheet metal frame with fabric clenched by means of double locked seams.
- .2 Material:
 - .1 Fire-resistant, self-extinguishing, neoprene coated glass fabric, temperature rated at minus 40 degrees C (104 degrees F) to plus 90 degrees C (194 degrees F), density of 1.3 kg/m²(0.267lb/ft²)
- .3 As manufactured by: Duro Dyne

2.02 ACCESS DOORS IN DUCTS

- .1 Ductwork: Provide latched access doors where required. constructed with flat iron or angle iron stiffening frame so that the door can be operated without twisting or distortion.
- .2 Insulated Ducts: Sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm thick complete with sheet metal angle frame and 25 mm (1") thick rigid glass fibre insulation.
- .3 Non-Insulated Ducts: Sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm thick complete with sheet metal angle frame.
- .4 Doors for kitchen exhaust duct shall be ULC listed and shall have a gasket or sealant that is rated for 815.6 degrees C (1,500 degrees F) and shall be grease tight.
- .5 All doors shall be complete with gaskets to provide a tight seal.
- .6 Hardware:
 - .1 Up to 300 x 300 mm (12" x 12"): Two sash locks complete with safety chain.
 - .2 301 to 450 mm (12" to 18"): Four sash locks complete with safety chain.
 - .3 451 to 1000 mm (18" to 39"): Piano hinge and minimum two sash locks.
 - .4 Doors over 1000 mm (39"): Piano hinge and two handles operable from both sides.
 - .5 Hold open devices.
- .7 Acceptable manufacturers: Nailor

2.03 TURNING VANES

- .1 Constructed of the same materials as the adjacent duct, adequately reinforced to suit pressure and velocity of system inline with SMACNA standards.

2.04 INSTRUMENT TEST

- .1 1.6 mm thick steel zinc plated after manufacture.
- .2 Cam lock handles with neoprene expansion plug and handle chain.
- .3 28 mm minimum inside diameter. Length to suit insulation thickness.
- .4 Neoprene mounting gasket.
- .5 Acceptable Manufacturers: Duro Dyne.

2.05 SPIN-IN COLLARS

- .1 Conical galvanized sheet metal spin-in collars with lockable butterfly damper.
- .2 Sheet metal thickness to co-responding round duct standards.

PART 3 - EXECUTION

3.01 MANUFACTURER'S INSTRUCTIONS

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

3.02 INSTALLATION

- .1 Flexible Connections:
 - .1 Install in following locations:
 - .1 Inlets and outlets to supply air units and fans.
 - .2 Inlets and outlets of exhaust and return air fans.
 - .3 As indicated.
 - .2 Install in accordance with recommendations of SMACNA.
 - .3 When fan is running:
 - .1 Ducting on sides of flexible connection to be in alignment.
 - .2 Ensure slack material in flexible connection.
- .2 Access Doors:
 - .1 Size:
 - .1 To suit servicing and accessibility requirements.
 - .2 Locations:
 - .1 Fire and smoke dampers.
 - .2 Control dampers.
 - .3 Devices requiring maintenance.
 - .4 Required by code.
 - .5 Reheat coils.
 - .6 Elsewhere as indicated.
- .3 Instrument Test Ports:
 - .1 General:

- .1 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's instructions.
- .2 Locate to permit easy manipulation of instruments.
- .3 Install insulation port extensions as required.
- .4 Locations:
 - .1 For traverse readings:
 - .1 Ducted inlets to roof and wall exhausters.
 - .2 Inlets and outlets of other fan systems.
 - .3 Main and sub-main ducts.
 - .4 And as indicated.
 - .2 For temperature readings:
 - .1 At outside air intakes.
 - .2 In mixed air applications in locations as approved by the Consultant.
 - .3 At inlet and outlet of coils.
 - .4 Downstream of junctions of two converging air streams of different temperatures.
 - .5 And as indicated.
- .4 Turning vanes:
 - .1 Install in accordance with recommendations of SMACNA and as indicated.

3.03 CLEANING

- .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

END OF SECTION 23 33 00

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- 3.02 INSTALLATION
- 3.03 FIELD QUALITY CONTROL
- 3.04 CLEANING

PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Mechanical Work General Instructions Section 20 05 05 and Basic Mechanical Materials and Methods Section 20 05 10.
- .3 Comply with the requirements of Section 23 05 00 Common Work Results for HVAC.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Section Includes:
 - .1 Fire and smoke dampers and fire stop flaps.
 - .2 Operating dampers and Balancing dampers for mechanical forced air ventilation and air conditioning systems.
 - .3 Sustainable requirements for construction and verification.
- .2 Related Sections:
 - .1 23 31 13 – Ductwork
 - .2 23 33 00 – Air Duct Accessories

1.03 QUALITY ASSURANCE

- .1 Materials in accordance with Section 20 05 05 and 20 05 10.
- .2 Health and Safety Requirements:
 - .1 Do construction occupational health and safety in accordance with Division 01 and to suit Health and Safety Requirements.
- .3 Certificates:
 - .1 Catalogue or published ratings those obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency.

1.04 REFERENCES

- .1 Sheet Metal and Air Conditioning National Association (SMACNA)
 - .1 SMACNA HVAC Duct Construction Standards, Metal and Flexible.
- .2 American Society for Testing and Materials International (ASTM)
 - .1 ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by Hot-Dip Process.
- .3 American National Standards Institute/National Fire Protection Association (ANSI/NFPA)
 - .1 ANSI/NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
- .4 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).
- .5 Underwriters Laboratories of Canada (ULC)
 - .1 CAN4-S112, Fire Test of Fire Damper Assemblies.
 - .2 CAN4-S112.2, Standard Method of Fire Test of Ceiling Firestop Flap Assemblies.
 - .3 ULC-S505, Fusible Links for Fire Protection Service.

1.05 SUBMITTALS

- .1 Submit manufacturer's printed product literature, specifications and datasheet. Indicate performance data, fire dampers, smoke dampers, fire stop flaps, operators, fusible links, design details of break-away joints in accordance with Section 20 05 01.
- .2 Test Reports: Submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.
- .3 Certificates: Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .4 Closeout Submittals
 - .1 Refer to Section 20 05 05.
- .5 Spares:
 - .1 Provide maintenance materials in accordance with Division 01 and Section 25 05 01.
 - .2 Provide following:
 - .1 6 fusible links of each type.
- 1.06 DELIVERY, STORAGE, AND HANDLING
 - .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.
- 1.07 WARRANTY
 - .1 Provide warranties as outlined in Section 20 05 05.
- PART 2 - PRODUCTS
- 2.01 SUSTAINABLE REQUIREMENTS
 - .1 Materials and products in accordance with Division 01 and to suit Sustainable Requirements: Construction.
- 2.02 GENERAL
 - .1 Manufacture to SMACNA standards.
- 2.03 MULTI-LEAF DAMPERS
 - .1 Opposed or parallel blade type.
 - .2 Opposed blade dampers shall be used in applications requiring modulation.
 - .3 Parallel blade dampers shall be used in applications requiring open/close (two-position) control.
 - .4 Interlocking blades, complete with extruded vinyl seals, spring stainless steel side seals, materials to match adjacent ductwork.
 - .5 Pressure fit self-lubricated bronze bearings.
 - .6 Linkage: Plated steel tie rods, brass pivots and plated steel brackets, complete with plated steel control rod.
 - .7 Locking quadrant with shaft extension to accommodate insulation thickness.
 - .8 Performance:
 - .1 Leakage: In closed position less than 2% of rated air flow.
 - .2 Pressure drop: At full open position less than 25Pa differential across damper.
 - .9 When exposed to unconditioned air or when part of an insulated ductwork system the frame and blades shall be insulated:
 - .1 Frames: Insulated with extruded polystyrene foam with RSI 0.88.

- .2 Blades: Insulated with polyurethane or polystyrene foam, RSI 0.88.
- 2.04 SINGLE BLADE TYPE DAMPERS (ROUND OR SQUARE/RECTANGULAR)
 - .1 Frame: brake formed, welded, materials to match adjacent ductwork. When exposed to unconditioned air or when part of an insulated ductwork system the frame shall be insulated.
 - .2 Blade: , materials to match adjacent ductwork to . When exposed to unconditioned air or when part of an insulated ductwork system the disc shall be insulated.
 - .3 Gasket: Extruded neoprene, field replaceable, with 10-year warranty.
 - .4 Bearings: Roller self-lubricated and sealed.
 - .5 Operator: Compatible with damper, linear stroke operator, actuator, zinc-aluminum foundry alloy casting cam follower.
 - .6 Locking quadrant with shaft extension to accommodate insulation thickness.
 - .7 Performance:
 - .1 Leakage: In closed position less than 0.001 % of rated air flow
 - .2 Pressure drop: At full open position less than 25Pa differential across damper.
- 2.05 BACK DRAFT DAMPERS
 - .1 Automatic gravity operated, multileaf, steel construction with nylon bearings, centre pivoted spring assisted.
- 2.06 RELIEF DAMPERS
 - .1 Multi-leaf dampers with ball bearing centre pivoted and counter-weights set to open as indicated.
- 2.07 SPLITTER DAMPERS
 - .1 Provide splitter dampers as described in the detail drawings.
 - .2 Fabricate from same material as duct but one sheet metal thickness heavier, with appropriate stiffening.
 - .3 Control rod with locking device and position indicator.
 - .4 Rod configuration to prevent end from entering duct.
 - .5 Pivot: Piano hinge.
 - .6 Folded leading edge.
- 2.08 QUADRANT DAMPERS
 - .1 Construct quadrant dampers of not less than 22 gauge material. Where installed in ducts up to 300mm (12") deep, provide single blade, and in ducts greater than 300mm (12") provide multi-blade with linkages, each blade being not wider than 228mm (9").
- 2.09 MOTORIZED DAMPERS
 - .1 Standard Dampers for Return Air: TAMCO series 1000 supplied by the automatic control manufacturer. Provide parallel blade type for mixing applications. All bearings to be "oilite" bronze. Size all dampers as NET dimensions (damper blade area = duct cross sectional area) as shown on drawings.
 - .2 Low Leakage Dampers for Outdoor Intake and Exhaust Applications: Provide, in sizes and in locations as shown on the drawings, parallel blade (air flow directed upwards) extruded aluminium Tamco air foil dampers series 9000 as manufactured by T.A. Morrison with features as follows:
 - .1 1% leakage at 1 kPa (4") static pressure differential.
 - .2 12 ga. extruded aluminium air foil single unit internally reinforced blades with continuous extruded overlapping vinyl seals.

- .3 12 ga. extruded frame with extruded vinyl seals on all sides.
- .4 Out-of-airstream aluminium alloy linkages and crank arms with celcon bearings.
- .5 Celcon and polycarbonate bearings with no metal to metal contact.
- .3 Sized for "flanged" installation (damper blade area to be equal to duct cross sectional area).
- .4 Actuators are specified in Section 25 01 01 and are to be provided by Division 25 contractor. Coordinate actuator requirements with Division 25 contractor.

2.10 FIRE DAMPERS AND CEILING DAMPERS

- .1 Provide ULC labelled and listed units as manufactured by Controlled Air Manufacturing Ltd. type "B" or "C" spring type (dynamic) dampers.
- .2 Provide Fire Dampers in sizes and in arrangements to suit openings shown on the drawings to ULC requirements as they relate to maximum sizes permissible in the applicable fire separation construction. Where installed in metal studs walls, comply with ULC requirements and advise other affected Trades i.e. stud and drywall installers.
- .3 Do not use asbestos in any form in the construction of fire dampers or ceiling dampers.
- .4 On ceiling dampers, in place of using ceiling tile material for diffuser protection as detailed, the CK2000 thermal blanket along with required transitions may be used.
- .5 Other acceptable manufacturers: Ruskin, Kerr-Hunt, Nailor Industries, Air Balance of Canada Ltd.
- .6 Fire dampers (wall type): Arrangement Type B or C, listed and bear label of ULC, meet requirements of the Authority Having Jurisdiction and ANSI/NFPA 90A. Fire damper assemblies fire tested in accordance with CAN4-S112.
 - .1 For high velocity applications 7.62m/s (1500fpm) or when transitioning between round and square/rectangular provide Type C fire dampers.
- .7 Fire dampers (ceiling type): Warnock HerseyType [CFD4W] [CFD4] [CFD®2W and CFD®3W], meet requirements of the Authority Having Jurisdiction and ANSI/NFPA 90A. Fire damper assemblies fire tested in accordance with CAN4-S112.
- .8 Mild steel, factory fabricated for fire-rating requirement to maintain integrity of fire wall and/or fire separation.
 - .1 Fire dampers: Rating to suit fire separation rating.
 - .2 Fire dampers: Automatic operating type and have dynamic rating suitable for maximum air velocity and pressure differential to which it will be subjected.
- .9 Fusible link actuated, having negator-spring-closing operator for multi-leaf type or roll door type in either horizontal or vertical position.
- .10 Retaining angle iron frame to suit the installation, on full perimeter of fire damper, on both sides of fire separation being pierced.
- .11 Equip fire dampers with steel sleeve or frame installed disruption ductwork or impair damper operation.
- .12 Equip sleeves or frames with perimeter mounting angles attached on both sides of wall or floor opening. Construct ductwork in fire-rated floor-ceiling or roof-ceiling assembly systems with air ducts that pierce ceiling to conform with ULC.
- .13 Design and construct dampers to not reduce duct or air transfer opening cross-sectional area.
- .14 Dampers shall be installed so that the centerline of the damper depth or thickness is located in the centerline of the wall, partition of floor slab depth or thickness.
- .15 Unless otherwise indicated, the installation details given in SMACNA Install Fire Damp HVAC and in manufacturer's instructions for fire dampers shall be followed.

2.11 SMOKE DAMPERS

- .1 Smoke Dampers: To be ULC or UL listed and labelled.
- .2 Smoke dampers meeting or exceeding the following specifications shall be furnished and installed at locations shown on plans or as described in schedules. AMCA Certified smoke dampers shall meet the requirements of NFPA80, 90A, 92A, 92B, 101 and 105 and shall be classified as Smoke Dampers in accordance with the latest version of UL555S. The leakage rating under UL555S shall be Leakage Class 3. Smoke dampers shall be produced in an ISO 9001 certified factory and warrantied to be free from defects in material and workmanship for a period of 5 years after date of shipment.
- .3 Square Damper frame shall be minimum 16 (1.6) gauge galvanized steel formed into a structural hat channel. Top and bottom frame members on dampers less than 13" (330) high shall be low profile design to maximize the free area of these smaller dampers. Damper blades shall be single skin galvanized steel 16 (1.6) gauge minimum with three longitudinal grooves for reinforcement. Bearings shall be stainless steel, permanently lubricated sleeve type turning in an extruded hole in the frame for maximum life. Jamb seals shall be stainless steel compression type.
- .4 Round Damper frame shall be a minimum of 20 (.9) gage galvanized steel and blade shall be two piece 14 (19) gage equivalent thickness galvanized. Bearings shall be stainless steel, permanently lubricated sleeve type pressed in the frame. Damper seals shall be silicone rubber mechanically fastened between damper blades.
- .5 Smoke dampers and their actuators shall be qualified in accordance with UL555S to an elevated temperature of 250°F (121°C) or 350°F (177°C). Appropriate electric shall be installed by the damper manufacturer at time of damper fabrication. Electric actuators, factory installed on dampers, shall have been tested for prolonged periods of holding (minimum 1 year with no evidence of reduced spring return performance). Each damper shall be rated for leakage and airflow in either direction through the damper. In addition to the leakage ratings already specified, the dampers shall be AMCA licensed for Air Performance.
- .6 Normally closed reverse action smoke vent (S/D RASV): Folding blade type, opening by gravity upon detection of smoke, [and/or] [from remote alarm signalling device actuated by an electro thermal link] [as indicated]. Two flexible stainless steel blade edge seals to provide required constant sealing pressure.
- .7 Normally open smoke/seal (S/D SSSD): Folding blade type, closing when actuated by means of electro thermal link [and/or] [from remote alarm signaling device]. Blade edge seals of flexible stainless steel to provide required constant sealing pressure. Provide stainless steel negator springs with locking devices to ensure positive closure for units mounted horizontally in vertical ducts.
- .8 Motorized (S/D M): Folding blade type, normally open with power on. When power is interrupted damper shall close automatically. Both damper and damper operator shall be ULC listed and labelled.
- .9 Electro thermal link (S/D ETL): Dual responsive fusible link which melts when subjected to local heat of 74 degrees C and from external electrical impulse of low power and short duration; ULC or UL listed and labelled.
- .10 Actuator: controlled from smoke sensor or smoke detection system. Coordinate final termination with Division 26.
- .11 Dampers to be as manufactured by Ruskin model SD35 or SDRS25
- .12 Other Acceptable manufacturers: Kerr Hunt, Nailor Industries, EH Price.

2.12 COMBINATION FIRE AND SMOKE DAMPERS

- .1 Provide as shown on drawings and as required by the Authority Having Jurisdiction, combination fire/smoke dampers meeting the requirements of NFPA90A, 92A, and 92B. Dampers shall have a fire rating in accordance with the latest edition of UL555 and shall be classified as Leakage Class I Smoke Dampers in accordance with the latest version of UL555S.
- .2 Dampers to be complete with factory installed, tested, certified, listed and labelled 120v actuator (fail position: close), Ruskin electronic fusible link and switch package EFL/SP100 fully wired and connected to the required devices as one complete system and ready to be connected to the 120v electrical power.
- .3 Square Damper frame shall be minimum 16 (1.6) gauge galvanized steel formed into a structural hat channel. Top and bottom frame members on dampers less than 13" (330) high shall be low profile design to maximize the free area of these smaller dampers. Damper blades shall be single skin galvanized steel 16 (1.6) gauge minimum with three longitudinal grooves for reinforcement. Bearings shall be stainless steel, permanently lubricated sleeve type turning in an extruded hole in the frame for maximum life. Jamb seals shall be stainless steel compression type.
- .4 Round Damper frame shall be a minimum of 20 (.9) gage galvanized steel and blade shall be two piece 14 (19) gage equivalent thickness galvanized. Bearings shall be stainless steel, permanently lubricated sleeve type pressed in the frame. Damper seals shall be silicone rubber mechanically fastened between damper blades.
- .5 Smoke dampers and their actuators shall be qualified in accordance with UL555S to an elevated temperature of 250°F (121°C) or 350°F (177°C). Appropriate electric shall be installed by the damper manufacturer at time of damper fabrication. Electric actuators, factory installed on dampers, shall have been tested for prolonged periods of holding (minimum 1 year with no evidence of reduced spring return performance). Each damper shall be rated for leakage and airflow in either direction through the damper. In addition to the leakage ratings already specified, the dampers shall be AMCA licensed for Air Performance.
- .6 Combined actuator: controlled from smoke sensor or smoke detection system and from fusible link.
 - .1 Inline duct application:
 - .1 Dampers to be as manufactured by Ruskin model FSD60-1.5 (1.5HR, leakage Class 1) and FSD60-3 (3 HR, leakage Class 1) to meet or exceed the wall and or floor fire-rating requirement that is shown on the architectural life safety drawings.
 - .2 Damper to be complete with built in smoke detector.
 - .3 Damper to close upon receiving a signal form the built-in smoke detector or upon sensing rise in temperature above the code required settings.
 - .4 Coordinate final termination with Division 26.
 - .2 Off the wall application:
 - .1 Dampers to be as manufactured by Ruskin model FSD60FA. 1.5 (1.5HR, leakage Class 1) and FSD60FA-3 (3 HR, leakage Class 1) to meet or exceed the wall and or floor fire-rating requirement that is shown on the architectural life safety drawings.
 - .2 Damper to close upon receiving a signal form the smoke detector provided by electrical contractor complete with 24v to 120v relay or upon sensing rise in temperature above the code required settings.
 - .3 Coordinate final termination with Division 26.
 - .3 Off the wall application (high air volume only):

- .1 Dampers to be as manufactured by Ruskin model FSD60GA. 1.5 (1.5HR, leakage Class 1) and FSD60GA-3 (3 HR, leakage Class 1) to meet or exceed the wall and or floor fire-rating requirement that is shown on the architectural life safety drawings.
- .2 Damper to close upon receiving a signal from the smoke detector provided by electrical contractor complete with 24v to 120v relay or upon sensing rise in temperature above the code required settings.
- .3 Coordinate final termination with Division 26.
- .7 Other Acceptable manufacturers: Kerr-Hunt, Nailor Industries, EH Price.

2.13 FIRE STOP FLAPS

- .1 Fire smoke flaps: ULC listed and labelled and fire tested in accordance with CAN4-S112.2.
- .2 Construct of minimum 1.5 mm thick sheet steel with 1.6 mm thick non-asbestos ULC listed insulation and corrosion-resistant pins and hinges.
- .3 Flaps held open with fusible link conforming to ULC-S505 and close at 74 degrees C.

PART 3 - EXECUTION

3.01 MANUFACTURER'S INSTRUCTIONS

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

3.02 INSTALLATION

- .1 Install where indicated.
- .2 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's instructions.
- .3 Locate balancing dampers in each branch duct, for supply, return and exhaust systems.
- .4 Run-outs to registers and diffusers: Install single blade damper located as close as possible to main ducts.
- .5 Seal multiple damper modules with silicon sealant.
- .6 Install access door adjacent to each damper. See Section 23 33 00 - Air Duct Accessories.
- .7 Dampers: Vibration free.
- .8 Ensure damper operators are observable and accessible.
- .9 Corrections and adjustments conducted by Engineer.
- .10 Fire Dampers, Smoke Dampers, Ceiling Dampers and Fire Stop Flaps
 - .1 Fire Dampers and Ceiling Dampers
 - .1 Install to ULC requirements. Locate in fire walls, ceilings and partitions where indicated. Coordinate with and provide ULC installation details to drywall installer.
 - .2 Seal around fire damper assembly.
 - .3 After completion, have installation approved prior to concealment.
 - .2 Install in accordance with ANSI/NFPA 90A and in accordance with conditions of ULC listing.
 - .3 Maintain integrity of fire separation.
 - .4 After completion and prior to concealment obtain approvals of complete installation from authority having jurisdiction.
 - .5 Co-ordinate with installer of firestopping.

- .6 Ensure access doors/panels, fusible links damper operators are easily observed and accessible.
- .7 Install break away joints of approved design on each side of fire separation.

3.03 FIELD QUALITY CONTROL

- .1 Tests:
 - .1 Tests to demonstrate that system is functioning as specified.
- .2 Verification requirements in accordance with Division 01 and include:
 - .1 Materials and resources.
 - .2 Storage and collection of recyclables.
 - .3 Construction waste management.
 - .4 Resource re-use.
 - .5 Recycled content.
 - .6 Local/regional materials.
 - .7 Low-emitting materials.

3.04 CLEANING

- .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

END OF SECTION 23 33 10

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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Mechanical Work General Instructions Section 20 05 05 and Basic Mechanical Materials and Methods Section 20 05 10.
- .3 Comply with the requirements of Section 23 05 00 Common Work Results for HVAC.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Section Includes:
 - .1 Materials and installation for acoustic duct lining.

1.03 REFERENCES

- .1 American Society for Testing and Materials International, (ASTM).
 - .1 ASTM C423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
 - .2 ASTM C916, Standard Specification for Adhesives for Duct Thermal Insulation.
 - .3 ASTM C1071, Standard specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
 - .4 ASTM C1338, Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.
 - .5 ASTM G21, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
- .2 Department of Justice Canada (Jus).
 - .1 Canadian Environmental Protection Act (CEPA), 1999, c. 33.
- .3 Health Canada/Workplace Hazardous Materials Information System (WHMIS).
 - .1 Material Safety Data Sheets (MSDS).
- .4 National Fire Protection Association (NFPA).
 - .1 NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
 - .2 NFPA 90B, Standard for the Installation of Warm Air Heating and Air Conditioning Systems.
- .5 North American Insulation Manufacturers Association (NAIMA).
 - .1 NAIMA AH116, Fibrous Glass Duct Construction Standards.
- .6 Sheet Metal and Air Conditioning Contractor's National Association (SMACNA).
 - .1 SMACNA, HVAC DCS, HVAC, Duct Construction Standards, Metal and Flexible.
 - .2 SMACNA IAQ Guideline for Occupied Buildings.
- .7 Transport Canada (TC).
 - .1 Transportation of Dangerous Goods Act (TDGA), 1992, c. 34.
- .8 Underwriter's Laboratories of Canada (ULC).
 - .1 CAN/ULC S102, Methods of Test for Surface Burning Characteristics of Building Materials and Assemblies.

1.04 QUALITY ASSURANCE

- .1 Materials in accordance with Section 20 05 05 and 20 05 10.

- .2 Develop and implement an Indoor Air Quality (IAQ) Management Plan in accordance with Division 01, for construction and preoccupancy phases of building.
- .3 Do construction occupational health and safety in accordance with Division 01.
- .4 During construction meet or exceed the requirements of SMACNA IAQ Guideline for Occupied Buildings under Construction.
- .5 Construction requirements detailed in Division 01 form integral part of this project including materials and products of this Section. Sustainable construction requirements include:
 - .1 Specific construction requirements for project.
 - .2 Specification text to ensure that project will comply with [PWGSC] [] green design process and sustainability requirements.
 - .3 Administrative, temporary and procedural requirements for the use of materials and methods of construction.

1.05 SUBMITTALS

- .1 Submit manufacturer's printed product literature, specifications and data sheets in accordance with Section 20 05 01.

1.06 DELIVERY, STORAGE AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

1.07 WARRANTY

- .1 Provide warranties as outlined in Section 20 05 05.

PART 2 - PRODUCTS

2.01 DUCT LINER

- .1 Flexible coated glass fibre blanket with noise absorbing properties to ASTM C1071 with NRC not less than .70 for rigid type and not less than 0.65 for flexible type based on Type A mounting to ASTM C423, thermal performance of .70 m² C/W for 25mm (1") thickness, in conformance to ASHRAE 62 and in compliance with CAN/ULC S102 and NFPA 90A and 90B.
- .2 Surface burning characteristics: flame spread not exceed 25 and smoke development not to exceed 50 in accordance with CAN/ULC S102, NFPA 90A and NFPA 90B.
- .3 Maximum velocity: 20.3 m/sec (4000 fpm).
- .4 Non supportive of microbial growth, in accordance with ASTM C1338, when surfaces maintained in clean condition.
- .5 Use fibrous glass rigid board type duct liner for rectangular ducts and flat surfaces. Minimum density is 48 kg/m³.
- .6 Use flexible fibrous glass blanket type duct liner for round or oval ducts and surfaces. Minimum density is 24 kg/m³.
- .7 Duct liner sealants:
 - .1 Superseal joint and edge sealants on internal duct insulation as manufactured by Shuller.
 - .2 Sealant to be acrylic polymer conforming to ASHRAE 62 as well as ASTM G-21 and G-22 for prevention of fungus and bacterial growth.
- .8 Acceptable Manufacturers: Schuller, Knauf, Microtex, Certainteed, Owens-Corning.

2.02 ADHESIVE

- .1 Adhesive: To NFPA 90A, NFPA 90B and ASTM C916.

- .2 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50. Temperature range -29°C to +93°C.

- .3 Water-based fire retardant type.

2.03 FASTENERS

- .1 Weld pins 2.0 mm diameter, length to suit thickness of insulation. Polymer, nylon or metal retaining clips, 32 mm square.

2.04 JOINT TAPE

- .1 Poly vinyl treated open weave fibreglass membrane 50mm wide.

2.05 SEALER

- .1 Meet requirements of NFPA 90A and NFPA 90B.
- .2 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50. Temperature range -68°C to +93°C.

2.06 METAL INNER LINING

- .1 22 gage (0.85mm) galvanized steel with 2.4mm (3/32") diameter holes on 4.8mm (3/16") or 6.4mm (1/4") centers.

PART 3 - EXECUTION

3.01 GENERAL

- .1 Do work in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible except as specified otherwise.
- .2 Line inside of ducts where indicated.
- .3 Duct dimensions, as indicated, are clear inside duct lining. Increase duct dimensions as necessary to compensate for liner thickness.

3.02 LINER INSTALLATION

- .1 Install, with facing on the air stream side, to SMACNA HVAC Duct Construction Standards pages 2-25, 2-26 and 2-27 as well as in accordance with Fig. 2-22, 2-23, 2-24 and 2-25.
- .2 Adhesive: water proof in accordance to ASTM C-916. Coat and seal all insulation edges and joints.
- .3 In air handling unit casings, imbed glassfab tape in the sealant at all insulation joints and edges and pin washers. Provide pins and washers for duct and unit casings per SMACNA Fig. 2-22 and 2-23.
- .4 Provide metal inner lining where indicated on drawings. Install in accordance with manufacturer's instructions and in accordance with SMACNA Duct Construction Standards.

3.03 LINER SCHEDULE

- .1 Except where noted otherwise, provide ductwork liner as indicated in the following table:
- .2 APPLICATION THICKNESS

Application	Thickness
1. Low pressure supply/return in conditioned space	25mm (1")
2. Low pressure supply in return air plenum	25mm (1")
3. Low pressure supply/return in unconditioned space or in plenums not used for return air whether or not above conditioned space	300mm (12")
4. Exhaust within 3m (10 feet) of fan inlet	50mm (2")
5. Sound isolation boots	25mm (1")

Application	Thickness
6. Exhaust within 1.5m (5 feet) of inlet grille	25mm (1")
7. Ductwork downstream of VAV or mixing boxes and fan powered terminal units	25mm (1")
8. Interior of air handling unit plenums	25mm (1")

Note: Conditioned space: any space or plenum (i.e., above plaster or lay-in ceilings or the interior of an air handling unit or spaces without ceilings) where ambient temperature range of 10°C to 30°C may occur.

3.04 DUCT LINER

- .1 Install in accordance with manufacturer's recommendations, and as follows:
 - .1 Fasten to interior sheet metal surface with 90% coverage of adhesive to ASTM C916.
 - .1 Exposed leading edges and transverse joints to be factory coated or coated with adhesive during fabrication.
 - .2 In addition to adhesive, liners are to be installed with mechanical fastening devices in accordance with SMACNA Duct Construction Standards. Type of fastening device used is to be compatible with the liner and adhesive used without damaging the liner or adversely affecting the fire resistance rating of the liner or adhesive.
 - .1 Spacing of mechanical fasteners in accordance with SMACNA HVAC Duct Construction Standards.
 - .2 Ducts with interior widths of 200mm (8") or less do not require mechanical fasteners in addition to adhesive.
- .2 In systems where air velocities exceeds 20.3 m/sec or wherever duct liner if preceded by unlined metal, install galvanized sheet metal nosing to leading edges of duct liner. Nosing may be formed on duct or be channel or zee attached by screws, rivets or welds.

3.05 JOINTS

- .1 Seal butt joints, exposed edges, weld pin and clip penetrations and damaged areas of liner with joint tape and sealer. Install joint tape in accordance with manufacturer's written recommendations and as follows:
 - .1 Bed tape in sealer.
 - .2 Apply two coats of sealer over tape.
- .2 Replace damaged areas of liner at discretion of Owner and/or Consultant.
- .3 Protect leading and trailing edges of duct sections with sheet metal nosing having 15mm overlap and fastened to duct.

3.06 VERIFICATION

- .1 Verification requirements in accordance with Division 01, include:
 - .1 Materials and resources.
 - .2 Storage and collection of recyclables.
 - .3 Construction waste management.
 - .4 Resource re-use.
 - .5 Recycled content.
 - .6 Local/regional materials.
 - .7 Low-emitting materials.

3.07 OPERATION REQUIREMENTS

- .1 Operational requirements in accordance with Division 01, include:
 - .1 Cleaning materials and schedules.
 - .2 Repair and maintenance materials and instructions.

3.08 CLEANING

- .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.
- .2 Separate waste materials for recycling and/or disposal in accordance with Division 01 and in accordance with the Waste Management Plan.
- .3 Remove from site and dispose of packaging materials at appropriate recycling facilities.
- .4 Collect and separate all packaging material for disposal in appropriate on site bins for recycling in accordance with Waste Management Plan.
- .5 Place materials defined as hazardous or toxic in designated containers.
- .6 Handle and dispose of hazardous materials in accordance with CEPA, TDGA, Regional and Municipal regulations.
- .7 Ensure emptied containers are sealed and stored safely.
- .8 Fold up metal banding, flatten and place in designated area for recycling.

END OF SECTION 23 33 53

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- 1.02 WORK PERFORMED BY THIS SECTION
- 1.03 QUALITY ASSURANCE
- 1.04 SUBMITTALS
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- 1.06 WARRANTY

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- 2.01 ACOUSTIC SILENCERS

PART 3 - EXECUTION

- 3.01 INSTALLATION
- 3.02 CLEANING

PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Section 20 05 05 Mechanical Work General Instructions and Section 20 05 10 Basic Mechanical Materials and Methods.
- .3 Comply with the requirements of Section 23 05 00 Common Work Results for HVAC.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Provide silencers, properly selected to provide sound attenuation and with performance in accordance with drawing schedule.

1.03 QUALITY ASSURANCE

- .1 Materials in accordance with Section 20 05 05 and 20 05 10.
- .2 Silencer performance is to be substantiated by laboratory testing in a duct-to-reverberant room test facility according to ASTM E477, Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Material and Prefabricated Silencers.
- .3 Provide all equipment to control noise and vibration such that the average noise criteria curves for the conditioned occupied space, do not exceed the NC levels and vibration levels specified in the acoustic report or, in the absence of such report, the table below:

Room Types		Octave Band Analysis NC
Office Buildings	Executive and private offices	30
	Conference rooms	30
	Teleconference rooms	25
	Open-plan offices	40
	Corridors and lobbies	40
Libraries, Indoor Stadiums, Gymnasiums	Gymnasiums and natatoriums	45
	Large-seating-capacity spaces with speech amplification	50

- .4 Provide the inspection and supervision services of the noise control equipment. Manufacturer to ensure that during construction all equipment is installed as required to achieve specified performance.
- .5 Silencer acoustic media and any lining/wrapping material must have a maximum flame spread rating of 20 and a smoke developed rating of 20 when tested in accordance with CAN/ULC S102, Surface Burning Characteristics of Building Materials, and Accessories.
- .6 Acceptable Silencer Manufacturers: Vibro-Acoustics, Price Industries, Kinetics Noise Control, and VAW Systems.

1.04 SUBMITTALS

- .1 Submit shop drawings in accordance with Section 20 05 01. Shop drawings to include all required silencers detailing geometry and construction, dynamic insertion losses, pressure drops and regenerated noise.

- .2 Submit acoustics analysis report with silencer shop drawing. Acoustical data is to demonstrate that duct systems with silencers will reduce mechanical fan system noise to required NC levels in occupied spaces.
- .3 Submit a copy of silencer manufacturer's National Voluntary Laboratory Accreditation Program (NVLAP) accreditation certificate for latest ASTM E477 test standards as part of shop drawing submission.

1.05 DELIVERY, STORAGE AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

1.06 WARRANTY

- .1 Provide warranties as outlined in Section 20 05 05.

PART 2 - PRODUCTS

2.01 ACOUSTIC SILENCERS

- .1 Provide silencers as listed in the equipment schedules. Only silencers with duct-to-reverberant room insertion ratings will be accepted.
- .2 Silencer inlet and outlet dimensions are to be equal to duct sizes shown on drawings. Unless otherwise shown or specified, transitions will not be permitted.
- .3 Silencers are to be constructed in accordance with SMACNA HVAC Duct Construction Standards Metal and Flexible, to suit duct system pressure and velocity classification. Material gauges notes in this Section are minimums and are to be increased as required for the system pressure and velocity classification. Silencers are to be constructed so as not to fail when subjected to an internal static pressure of 3.9 kPa (8" wg) unless otherwise specified.
- .4 Unless otherwise specified, casing seams and joints are to be lock-formed, lock-formed and sealed or stitch welded and sealed. Airtight construction is to be provided by use of a duct sealing compound.
- .5 Perforated steel is to be adequately stiffened to ensure flatness and form, and welds are to be factory protected with a corrosion resistant (zinc rich) coating.
- .6 Silencers are to be shipped with factory installed end caps.
- .7 Galvanized steel is to be in accordance with ASTM A653/A653M Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- .8 Outer Casing Construction:
 - .1 Rectangular or Rectangular Elbow Silencers:
 - .1 Unless otherwise specified or noted on drawing schedule, minimum #22 gauge, G90 galvanized steel in accordance with ASTM A653.
 - .2 Transitional Silencers:
 - .1 Unless otherwise specified or noted on drawing schedule, minimum #22 gauge, G90 galvanized steel in accordance with ASTM A653.
 - .2 Transitioning is to occur internal to silencer such that height of air passage is uniformly changing with the length of the splitters/baffles.
 - .3 Circular Silencers:
 - .1 Unless otherwise specified or noted on drawing schedule, G90 galvanized steel in accordance with ASTM A653 with minimum material gauges as follows:
 - .1 up to 500 mm (20") dia. duct – #22 gauge;
 - .2 525 mm to 1,100 mm (21" to 44") dia. duct – #18 gauge;

- .3 Over 1,100 mm (44") dia. duct – #16 gauge.
- .9 Inner Perforated Metal Liner:
 - .1 Unless otherwise specified or noted on the drawing schedule, G90 galvanized steel in accordance with ASTM A653 with minimum material gauges as follows:
 - .1 Rectangular, Elbow and Transitional Silencers: Minimum #22 gauge.
 - .2 Circular Silencers:
 - .1 up to 450 mm (18") dia. duct – #22 gauge;
 - .2 450 mm to 600 mm (18" to 24") dia. duct – #20 gauge;
 - .3 600 mm to 1,350 mm (24" to 54") dia. duct – #18 gauge;
 - .4 over 1,350 mm (54") dia. duct – #16 gauge.
- .10 High Transmission Loss (HTL) Outer Casing:
 - .1 Where indicated in the drawing schedule, provide silencers with HTL outer casing with gauge as indicated in the schedule.
 - .2 HTL walls are to be externally applied and completely sealed to the silencer casing by the silencer manufacturer.
 - .3 HTL walls are to consist of media, airspace, mass and outer protective metal skin, as required, to obtain the specified room noise criteria.
 - .4 Standard acoustical panels will not be accepted as HTL walls.
- .11 Alternative Silencer Materials:
 - .1 Where indicated in the drawing schedule, Type 304 or 316 stainless steel or aluminum 3003 H14 material to be used.
- .12 Principal Sound-Absorbing Mechanism:
 - .1 Glass Fibre Insulation
 - .1 Unless otherwise specified, media is to be acoustic quality, shot-free glass fibre insulation with long, resilient fibres bonded with thermosetting resin.
 - .2 Glass fibre is to be packed with minimum of 15% compression during silencer assembly.
 - .3 Media is to be resilient such that it will not crumble or break and conform to irregular surfaces. Media is to not rot, mildew or otherwise deteriorate, and have sufficient flexibility to readily form around corners and curved surfaces. Media is to not cause or accelerate corrosion of aluminum or steel.
 - .4 Mineral wool is not permitted as a substitute for glass fibre.
 - .2 Cotton Fibre Insulation
 - .1 For silencers as specified and/or scheduled, acoustic quality cotton fibre insulation consisting of natural cotton fibres treated with an EPA registered, non-toxic borate solution, and "flash dried" to actively inhibit the growth of mould, mildew, bacteria and fungi. Media is to not contain any formaldehydes, phenolic resins or Volatile Organic Compounds (VOC's) that can off-gas and/or cause health concerns.
 - .2 Insulation is to be packed with minimum of 15% compression during silencer assembly
 - .3 Media is to not cause or accelerate corrosion of aluminum or steel.
 - .4 Glass fibre and mineral wool are not permitted as substitute for cotton fibre insulation.

- .3 No-Media or Packless Silencers
 - .1 No media silencers are not to contain absorptive media of any kind, achieve attenuation with controlled impedance membranes and broadly tuned resonators.
- .13 Media Protection:
 - .1 Dissipative Silencers
 - .1 Where indicated in silencer schedule, acoustic media is to be encapsulated in glass fibre cloth to help prevent shedding, erosion and impregnation of the glass fibre.
 - .2 Film Lined Silencers
 - .1 Where internal air velocities exceed 23 m/s (75 ft/s) provide film liner to protect acoustic media.
 - .2 Where indicated in silencer schedule, acoustic media is to be lined/encapsulated with polymer film to help prevent shedding, erosion, and impregnation. Film is to be separated from the inner perforated metal liner by a factory-installed acoustically transparent spacer. Spacer is to be flame retardant and erosion resistant. Mesh, screen or corrugated perforated liner will not be acceptable as a substitute for the specified spacer.
- .14 Special Construction / Accessories:
 - .1 Where indicated on the silencer schedule, provide security bars running at 150mm (6") centers both ways inside the silencer casing to prevent ingress through the silencer.
 - .2 Where indicated on the silencer schedule, silencers are to be supplied with an access door(s) to permit fire damper service. Access doors are to be supplied as an integral part of the silencer by the silencer manufacturer. Where HTL walls are also supplied, the access doors are not to reduce the effectiveness of the HTL walls.
 - .3 Where indicated on the silencer schedule, silencers shall have airflow measuring devices factory installed as part of the silencer assembly.

PART 3 - EXECUTION

3.01 INSTALLATION

- .1 Provide silencers and install in accordance with manufacturer's instructions and recommendations. Ensure that silencers are installed with airflow directional arrows in the direction of airflow.
- .2 Support each silencer independent of connecting ductwork.
- .3 Where cross-talk silencers penetrate partition walls, seal joint between perimeter of silencer and the wall, on both sides of the wall, with proper acoustic caulking.
- .4 Seal silencer connections to ducts with proper fire/smoke rated duct sealer.

3.02 CLEANING

- .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

END OF SECTION 23 33 55

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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Mechanical Work General Instructions Section 20 05 05 and Basic Mechanical Materials and Methods Section 20 05 10.
- .3 Comply with the requirements of Section 23 05 00 Common Work Results for HVAC.

1.02 SUMMARY

- .1 Section Includes:
 - .1 Supply, return and exhaust grilles and registers, diffusers and linear grilles, for commercial and residential use.
 - .2 Sustainable requirements for construction and verification.

1.03 QUALITY ASSURANCE

- .1 Materials in accordance with Section 20 05 05 and 20 05 10.
- .2 Health and Safety Requirements:
 - .1 Do construction occupational health and safety in accordance with Division 01 and to suit Health and Safety Requirements.
- .3 Certificates:
 - .1 Catalogue or published ratings those obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency.
- .4 Performance Requirements:
 - .1 Catalogued or published ratings for manufactured items: Obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards.
- .5 Grilles, registers and diffusers of same generic type, products of one manufacturer.

1.04 SUBMITTALS

- .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 20 05 01. Include product characteristics, performance criteria, and limitations. Indicate capacity, throw and terminal velocity, noise criteria, pressure drop and neck velocity.
- .2 Samples:
 - .1 Submit samples in accordance with Section 20 05 01.
- .3 Certificates: Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .4 Spares:
 - .1 Provide maintenance materials in accordance with Division 01 and Section 25 05 01.
 - .2 Provide following:
 - .1 Keys for volume control adjustment.
 - .2 Keys for air flow pattern adjustment.

1.05 DELIVERY, STORAGE, AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

1.06 WARRANTY

- .1 Provide warranties as outlined in Section 20 05 05.

PART 2 - PRODUCTS

2.01 GENERAL

- .1 To meet capacity, pressure drop, terminal velocity, throw, noise level, neck velocity [as indicated].
- .2 Frames:
 - .1 Full perimeter gaskets.
 - .2 Plaster frames where set into plaster or gypsum board.
 - .3 Concealed fasteners.
- .3 Concealed manual volume control damper operators.
- .4 Colour: as directed by Consultant.
- .5 For corrosive environments (pool areas) construction, fasteners, screws and supports shall be stainless steel.

2.02 REGISTERS, GRILLES, DIFFUSERS

- .1 Provide registers, grilles and diffusers by manufacturer and sizes, styles and finishes as scheduled on the Drawings.
- .2 Ensure that the items supplied will be compatible with ceiling or wall construction.
- .3 Provide all required "boots" in the coffered ceiling system air distribution points as shown on the drawings.
- .4 All registers, grilles and diffusers are to be completed with fire rated assemblies with fire stop flap, UL and ULC listed. The design of registers, grilles and diffusers meets with NFPA 96A requirements.
- .5 Equipment as manufactured by E.H. Price, Carnes, Barber Coleman, Titus, Nailor Industries, Tuttle & Bailey, Metalaire and Krueger is acceptable.

PART 3 - EXECUTION

3.01 MANUFACTURER'S INSTRUCTIONS

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

3.02 INSTALLATION

- .1 Install in accordance with manufacturer's recommendations.
- .2 Install with screws in countersunk holes where fastenings are visible.
- .3 Bolt grilles, registers and diffusers, in place, in gymnasium and similar game rooms.
- .4 Provide concealed safety chain on each grille, register and diffuser in public accessible areas.

3.03 GRILLES, REGISTERS AND DIFFUSERS

- .1 Fit frame with gasket to prevent leakage, and smudging.
- .2 Install with oval head plated screws in countersunk holes where fastenings are visible.
- .3 Ensure unit is compatible with ceiling or wall construction.
- .4 Make connections of rigid or flexible ductwork to diffusers, VAV terminals and air distribution boots using a minimum of 3 self tapping screws and seal with glass fab tape and high velocity duct sealer.

3.04 FIELD QUALITY CONTROL

.1 Verification requirements in accordance with Division 01 and include:

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

3.05 CLEANING

.1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

END OF SECTION 23 37 13

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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Mechanical Work General Instructions Section 20 05 05 and Basic Mechanical Materials and Methods Section 20 05 10.
- .3 Comply with the requirements of Section 23 05 00 Common Work Results for HVAC.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Section Includes:
 - .1 Mechanical louvres, intakes, vents and reinforcement and bracing for air vents, intakes and gooseneck hoods.
 - .2 Sustainable requirements for construction and verification.

1.03 QUALITY ASSURANCE

- .1 Materials in accordance with Section 20 05 05 and 20 05 10.
- .2 Health and Safety Requirements:
 - .1 Do construction occupational health and safety in accordance with Division 01 and to suit Health and Safety Requirements.
- .3 Certificates:
 - .1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards.

1.04 REFERENCES

- .1 American National Standards Institute (ANSI)/ National Fire Protection Association (NFPA)
 - .1 ANSI/NFPA 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
- .2 American Society for Testing and Materials International (ASTM)
 - .1 ASTM E90, Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
- .3 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).
- .4 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
- .5 Society of Automotive Engineers (SAE)

1.05 SUBMITTALS

- .1 Product Data:
 - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 20 05 01. Include product characteristics, performance criteria, and limitations. Indicate pressure drop, face area, free area.
- .2 Certificates: Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .3 Test Reports:

- .1 Submit certified data from independent laboratory substantiating acoustic and aerodynamic performance to ASTM E90.

1.06 DELIVERY, STORAGE, AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

1.07 WARRANTY

- .1 Provide warranties as outlined in Section 20 05 05.

PART 2 - PRODUCTS

2.01 GRAVITY ROOF OUTSIDE AIR INTAKES AND RELIEF VENTS

- .1 Factory manufactured with all external components being made of aluminum and internal structural components made of galvanized steel.
 - .1 Complete with integral birdscreen of aluminum wire mounted parallel to the opening
 - .2 For airflows up to 300 cfm (142 l/s) provide Backdraft dampers on all faces.
 - .3 For airflows above 300 cfm (142 l/s) provide motorized dampers on all faces.
- .2 Acceptable manufacturers: Greenheck.

2.02 GOOSENECK HOODS

- .1 Thickness: As per SMACNA.
 - .1 Kitchen: To ANSI/NFPA 96.
 - .2 Elsewhere: To SMACNA.
- .2 Fabrication: As per SMACNA.
 - .1 Kitchen: To ANSI/NFPA 96.
 - .2 Elsewhere: To SMACNA.
- .3 Joints: As per SMACNA
- .4 Supports: As required to meet wind and snow loads.
- .5 Complete with integral birdscreen of aluminum wire.
- .6 For airflows below 300 cfm (142 l/s) provide backdraft dampers on all faces.
- .7 For airflows above 300 cfm (142 l/s) provide motorized dampers on all faces.

2.03 FIXED LOUVRES

- .1 Stationary, extruded aluminum, site proof, weatherproof as manufactured by Airolite Type K 6776, 150mm (6") deep, 35° blades, complete with 12mm (2") mesh 16 ga. aluminum removable bird screen 50% minimum free area.
- .2 Other acceptable manufacturers: EH Price, Nailor, Ruskin, Ventex, Construction Specialities.

2.04 ROOF MOUNTED LOUVRED ASSEMBLIES (EXHAUST AND INTAKE)

- .1 As described on the Drawings, provide rainproof roof mounted louvred aluminium alloy exhaust and intake assemblies complete with bird screens as manufactured by Penn, Airolite or Greenheck.

PART 3 - EXECUTION

3.01 MANUFACTURER'S INSTRUCTIONS

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

3.02 INSTALLATION

- .1 Install in accordance with manufacturer's recommendations.
- .2 Reinforce and brace as indicated.
- .3 Anchor securely into opening. Seal with caulking to ensure weather tightness.

3.03 OUTSIDE AIR AND EXHAUST LOUVRES

- .1 Install to ULC requirements. Locate in fire walls, ceilings and partitions where indicated. Coordinate with and provide ULC installation details to drywall installer.
- .2 Seal around fire damper assembly.
- .3 After completion, have installation approved prior to concealment.

3.04 CLEANING

- .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Mechanical Work General Instructions Section 20 05 05 and Basic Mechanical Materials and Methods Section 20 05 10.
- .3 Comply with the requirements of Section 23 05 00 Common Work Results for HVAC.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Section Includes:
 - .1 Materials, accessories and installation for breechings, chimneys and stacks.
- .2 Sustainable requirements for construction and verification.

1.03 QUALITY ASSURANCE

- .1 Materials in accordance with Section 20 05 05 and 20 05 10.
- .2 Health and Safety Requirements:
 - .1 Do construction occupational health and safety in accordance with Division 01 and to suit Health and Safety Requirements.
- .3 Certificates:
 - .1 Catalogue or published ratings those obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency.
- .4 Regulatory Requirements: Work to be performed in compliance with CEPA, CEAA, TDGA, and applicable Provincial/Territorial regulations.

1.04 REFERENCES

- .1 Sheet Metal and Air Conditioning Contractors National Association (SMACNA)
- .2 Underwriters' Laboratories of Canada (ULC)
- .3 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).

1.05 SUBMITTALS

- .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 20 05 01. Include product characteristics, performance criteria, and limitations. Indicate methods of sealing sections, methods of expansions, details of thimbles, bases/foundations, supports, guy details and rain caps.
 - .1 Submit drawings stamped and signed by Professional Engineer registered or licensed in Ontario, Canada.
- .2 Certificates: Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .3 Close-out Submittals
 - .1 Refer to Section 20 05 05.

1.06 DELIVERY, STORAGE, AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

1.07 WARRANTY

- .1 Provide warranties as outlined in Section 20 05 05.

PART 2 - PRODUCTS

2.01 BREECHINGS

- .1 Shop fabricated 3.5 mm thick stainless steel with sweep bends from boiler outlet to thimble or chimney as indicated.

2.02 TYPE B GAS VENT

- .1 ULC labelled, 288 degrees C rating maximum, atmospheric gas vent only.
- .2 Sectional, pre-fabricated, double wall with 13 mm air space. Aluminum inner wall. Galvanized steel outer wall. Mated fittings and couplings.

2.03 GAS VENTS AND STACKS

- .1 Gas vents for atmospheric gas fired equipment: Type B ULC labelled complete with all supports, flashings, rain caps and bands, in sizes as shown complete to meet requirements of Authorities having jurisdiction. Provide ULC labelled vent in accordance code and suitable for outdoor installation where located above the roof line or beyond exterior walls.
- .2 Gas vents for forced draft fired equipment: Metalbestos Model PS Insulated 316 stainless steel lined and clad all fuels type complete with all supports, flashings, rain caps and thimbles in size as shown complete to meet requirements of Authorities having jurisdiction.
- .3 Gas vents for generator exhaust:
 - .1 Provide certified UL and ULC listed, factory built exhaust system, tested and listed for use with medium heat equipment burning gas or liquid as described in NFPA 37 and NFPA 211 for temperatures not exceeding 760 C (1400 F).
 - .2 The double wall exhaust system is to have a stainless steel 304 [316] inner liner and a stainless steel 316 outer jacket casing. A minimum of 50mm (2 inches) fibreglass insulation is to be provided between the inner liner and the outer casing jacket providing a surface temperature meeting the requirements of UL 103.
 - .3 The exhaust system is to be designed and installed to be gas tight and to be UL, ULC tested and listed to 14.9 kPa (60 inches) internal water column pressure.
 - .4 Provide matching flanges for connections to silencers and expansion joints.
 - .5 Provide all supports, guides, bellow type expansion joints, pressure relief valves, guy sections, guy tensioners, roof thimbles, roof flashings, storm collars, flip top terminals and other necessary accessories and devices as required to provide a complete system per manufacturer's instruction.
 - .6 The exhaust system is also to be designed to compensate for all flue gas induced thermal expansion. Co-ordinate with Division 26.
 - .7 Provide certification documents and/or letters as required by the Authorities Having Jurisdiction.
 - .8 Warranty: A minimum of 10 years from date of installation against material and workmanship.

- .4 Acceptable Alternative Manufacture: Vanpacker, ICC Industrial Chimney Inc. and Heat Fab Inc.

2.04 STEEL CHIMNEY REFRACTORY LINED

- .1 Material:
 - .1 Pre-fabricated sections with 90 mm thick high temperature impervious insulating refractory lining, centrifugally spun into 3.5 mm thick circular casing.
- .2 Construction:

- .1 Pre-fabricated sections, welded on site or at factory. Use high temperature insulating cement at joints in refractory lining.
- .3 Welding:
 - .1 To full thickness; grind welds smooth.
- .4 Supports:
 - .1 Welded gussets, cleats and bolts for installation on concrete base.
 - .2 Chimney laterally and vertically braced.
- .5 Breeching entry:
 - .1 Tee section with 150 mm minimum refractory lined projection.
- .6 Access door: In bottom section.
- .7 Drain connection: At base of stack.
- .8 Dimensions: As indicated.

2.05 ACCESSORIES

- .1 Cleanouts: Bolted, gasketed type, full size of breeching, as indicated.
- .2 Barometric dampers: double acting, 70% of full size of breeching area.
- .3 Hangers and supports: In accordance with recommendations of Sheet Metal and Air Conditioning Contractors National Association Inc. (SMACNA).
- .4 Rain cap.
- .5 Expansion sleeves with heat resistant caulking, held in place as indicated.

2.06 STAND-BY GENERATOR EXHAUST

- .1 Refer to detail drawing and install exhaust, muffler, flexible connection as shown. Flexible connection and muffler supplied by Division 26.
- .2 Refer to section 23 35 16 for the requirements of Equipment Exhaust System.

2.07 PLASTIC VENT PIPING (CONDENSING APPLIANCES ONLY)

- .1 ULC S636 PVC piping.
- .2 Use only ULC S636 approved cement and primer for joints.
- .3 Do not insulate plastic vent piping.
- .4 Do not mix vent systems of different types or manufacturers.
- .5 Refer to manufacturer's instructions for a list of acceptable adapters, fittings, etc. for use with the venting system.
- .6 PVC piping is to be used for the following applications:
 - .1 High efficiency (condensing) domestic water heaters, as per manufacturer's instructions.
 - .2 Small capacity condensing boilers, as per manufacturer's instructions.
 - .3 Plastic vent piping shall only be used with appliances for which it is certified (refer to manufacturer's installation instructions).

PART 3 - EXECUTION

3.01 MANUFACTURER'S INSTRUCTIONS

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

3.02 INSTALLATION – GENERAL

- .1 Follow manufacturer's and SMACNA installation recommendations for shop fabricated components.
- .2 Suspend breeching at 1.5m centres and at each joint.
- .3 Support chimneys at bottom, roof and intermediate levels as indicated.
- .4 Install thimbles where penetrating roof, floor, ceiling and where breeching enters masonry chimney. Pack annular space with heat resistant caulking.
- .5 Install flashings on chimneys penetrating roofs, as indicated.
- .6 Install rain caps and clean-outs, as indicated.

3.03 INSTALLATION - REFRACTORY LINED STEEL CHIMNEY

- .1 Grind welds smooth to form appearance of single tube.
- .2 Seal insulating refractory at top of stack.
- .3 Pack annular space around breeching at entry tee with heat resistant caulking.
- .4 Run drain line from drain connection to nearest floor drain.
- .5 On completion, paint one coat of rust inhibitive primer and two coats of heat resisting paint of colour, make and quality approved by the Consultant.

3.04 FIELD QUALITY CONTROL

- .1 Verification requirements in accordance with Division 01 and include:
 - .1 Materials and resources.
 - .2 Storage and collection of recyclables.
 - .3 Construction waste management.
 - .4 Resource re-use.
 - .5 Recycled content.
 - .6 Local/regional materials.
 - .7 Low-emitting materials.

3.05 CLEANING

- .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

END OF SECTION 23 51 00

CONTENTS

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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Mechanical Work General Instructions Section 20 05 05 and Basic Mechanical Materials and Methods Section 20 05 10.
- .3 Comply with the requirements of Section 23 05 00 Common Work Results for HVAC.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Section Includes:
 - .1 Heating boiler units:
 - .1 Forced draft.
 - .2 Cast-iron.
 - .3 Atmospheric fired hot water
 - .4 Electric.
 - .5 Steam boilers.
 - .6 High efficiency condensing.
 - .7 Gas and oil burners.
 - .8 Installation.
 - .9 Commissioning.
 - .2 Sustainable requirements for construction and verification.

1.03 QUALITY ASSURANCE

- .1 Materials in accordance with Section 20 05 05 and 20 05 10.
- .2 Regulatory Requirements: Work to be performed in compliance with CEPA, CEAA, TDGA and applicable Ontario regulations
- .3 Health and Safety Requirements:
 - .1 Do construction occupational health and safety in accordance with Division 01 and to suit Health and Safety Requirements.
- .4 Certificates:
 - .1 Catalogue or published ratings those obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency.

1.04 REFERENCES

- .1 American Boiler Manufacturer's Association (ABMA)
- .2 American National Standards Institute (ANSI)
 - .1 ANSI Z21.13/CSA 4.9, Gas-Fired Low-Pressure Steam and Hot Water Boilers.
- .3 American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME)
 - .1 ANSI/ASME Boiler and Pressure Vessel Code, Section IV,.
- .4 Canadian Gas Association (CGA)
 - .1 CAN1-3.1-77, Industrial and Commercial Gas-Fired Package Boilers.
 - .2 CAN/CSA-B149.1, Natural Gas and Propane Installation Code.

- .5 Canadian Standards Association (CSA International)
 - .1 CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code.
 - .2 CSA B139, Installation Code for Oil Burning Equipment.
 - .3 CSA B140.7, Oil Burning Equipment: Steam and Hot-Water Boilers.
- .6 Electrical and Electronic Manufacturer's Association of Canada (EEMAC)
- .7 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).
- 1.05 SUBMITTALS
 - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 20 05 01. Include product characteristics, performance criteria, and limitations. Indicate the following:
 - .1 General arrangement showing terminal points, instrumentation test connections.
 - .2 Clearances for operation, maintenance, servicing, tube cleaning, tube replacement.
 - .3 Foundations with loadings, anchor bolt arrangements.
 - .4 Piping hook-ups.
 - .5 Equipment electrical drawings.
 - .6 Burners and controls.
 - .7 All miscellaneous equipment.
 - .8 Flame safety control system.
 - .9 Breeching and stack configuration.
 - .10 Stack emission continuous monitoring system to measure CO, O₂, NO_x, SO₂, stack temperature and smoke density of flue gases.
 - .11 Engineering data to include:
 - .1 Boiler efficiency at 25%, 50%, 75%, 100% and 110% of design capacity.
 - .2 Radiant heat loss at 100% design capacity.
 - .2 Certificates: Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - .3 Close-out Submittals:
 - .1 Submit operation and maintenance data for incorporation into manual specified in Section 20 05 05.
 - .4 Spares:
 - .1 Provide maintenance materials in accordance with Division 01 and Section 25 05 01.
 - .2 Provide the following:
 - .1 Special tools for burners, manholes, handholes and Operation and Maintenance.
 - .2 Spare parts for 1 year of operation.
 - .3 Spare gaskets.
 - .4 Spare gauge glass inserts.
 - .5 Probes and sealants for electronic indication.
 - .6 Spare burner tips.

- .7 Spare burner gun.
- .8 Safety valve test gauge.

1.06 DELIVERY, STORAGE, AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

1.07 WARRANTY

- .1 Provide warranties as outlined in Section 20 05 05.
- .2 Warranty periods for boilers to start on the date of verification of acceptance issued in writing by the Consultant.
- .3 The date of verification of acceptance is independent of Substantial Performance of the Work and may occur after certification of Substantial Performance.
- .4 Boilers will be accepted after start up, a minimum of six hours of logged operation and submission of written verification of same by manufacturer's representative. The Consultant may also witness a portion of any of these this procedure.
- .5 Include verification of acceptance certificates with the maintenance and operating manuals in the appropriate sections.

PART 2 - PRODUCTS

2.01 BOILER[S] – HIGH EFFICIENCY CONDENSING

- .1 Provide natural gas-fired condensing type hot water boilers with capacities and characteristics as indicated in the equipment schedules and with features and components as follows:
 - .1 Boiler Design:
 - .1 The boiler shall be designed to operate in a condensing mode while firing on natural gas, in order to extract the latent heat from the combustion products. With a return water temperature of 80°F, the boiler shall have a minimum acceptable fuel-to-water efficiency of 93% at the full rated input capacity and 99% at the low fire rated input capacity.
 - .2 External convection and radiation heat losses to the boiler room from the boiler shall be less than 0.5% of the rated boiler input.
 - .3 The boiler shall have no minimum return water temperature requirements.
 - .4 A zero flow condition will not cause any harm to the boiler. Flow switches and primary/secondary piping arrangements are not required.
 - .5 Boilers are to be exempted from the current Technical Standards and Safety Act, 2000 Operating Engineers. Manufacturer to provide all necessary safety devices as required in the Act.
 - .2 Constructions:
 - .1 The boiler shall be completely factory assembled as a self-contained unit. Each boiler shall be neatly finished, thoroughly tested, and properly packaged for shipping.
 - .2 The primary and secondary (condensing) pressure vessel design and construction shall be in accordance with Section IV of the ASME Code for heating boilers. The maximum water working pressure shall be 1,103 kPa (160PSI) and the maximum design temperature shall be 98.8C (210F). Boiler shall also comply with CSD-1 Code requirements.

- .3 The Forced Draft Combustion Boiler shall be UL approved as a Direct Vent Boiler. The boiler will require a stack utilizing AL-29-4C or equivalent. The boiler can draw combustion air from inside the boiler room or ducted outside air. The boiler shall be capable of operating with an exhaust draft not exceeding $-0.04''$ wc and a combined air intake venting and exhaust venting pressure drop not exceeding $0.35''$ wc.
- .4 The vessel shall be SA-53B ERW pipe or SA-516 Grade 70 plate. The heads shall be SA-516 Grade 70 plate. The pressure vessel shall be fully insulated with high temperature insulation. Adequate openings shall be provided for access to the waterside of the boiler.
- .5 The primary heat exchanger shall have a carbon steel shell and tubesheet. The condensing section of the exhaust pipes shall be constructed of SAF 2205 Duplex Stainless Steel. The condensate collection area shall be 316 Stainless Steel. The entire boiler shall be manufactured in accordance with Section IV of the ASME Code for Heating Boilers.
- .6 The boiler shall be a firetube design. The furnace location shall be such that all furnace components are within water-backed areas.
- .7 The boiler is to have a maximum width and height not to exceed 1 dimensions as shown on the drawings and to be capable of being maneuvered through a 1066 mm (42'') doorway.
- .8 A temperature and pressure gauge shall be provided with the boiler.
- .3 Controls:
 - .1 The flame safeguard shall be capable of providing linkage-less modulation and shall provide the following:
 - .1 The control shall provide a 30 second pre-purge and post-purge time.
 - .2 The control shall maintain a running history of operating hours, number of cycles, and the most recent six control lockouts.
 - .3 The control is connected to a display module, which is capable of retrieving the information listed above.
 - .2 Each boiler shall be equipped for fully modulating operation with a 5:1 turndown ratio. Airflow shall be controlled by a butterfly valve connected to a precision servomotor.
 - .3 Boiler safety controls shall include:
 - .1 Operating Temperature Controller for automatic start and stop.
 - .2 High Limit Temperature Controller with manual reset.
 - .3 One Low Water Cutoff Probe in boiler shell.
 - .4 Air Safety Switch to prevent operation unless sufficient combustion air is assured.
 - .5 Flame detector to prove combustion.
 - .4 All controls are to be panel mounted and so located on the boiler as to provide ease of servicing the boiler without disturbing the controls. All controls shall be mounted and wired according to UL requirements. Electrical power supplied shall be 575/3/60. A control circuit transformer shall be factory supplied, wired and mounted.

- .4 Main Fuel Train Components: A factory mounted main gas train shall be supplied. The gas train shall be fully assembled, wired, and installed on the boiler and shall comply with CSD-1 code. Compliance with other codes is available upon request. The maximum pressure rating of the components shall not be less than one psi. The gas train shall consist of at least two manual shutoff valves, one gas pressure regulator, one automatic safety shutoff valve with prove of closure, one flow control valve, one high gas pressure switch, and one low gas pressure switch. The automatic safety shutoff valve and flow control valve may be the same valve.
- .5 Boiler Fittings
 - .1 Boiler shall be supplied with a safety relief valve. The safety relief valve size shall be in accordance with ASME code requirements.
 - .2 Temperature and pressure gauges shall be mounted on top of the boiler.
 - .3 A condensate drain connection shall be provided in the exhaust outlet. A Fulton condensate drain kit will be provided to collect and drain the flue gas condensate.
 - .4 The water supply and return connections on the boiler shall be 150psi flanged connections. The water connections shall not be designed to support any external mechanical load from the piping system.
- .6 Venting: The boiler shall be UL approved as a direct vent boiler. A conventional chimney or stack shall not be used. Direct venting shall be accomplished utilizing AL29-4C material and be rated for positive pressure. The exhaust vent shall be [350mm (14")] diameter double wall. Vent piping shall be installed in accordance with applicable national and local codes and per the boiler manufacturers' recommendations.
- .7 Combustion Air: Use of room air for combustion.
- .8 Emissions: The boiler shall operate with CO emissions less than 100 PPM corrected to 3%.
- .9 Unit to be completed with:
 - .1 Lifting lugs
 - .2 Observation ports on each end for flame condition inspection.
 - .3 Combination temperature pressure gauge.
 - .4 Operating and high limit temperature controls.
 - .5 Low water cut off with drain.
 - .6 Framed certificate issued by Provincial Government Authority having jurisdiction.
 - .7 Manual reset elapsed time meter on burners.
 - .8 Vibration isolation pads. Refer to Section 20 05 20.
- .10 Provide the following terminals for remote EMCS controls:
 - .1 Remote start/stop
 - .2 Modulating gas
 - .3 Alarm
- .11 Venting:
 - .1 The boilers are to be complete with an engineered exhaust venting system as designed and supplied by the boiler manufacturer. The system must meet the requirements of category IV (II) boiler venting (corrosion resistant, water and gas tight).

- .2 The vents consist of double wall stainless steel positive pressure vent inside the building, and double wall insulated stainless steel positive pressure vent through the roof and outside the building. The system is to be complete with the appropriate connectors, hangers, etc. and shall be fully approved and listed by ULC.
- .3 The vent shall have a 25mm (1 inch) space between the inner and outer tubes.
 - .1 Vent installed indoors or exposed to ambient temperatures higher than 32 degrees F (0 degrees C) shall have 25mm (1 inch) of air space between the tubes.
 - .2 Vent exposed to ambient temperatures less than 32 degrees (0 degrees C) shall have 25mm (1 inch) of insulation between the tubes.
- .4 The inner tube (flue) shall be constructed of a material that meets the requirements of UL corrosion resistance standard. The flue shall be constructed of AL29-4C® or 444 stainless steel. The outer tube (casing) shall be constructed of 430 stainless steel. Minimum thickness 24G (0.018").
- .5 The vent shall be sealed by a factory installed high temperature silicone gasket located in the flue.
- .6 Submit venting shop drawing with an engineered stamp with the boiler shop drawing submission.
- .12 Co-ordinate with the Building BAS contractor for controls requirement as related to DDC and the controls sequence. The boilers to be supplied with a BACNet interface module to permit communication with a standard BACNet network.
- .13 Start-up Service and Field Quality Control:
 - .1 Boilers are to be fully started-up and commissioned by factory-trained and authorized personnel, and copies of the start-up report shall be submitted to the Consultants and attached to the Operation and Maintenance Manuals.
 - .2 Arrange with Authority Having Jurisdiction for inspection of boilers and piping. Obtain certification for completed boiler units, deliver to Owner, and obtain receipt.
- .14 Warranties:
 - .1 Boiler manufacturer shall guarantee in writing equipment to be free of defects for one year from the substantial completion date of the project, and to repair or replace at manufacturer's expense any defective parts. Unit shall receive such factory tests as are deemed advisable by the manufacturer to check construction and operation.
 - .2 The pressure vessel shall be guaranteed against thermal shock for 10 years when utilized in a closed loop hydronic heating system with a maximum temperature differential rating of 170°F. The boiler pressure vessel shall be guaranteed accordingly without a minimum flow rate or return water temperature requirement. The boiler shall not require the use of flow switches or other devices to ensure minimum flow.
 - .3 The pressure vessel shall carry a 5-year warranty against material and workmanship defects.
 - .4 The heat exchangers shall be guaranteed against flue gas corrosion for a period of 5 years from factory shipment.
 - .5 All parts not covered by the above warranties shall carry a one-year warranty. This shall include all electrical and burner components.

- .15 Boiler manufacturer to provide acid neutralizer (one for each boiler). The complete neutralizing kit shall include polyethylene container, magnesium oxide medium. Size all acid neutralizer to meet the capacity of the boiler input. Provide sufficient chemical for a minimum of 6 months operation.

- .2 Acceptable alternates: Viessmann, Lochinvar, Riello, Laars

PART 3 - EXECUTION

3.01 MANUFACTURER'S INSTRUCTIONS

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

3.02 INSTALLATION

- .1 Install in accordance with ANSI/ASME Boiler and Pressure Vessels Code Section IV, regulations of Ontario having jurisdiction, except where specified otherwise, and manufacturer's recommendations.
- .2 Make required piping connections to inlets and outlets recommended by boiler manufacturer.
- .3 Maintain clearances as indicated or if not indicated, as recommended by manufacturer for operation, servicing and maintenance without disruption of operation of any other equipment/system.
- .4 Mount unit level using specified vibration isolation in Section 20 05 20 – Mechanical Vibration Control.
- .5 Pipe hot water relief valves full size to nearest drain.
- .6 Natural gas-fired installations: In accordance with CAN/CSA-B149.1.

3.03 MOUNTINGS AND ACCESSORIES

- .1 Safety valves and relief valves:
 - .1 Run separate discharge from each valve.
 - .2 Terminate discharge pipe as indicated.
 - .3 Run drain pipe from each valve outlet and drip pan elbow to above nearest drain.
- .2 Blow down valves:
 - .1 Run discharge to terminate as indicated.

3.04 EQUIPMENT START UP

- .1 Follow manufacturer's instructions and have manufacturer's representative present to certify the installation.
- .2 Check each item of equipment to ensure proper electrical connections, etc., and to verify proper operation.

3.05 FIELD QUALITY CONTROL

- .1 Commissioning:
 - .1 Manufacturer to:
 - .1 Certify installation.
 - .2 Start up and commission installation.
 - .3 Carry out on-site performance verification tests.
 - .4 Demonstrate operation and maintenance.

- .2 Provide the Consultant at least 24 hours notice prior to inspections, tests, and demonstrations. Submit written report of inspections and test results.
- .2 Verification requirements in accordance with Division 01 and include:
 - .1 Materials and resources.
 - .2 Storage and collection of recyclables.
 - .3 Construction waste management.
 - .4 Resource re-use.
 - .5 Recycled content.
 - .6 Local/regional materials.
 - .7 Low-emitting materials.

3.06 CLEANING

- .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

END OF SECTION 23 52 00

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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Mechanical Work General Instructions Section 20 05 05, Basic Mechanical Materials and Methods Section 20 05 10.
- .3 Comply with the requirements of Section 23 05 00 Common Work Results for HVAC.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Section Includes:
 - .1 Materials and installation for piping and fittings used in HVAC heat exchangers.
 - .2 Sustainable requirements for construction and verification:
- .2 Related Sections:
 - .1 Division 01
 - .2 Division 02

1.03 REFERENCES

- .1 American Society of Mechanical Engineers (ASME)
 - .1 ASME Boiler and Pressure Vessel Code.
 - .1 BPVC-VIII B, BPVC Section VIII - Rules for Construction of Pressure Vessels Division 01.
 - .2 BPVC-VIII-2 B, BPVC Section VIII - Rules for Construction of Pressure Vessels Division 02 - Alternative Rules.
 - .3 BPVC-VIII-3 B, BPVC Section VIII - Rules for Construction of Pressure Vessels Division 03 - Alternative Rules High Press Vessels.
- .2 Canadian Standards Association (CSA International)
 - .1 CSA B51, Boiler, Pressure Vessel and Pressure Piping Code.
- .3 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).

1.04 QUALITY ASSURANCE

- .1 Pre-Installation Meetings:
 - .1 Convene pre-installation meeting one week prior to beginning work of this Section and on-site installations in accordance with Division 01, to suit Construction Progress Schedules.
 - .1 Verify project requirements.
 - .2 Review installation and substrate conditions.
 - .3 Co-ordination with other building subtrades.
 - .4 Review manufacturer's installation instructions and warranty requirements.
- .2 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Division 01, to suit Health and Safety Requirements.
- .3 Construction requirements: In accordance with Division 01, to suit Sustainable Requirements.

- .4 Verification: Contractor's verification in accordance with Division 01, to suit Sustainable Requirements.
- .5 Heat exchangers for pool water heating to be provided with titanium plate material and EPDM gaskets.

1.05 SUBMITTALS

- .1 Submit manufacturer's printed product literature, specifications and datasheet for heat exchangers in accordance with Section 20 05 01. Indicate project layout including layout, dimensions of heat exchangers and system.
- .2 Indicate manufacturer's recommended clearances for tube withdrawal and manipulation of tube cleaning tools.
- .3 Test Reports: Submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.
 - .1 Certificates: Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .4 Manufacturer's Field Reports: Manufacturer's field reports specified.
- .5 Closeout Submittals
 - .1 Refer to Section 20 05 05.
- .6 Spares:
 - .1 Provide maintenance materials in accordance with Division 01 and Section 25 05 01.
 - .2 Head gaskets.

1.06 DELIVERY, STORAGE AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

1.07 WARRANTY

- .1 Provide warranties as outlined in Section 20 05 05.

PART 2 - PRODUCTS

2.01 PLATE HEAT EXCHANGER

- .1 Domestic Water application: For potable water applications, all heat exchangers shall be made of 316 stainless steel plates with double wall construction. Heat exchanger for potable water applications shall be NSF certified.
- .2 Gasketed:
 - .1 Provide plate type cleanable heat exchangers with capacities and characteristics as indicated in the equipment schedules. Plate heat exchangers are to be certified and listed according to AHRI Standard 400.
 - .2 Plate and frame construction capable of operating up to of 1035 kPa (150 psi) and a maximum temperature of 98.0C meeting ASME and other local codes.
 - .3 Frames: Painted carbon steel, with chrome plated carbon steel guide bars, zinc plated carbon steel tie bolts and epoxy coated with ANSI 150 flanges.
 - .4 Gaskets: Non-glued gasketing system is to be used with gasket material EPDM. No special tool(s) is to be required to attach the gasket.

- .5 Plates: 304 stainless steel with Nitrile gaskets. Heat transfer plates for design pressures up to 1035 kPa (150 psi) shall have a minimum thickness of 0.016 inches (0.4mm), and shall have a minimum thickness of 0.020 inches (0.5 mm) for design pressures higher than 1035 kPa (150 psi). Plate heat exchanger is to be constructed not use more than 40% of the allowed pressure drop in the ports and port entry area.
- .6 Integral Filter Baskets: Material AISI 316 stainless steel, 2.4mm ($\frac{3}{32}$ ") mesh size. Filter must be accessible without removing piping.
- .3 Brazed Plate:
 - .1 Provide brazed plate heat exchangers with capacities and characteristics as indicated in the equipment schedules. Plate heat exchangers are to be certified and listed according to AHRI Standard 400.
 - .2 Brazed plate construction capable of operating up to of 1035 kPa (150 psi) and a maximum temperature of 98.0C meeting ASME and other local codes.
 - .3 Plates: 316 stainless steel. Brazed material shall be either copper or nickel. Heat transfer plates for design pressures up to 1035 kPa (150 psi) shall have a minimum thickness of 0.016 inches (0.4mm), and shall have a minimum thickness of 0.020 inches (0.5 mm) for design pressures higher than 1035 kPa (150 psi). Plate heat exchangers is to be constructed not use more than 40% of the allowed pressure drop in the ports and port entry area.
- .4 Acceptable manufacturers: Tranter, Alfa Laval, SA Armstrong, Bell and Gossett.

PART 3 - EXECUTION

3.01 MANUFACTURER'S INSTRUCTIONS

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

3.02 INSTALLATION

- .1 General: Install level and firmly anchored to supports in accordance with manufacturer's recommendations.
- .2 Tube in shell heat exchangers: Arrange piping so that tube bundle can be removed after disconnecting two unions or flanges adjacent to head and without disturbing other equipment and systems.
- .3 Plate and frame heat exchanger: Install heat exchanger level with shims under supports. Arrange piping around heat exchangers to allow plate and gasket removal and re-assembly.

3.03 APPURTENANCES

- .1 For gasketed plate and frame heat exchanger: Install with safety relief valve piped to drain set to a pressure of 10 psi below the rated pressure of the equipment, a vacuum breaker and a hose bib drain valve.
- .2 Install thermometer wells with thermometers on inlets and outlets.

3.04 FIELD QUALITY CONTROL

- .1 Manufacturer's Field Services:
 - .1 Have manufacturer of products supplied under this Section review work involved in handling, installation/application, protection and cleaning of its product/s, and submit written reports, in acceptable format, to verify compliance of work with Contract.
- .2 Start-up:

- .1 General: Perform start-up operations in accordance with Division 01 and Sections 20 05 05 and 20 05 10 - General Commissioning (Cx) Requirements, supplemented as specified herein.
- .2 Check heater for cleanliness on primary and secondary sides.
- .3 Check water treatment system is complete, operational and correct treatment is being applied.
- .4 Check installation, settings, operation of relief valves and safety valves.
- .5 Check installation, location, settings and operation of operating, limit and safety controls.
- .6 Check supports, seismic restraint systems.
- .3 Performance Verification:
 - .1 General: Perform performance verification in accordance with Division and Sections 20 05 05 and 20 05 10 - General Commissioning (Cx) Requirements, supplemented as specified.
 - .2 Timing: Only after TAB of hydronic systems have been successfully completed.
 - .3 Primary side:
 - .1 Measure flow rate, pressure drop, and either one steam pressure and temperature at heater inlet or two water temperature at heater inlet and outlet.
 - .2 Verify operation of steam traps. Measure temperature of condensate return at trap outlet.
 - .4 Control valve: Verify proper operation without binding, slack in components. Measure either steam pressure and temperature at control valve inlet or two if control is three-port type, pressure drop across inlet to common, bypass to common, inlet to bypass.
 - .5 Secondary side:
 - .1 Measure flow rate, pressure drop and water temperature at heater inlet and outlet.
 - .2 Verify installation and operation of air elimination devices.
 - .6 Calculate heat transfer from primary and secondary sides.
 - .7 Simulate heating water temperature schedule and repeat above procedures.
 - .8 Verify settings, operation, safe discharge from safety valves and relief valves.
 - .9 Verify settings, operation of operating, limit and safety controls and alarms.
 - .10 Reports:
 - .1 In accordance with Division and Sections 20 05 05 and 20 05 10 - General Commissioning (Cx) Requirements, supplemented as specified herein.
- 3.05 DEMONSTRATION
 - .1 Training: Provide training in accordance with Division 01 and Sections 20 05 05 and 20 05 10 - General Commissioning (Cx) Requirements, supplemented as specified.
- 3.06 CLEANING
 - .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

END OF SECTION 23 57 00

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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Mechanical Work General Instructions Section 20 05 05 and Basic Mechanical Materials and Methods Section 20 05 10.
- .3 Comply with the requirements of Section 23 05 00 Common Work Results for HVAC.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Centrifugal Water Chillers and associated parts and components.

1.03 REFERENCES

- .1 The Air-Conditioning and Refrigeration Institute (ARI)
 - .1 ARI 550/590, Standard for Water-Chilling Packages Using the Vapour Compression Cycle.
- .2 ASTM International Inc.
 - .1 ASTM C547, Standard Specification for Mineral Fibre Pipe Insulation.
- .3 Canadian Standards Association (CSA International)
 - .1 CSA B52, Mechanical Refrigeration Code.
- .4 Environment Canada/Environmental Protection Services (EPS)
 - .1 EPS 1/RA/2, Environmental Code of Practice for Elimination of Fluorocarbons Emissions from Refrigeration and Air Conditioning Systems.

1.04 QUALITY ASSURANCE

- .1 Materials in accordance with Section 20 05 05 and 20 05 10.
- .2 Health and Safety Requirements:
 - .1 Do construction occupational health and safety in accordance with Division 01 and to suit Health and Safety Requirements.
- .3 Certificates:
 - .1 Catalogue or published ratings those obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency.

1.05 SUBMITTALS

- .1 Provide manufacturer's printed product literature and datasheets for chillers and include product characteristics, performance criteria, physical size, finish and limitations in accordance with Section 20 05 01. Shop Drawings to include:
 - .1 Equipment including connections, piping and fittings, valves, strainers, control assemblies and ancillaries, identifying factory and field assembled.
 - .2 Wiring as assembled and schematically.
 - .3 Dimensions, construction details, recommended installation and support, mounting bolt hole sizes and locations and point loads.
 - .4 Space requirements for operation and maintenance.
 - .5 Type of refrigerant used.
- .2 Test Reports: Submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.

- .3 Certificates: Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .4 Closeout Submittals
 - .1 Refer to Section 20 05 05.
 - .2 Include:
 - .1 Description of equipment giving manufacturer's name, model type, capacity and serial numbers.
 - .2 Provide part load performance curves.
 - .3 Details on operation servicing and maintenance.
 - .4 Recommended spare parts list.
- .5 Spares:
 - .1 Provide maintenance materials in accordance with Division 01 and Section 25 05 01.
 - .2 Furnish spare parts data for each different item of equipment specified, after approval of detail drawings.
 - .3 Include with data complete list of parts and supplies, with current unit prices, source of supply, recommended spare parts list for 1 year of operation and list of parts recommended by manufacturer to be replaced on routine basis.

1.06 DELIVERY, STORAGE AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

1.07 WARRANTY.

- .1 Warranty periods for chillers to start on the date of verification of acceptance issued in writing by the Consultant.
- .2 The date of verification of acceptance is independent of Substantial Performance of the Work and may occur after certification of Substantial Performance.
- .3 Chillers will be accepted after start up, a minimum of six hours of logged operation and submission of written verification of same by manufacturer's representative. The Consultant may also witness a portion of any of these this procedure.
- .4 Include verification of acceptance certificates with the maintenance and operating manuals in the appropriate sections.
- .5 Provide equipment manufacturer's qualified personnel to ensure proper start-up, including leak testing, evacuation, dehydration and charging, that condenser pressure controls are properly installed, to check out all operating and safety components as well as instruct the Owner's representative in safe and proper operation and maintenance.
- .6 Provide warranties as outlined in Section 20 05 05.

PART 2 - PRODUCTS

2.01 GENERAL

- .1 Provide outdoor packaged air-cooled liquid chiller with the capacity as scheduled on drawings at job site elevation listed in Section 15050.
- .2 Chiller shall be designed to operate using R-410a Refrigerant.
- .3 The liquid to be chilled will be water containing corrosion
- .4 Inhibitors and antifreeze solution as required.

- .5 Chiller shall be designed to operate using 480 volt, 3 phase, 60 Hz electrical power supply.

2.02 OUTDOOR PACKAGED AIR-COOLED CHILLER

.1 General

- .1 The Equipment Vendor shall supply air source heat pump chillers as shown on the Equipment Schedules. The units shall produce the specified performance per the scheduled data in accordance with the latest revision of AHRI 550/590. The unit shall bear the AHRI certification label as applicable.
- .2 Each module shall be assembled on an integral white painted formed sheet metal steel frame. The required number of modules shall be assembled to a bank in factory.
- .3 Each module shall be fully charged with refrigerant and factory tested for controller functions prior to shipment.
- .4 The chiller system must be built for single point power supply connection.
- .5 The power distribution panel shall incorporate a circuit breaker for overload protection to each chiller module.
- .6 Electrical supply to each module shall consist of flexible conduit.
- .7 No electrical connection to a module shall carry the load of more than that module.
- .8 The electrical supply connections for each module shall be factory assembled and shipped with each module for field connection into the power distribution panel.

.2 Chiller Operation

- .1 The Heat pump shall be capable of operating in cooling mode from -4°F to 125°F (-20 to 51.7°C). Heat pump should be capable of operating in heating mode from 0°F to 95°F (-17.8 to 35°C). Load temperature and capacities will vary.
- .2 Chiller shall be capable of starting up with 95°F (35°C) entering fluid temperature to the evaporator. Maximum water temperature that can be circulated with the Chiller not operating is 125°F(52°C)
- .3 Chiller shall provide evaporator freeze protection and low limit control to avoid low evaporator refrigerant temperature trip-outs during critical periods of chiller operation. Whenever this control is in effect, the controller shall indicate that the chiller is in adaptive limit. If the condition exists for more than 30 seconds, a limit warning alarm relay shall energize.

.3 Compressors

- .1 Construct chiller using fully hermetic scroll type compressors with R454B optimized and dedicated scroll profile. Refrigerant shall have a GWP of less than 600.
- .2 Provide direct drive motor cooled by suction gas with only three major moving parts and a completely enclosed compression chamber which leads to increased efficiency.
- .3 Each compressor shall have Intermediate Discharge Valves (IDV) or variable volume ratio technology
- .4 Each compressor shall have overload protection internal to the compressor
- .5 Each compressor shall include: oil level sight glass and oil charging valve
- .6 Each compressor will have crankcase heaters installed and properly sized to minimize the amount of liquid refrigerant present in the oil sump during off cycles.

- .4 Load Heat Exchanger
 - .1 The evaporator shall be a high efficiency, brazed plate-to-plate type heat exchanger consisting of parallel plates. Braze plates shall be stainless steel with copper braze material.
 - .2 The water side working pressure shall be rated at 150 psig (10.3 bar) and tested at 1.5 times maximum allowable water side working pressure.
 - .3 The refrigerant side working pressure shall be rated at 650 psig (44.8 bar) and tested at 1.1 maximum allowable refrigerant side working pressure.
 - .4 Heat pump must utilize a suction liquid heat exchanger in addition to load heat exchanger for optimized refrigerant circuit operation
 - .5 Insulate the evaporator with a minimum of 0.75 inch (K=0.28) UV rated insulation. If the insulation is field installed, the additional money to cover material and installation costs in the field should be included in the bid.
 - .6 Evaporator heaters shall be factory installed and shall protect chiller down to -20°F (-29°C). Contractor shall wire separate power to energize heat tape and protect evaporator while chiller is disconnected from the main power.
 - .7 Provide water drain connection, vent and fittings. Factory installed leaving water temperature control and low temperature cutout sensors.
 - .8 Water connections shall be grooved pipe.
 - .9 Proof of flow shall be provided by the equipment manufacturer, mechanically installed and electrically wired, at the factory of origin.
- .5 Fans
 - .1 Low sound fans shall be balanced and direct driven.
 - .2 All condenser fan TEAO motors have permanently lubricated ball bearings and internal overload protection.
 - .3 All condenser fans are electrically commutated motors to provide variable speed for optimized efficiency and lower part load sound.
- .6 Coils
 - .1 Construct condenser coils of aluminum fins mechanically bonded to internally finned copper tube. The condenser coils shall have an integral subcooling circuit and shall be designed for 650 psig or higher working pressure. Leak tested at 650 psig.
 - .2 Condenser coils shall be transverse design. If coils are not transverse design, provide coil protection for shipping.
- .7 Enclosure/chiller Construction
 - .1 Unit panels, structural elements and control boxes are constructed of galvanized steel and mounted on a bolted galvanized steel base. Unit panels, control boxes and the structural base are finished with a baked on powder paint.
 - .2 Control panel doors shall have door stays.
 - .3 Mount starters and Terminal Blocks in a UL 60335-2-40 rated weatherproof panel provided with full opening access doors. If a circuit breaker is chosen, it should be a lockable, through-the-door type with an operating handle and clearly visible from outside of chiller indicating if power is on or off.
 - .4 The coating or paint system shall withstand 500 hours in a salt-spray fog test in accordance with ASTM B117.

- .8 Electrical
 - .1 The starter shall be across-the-line configuration, factory-mounted and fully pre-wired to the compressor motor(s) and control panel.
 - .2 Unit shall have a single point power connection.
 - .3 A molded case high fault interrupting capacity circuit breaker shall be factory pre-wired with terminal block power connections and equipped with a lockable external operator handle, making it available to disconnect the chiller from main power.
 - .4 A control power transformer shall be factory-installed and factory-wired to provide unit control power.
 - .5 Unit wiring shall run in liquid-tight conduit.
 - .6 High short circuit current rating (SCCR) of 65kA.
- .9 Refrigerant Circuit
 - .1 All chillers shall have 2 refrigeration circuits, each with two or three (manifolded) compressor on each circuit.
 - .2 Provide for refrigerant circuit:
 - .1 Liquid line shutoff valve
 - .2 Discharge service valve
 - .3 Replaceable Core Filter Drier
 - .4 Liquid line sight glass.
 - .5 Dual electronic expansion valves on each circuit (sized for maximum operating pressure) - One dedicated for cooling mode and one dedicated for heating mode.
 - .6 Electronic expansion valves installed with check valves
 - .7 Charging valve
 - .8 Reversing valve
 - .9 Suction line heat exchanger with refrigerant control valves.
 - .3 Full operating charge of R454B and oil.
- .10 Controls
 - .1 A color, touch sensitive liquid crystal display (LCD) shall be unit mounted and a minimum of 7" diagonal.
 - .2 Display shall consist of a menu driven interface with easy touch screen navigation to organized sub-system reports for compressor and evaporator information as well as associated diagnostics.
 - .3 The chiller control panel shall provide password protection of all setpoints with configurable user settings for each user.
 - .4 The controller shall have the ability to display all primary sub-system operational parameters on dedicated trending graphs. The operator must be able to create up to 6 additional custom trend graphs, choosing up to 10 unique parameters for each graph to trend log data parameters simultaneously over an adjustable period and frequency polling.
 - .5 Chilled water temperature control shall be microprocessor-based, proportional and integral controller to show water and refrigerant temperature, refrigerant pressure, and diagnostics. This microprocessor-based controller is to be supplied with each chiller by the chiller manufacturer.

- .6 The front of the chiller control panel shall display the following in clear language, without the use of codes, look-up tables, or gauges:
 - .1 Run time.
 - .2 Number of starts.
 - .3 Current chiller operating mode.
 - .4 Chilled water set point and set point source.
 - .5 Demand current limit set point and set point source.
 - .6 Entering and leaving evaporator water temperatures.
 - .7 Saturated evaporator and condenser refrigerant temperatures.
 - .8 Evaporator and condenser refrigerant pressure.
 - .9 Phase reversal/unbalance/single phasing and over/under voltage protection.
 - .10 Low chilled water temperature protection.
 - .11 High and low refrigerant pressure protection.
 - .12 Load limit thermostat to limit compressor loading on high return water temperature.
 - .13 Condenser fan sequencing to automatically cycle fans in response to load, expansion valve pressure, condenser pressure, and differential pressure to optimize chiller efficiency.
 - .14 Display diagnostics.
 - .15 Compressors: Status (on/off), anti-short cycle timer, and automatic compressor lead-lag.
- .7 Weatherproof control panel shall be mounted on chiller, containing starters, power and control wiring, factory wired with terminal block power connection. Provide primary and secondary fused control power transformer.
- .8 The chiller controller shall utilize a microprocessor that will automatically take action to prevent chiller shutdown due to abnormal operating conditions associated with: evaporator refrigerant temperature, high condensing pressure and motor current overload.
 - .1 Provide the following safety controls with indicating lights or diagnostic readouts:
 - .2 Low chilled water temperature protection.
 - .3 High refrigerant pressure.
 - .4 Loss of chilled water flow.
 - .5 Contact for remote emergency shutdown.
 - .6 Motor current overload.
 - .7 Phase reversal/unbalance/single phasing.
 - .8 Over/under voltage.
 - .9 Failure of water temperature sensor used by controller.
 - .10 Compressor status (on or off).
- .9 Provide the following operating controls:

- .1 A variable compressor staffing method to control capacity in order to maintain leaving chilled water temperature based on PI algorithms. Five minute solid state anti-recycle timer to prevent compressor from short cycling. Compressor minimum stop-to-start time limit shall be 2 minutes. If a greater than 5 minute start-to-start, or greater than 2 minute stop-to-start timer is included.
- .2 Chilled water pump output relay that closes when the chiller is given a signal to start.
- .3 Load limit thermostat to limit compressor loading on high return water temperature to prevent nuisance trips.
- .4 High ambient unloader pressure controller that unloads compressors to keep head pressure under control and help prevent high pressure nuisance trip outs on days when outside ambient is above design.
- .5 Low ambient lockout control with adjustable setpoint.
- .6 Condenser fan sequencing which adjusts the speed of all fans automatically in response to ambient, condensing pressure and expansion valve pressure differential thereby optimizing chiller efficiency.
- .10 Provide user interface on the front of the panel. If display is on the inside of the panel, then a control display access door shall be provided to allow access to the display without removal of panels. Provide user interface with a minimum of the following features:
 - .1 Leaving chilled water setpoint adjustment from the front panel touchscreen display.
 - .2 Entering and leaving chilled water temperature output
 - .3 Pressure output of condenser
 - .4 Pressure output of evaporator
 - .5 Ambient temperature output
 - .6 Demand limit setpoint adjustment from the front panel touchscreen display.
- .11 The chiller control panel shall provide leaving chilled water temperature reset based upon return water temperature.
- .12 Advanced Defrost Logic including Loss of Flow Logic during Defrost changeover and Warm-up Cycle
- .13 Service Pump Down Control
- .14 Active Hot Water Reset Program
- .15 Configurable Users
- .16 Multiple Languages Selectable
- .17 Metric Conversions
- .18 Customer wired 20amp, 115-volt GFCI convenience outlet shall be factory mounted on the exterior of the control panel.
- .19 Digital Communications to BAS system shall consist of a BACnet MS/TP interface via a single twisted pair wiring.
- .20 The chiller control panel shall provide input for leaving chilled water temperature setpoint based upon a 2-10VDC or 4-20mA signal from a building automation system.
- .21 The chiller control panel shall provide input for demand limit based upon a 2-10VDC or 4-20mA signal from a building automation system.
- .22 The chiller control panel shall provide an output for chiller Percent Capacity via a 2-10VDC signal to a building automation system.

- .23 The chiller control panel shall provide an alarm relay output that shall energize whenever a fault requiring manual reset is detected by the panel.
- .24 Heat Pump Chiller Plant Control
 - .1 The heat pump chiller plant control sequencer panel shall be provided by the heat pump manufacturer. The heat pump plant control panel controls and sequences all components of the heat pump plant, optimal performance of the heat pump plant can be achieved resulting in system efficiency and reduced lifecycle costs.
 - .2 Supply the heat pump chiller plant control sequencer panel with application, capable of sequencing the associated heat pumps and their respective ancillary equipment, including but not limited to pumps (constant volume and VFD), heat rejection equipment (condensing units, dry coolers, fluid coolers, cooling towers, etc), heat exchangers, sensors (e.g. temperature, pressure, etc) and other end devices (e.g. control valves, metering devices, etc.) The control panel shall be expandable for future equipment integration.
 - .3 Upon receiving a start signal from the building automation system via BACnet/IP, the Trane heat pump plant control sequencer shall operate the Air source and Water source heat pump units as well as associated pumps and sensors to provide the setpoint temperatures as per design. The set point temperatures shall be configurable in the heat pump plant sequencer control panel and available for control by the BAS via BACnet/IP. The control panel shall then perform all required functions to provide necessary hot water, chilled water, and intermediate loop temperatures and flows. All Sensors and flow meters outlined on the drawings shall be provided by and controlled by the Trane heat pump plant controls sequencer control panel.
 - .4 The Heat Pump Chiller Plant Control Panel shall perform the following functions:
 - .1 Shall have the ability to control up to 25 chillers and heat pumps
 - .2 Shall be able to control both constant and variable flow systems including variable primary flow as well as parallel, series and decoupled piping configurations.
 - .3 Shall be able to control and / or monitor ancillary equipment including but not limited to pumps, cooling towers, fluid coolers, glycol fill stations, gas leak detection equipment, etc.
 - .4 Diagnostics/Protection - shall be able to integrate individual chiller diagnostics into control action decisions.
 - .5 Event Processing - all chiller plant control and status events shall be recorded, at the operator's selection to facilitate troubleshooting.
 - .6 Alarm Indications - The chiller plant control status screens shall display chiller plant and individual chiller alarm messages.
 - .7 Rotation of Chillers based on either runtime or schedule.
 - .5 The Heat Pump Chiller Plant Control Panel supplier shall provide a published applications guide that details the chiller plant application operation, configuration, setup, and troubleshooting. The applications guide documentation shall be maintained under version control, and updated by the manufacture to reflect most recent feature updates as made available.
 - .6 The chiller plant application shall present in plain user language the current and expected operation for upcoming Add, Subtract, and Rotation events using real time status and setpoint information.

- .7 The chiller plant application shall be able to generate an ASHRAE Standard 147 Report: Provide a daily report that shows the operating condition of each chiller as required by ASHRAE Standard 147. At minimum this report shall include:
- .1 Chilled Water (or other fluid) inlet and outlet temperature
 - .2 Chilled Water (or other fluid) flow status
 - .3 Chilled Water (or other fluid) inlet and outlet pressures
 - .4 Evaporator refrigerant pressure and temperature
 - .5 Condenser refrigerant pressure and liquid temperature
 - .6 Condenser water inlet and outlet temperatures
 - .7 Condenser water flow status
 - .8 Oil pressure and temperature
 - .9 Oil level (if applicable)
 - .10 Compressor refrigerant discharge temperature
 - .11 Compressor refrigerant suction temperature
 - .12 Manual entry field for addition of refrigerant
 - .13 Manual entry field for addition of oil
 - .14 Manual entry field for vibration levels
 - .15 Motor amperes per phase
 - .16 Motor volts per phase
 - .17 Purge exhaust time or discharge count
 - .18 Ambient temperatures (dry bulb and wet bulb)
 - .19 Date and time Data Logged

.11 Sound

- .1 Acoustics: Manufacturer must provide both sound power and sound pressure data in decibels, per AHRI 370. A-weighted sound pressure at 30 feet should be provided at 100%, 75%, 50% and 25% load points to identify the full operational noise envelope.
- .2 If manufacturer cannot meet the noise levels, sound attenuation devices and/or barrier walls must be installed to meet this performance level.

.12 Options and Accessories

- .1 Chiller shall ship with elastomeric Isolators
- .2 Chiller shall have a tarp covering full chiller
- .3 Condenser drain pan

2.03 FACTORY WITNESS TESTING

- .1 For factory witness tests, the Owner or his designated representative(s) shall be notified fourteen (14) days in advance to witness the factory performance test. The Chiller Manufacturer representative shall assume all expenses incurred by the Owner or his representative(s) (up to four [4] attendees) to witness the test.
- .2 One of each size chiller shall be factory performance tested with the proposed refrigerant under full-load conditions in an AHRI certified test facility. The manufacturer shall supply a certified test report to confirm performance as specified. Proper AHRI certification documents for the manufacturer's test loop shall be made available for inspection upon request.

- .3 The factory test instrumentation shall be per AHRI Standard 550/590, and the calibration of all instrumentation shall be traceable to the National Institute of Standards and Technology (NIST, formerly NBS).

2.04 ACCEPTABLE MANUFACTURERS

- .1 Acceptable Heat Recovery Chiller Manufacturers are:
 - .1 Trane;
 - .2 York (JCI);
 - .3 McQuay;
 - .4 Carrier;
 - .5 Multi-stack
 - .6 Owner approved manufacturer.

PART 3 - EXECUTION

3.01 APPLICATION

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

3.02 GENERAL

- .1 Provide appropriate protection apparatus.
- .2 Install unit as indicated, to manufacturer's recommendations and in accordance with EPS1/RA/2.
- .3 Ensure adequate clearances for servicing and maintenance.
- .4 Manufacturer to approve installation to supervise start-up and to instruct operators.

3.03 EQUIPMENT

- .1 Chillers:
 - .1 Provide all necessary refrigerant relief lines, break away flanges, valves, pneumatic and electric control connections and piping for chiller oil cooler and purge unit as required by chiller manufacturer.
 - .2 Install pipeline thermometers and/or sensor wells as required on system side of break away flanges.
 - .3 Install in arrangements as shown on the drawings and when chiller installation consists of two units, or pairs of units, install each pair such that the control panel fronts face inward toward each other. If chiller installation is an odd number, i.e., 3 or 5, all control panel fronts to face each other as above. The odd unit panel to face the opposite side of the adjacent unit.
 - .4 Provide spacing minimum between chiller control panel fronts. Provide rear service space as required by the manufacturer but in no case less than 600mm from any component on the chiller.
 - .5 Refer to Section 20 05 10 for wiring requirements.
 - .6 Install units on a flat surface level within 1/8" and of sufficient strength to support concentrated loading with isolation spring assemblies under the units.
 - .7 Install components furnished by the manufacturer.
 - .8 Provide all water piping so unit and water circuits are serviceable without having to dismantle excessive lengths of pipe.

- .9 Provide valves in water piping upstream and downstream of the evaporator and condenser water boxes connections for isolating the shells for maintenance.
- .10 Provide drain valves and vent cocks to each water box.
- .11 Install loose temperature sensors in accordance with the manufacturer's recommendations.
- .12 Provide all necessary auxiliary water piping for oil cooler in accordance with the manufacturer's recommendations.
- .13 Provide pressure relief piping from relief valve to outside in accordance with manufacturer's instructions and CSA-B52-1992.
- .14 Provide certified wiring schematics to the electrical division for the chiller, associated equipment and controls.
- .15 Provide all necessary control wiring as recommended by the manufacturer.
- .16 Provide vapour proof flow switches in both chilled and condenser water piping interlocked to the control panel.

3.04 START UP SERVICE AND WARRANTY

- .1 **Manufacturer's Warranty:** Manufacturer shall provide full parts-only warranty coverage for entire chiller for a period of one year. All parts shall be warranted against defects in material and workmanship. Similar parts-only coverage shall be provided for the chillers compressors for a period of five years. The warranty period shall commence either on the equipment start-up date or six months after shipment, whichever is earlier.
- .2 Manufacturer shall provide the services of a Factory Authorized Service Engineer to provide complete start-up supervision. Factory Authorized Service Engineer shall also be responsible for assembly of the chillers cabinetry package and electrical bus bar system. After start-up a Manufacturer's Representative shall provide a minimum of 8-hours of operator training to the owner's designated representative(s).

3.05 COMMISSIONING

- .1 Supply the services of a factory trained representative to perform the field leak testing, dehydration, charging of refrigerant, and start-up of chiller.
- .2 The mechanical contractor will notify the manufacturer at least two weeks in advance of required commissioning date.
- .3 The manufacturer's representative shall carry-out the following functions:
 - .1 Ensure that all chilled water systems are connected and that all pumps run and control valves open to provide maximum cooling load.
 - .2 Start up chiller and check refrigerant pressures, chilled water pull down, oil pressure, condenser operation and machine cycling. Check electric power, amps draw at start-up, running amps, voltage for each phase and kilowatt draw at 100% load.
 - .3 Verify that condenser pressure controls are properly installed.

3.06 PIPING SYSTEM FLUSHING PROCEDURE

- .1 Prior to connecting the chiller to the building chilled water loop, the piping shall be flushed with a detergent and hot water (110-130° F) mixture to remove previously accumulated dirt and other organic residue. In old piping systems with heavy encrustation of inorganic materials consult a water treatment specialist for proper passivation and/or removal of these contaminants.

- .2 During the flushing a 30 mesh (max.) Y-strainers (or acceptable equivalent) shall be in place in the system piping and examined periodically as necessary to remove collected residue. The use of on board chiller strainers shall not be acceptable. The flushing process shall take no less than 6 hours or until the strainers, when examined after each flushing, are clean. Old systems with heavy encrustation shall be flushed for a minimum of 24 hours and may take as long as 48 hours before the filters run clean. Detergent and acid concentrations shall be used in strict accordance with the respective chemical manufacturer's instructions. After flushing with the detergent and/or dilute acid concentrations the system loop shall be purged with clean water for at least one hour to ensure that all residual cleaning chemicals have been flushed out.
- .3 Prior to supplying water to the chiller the Water Treatment Specification shall be consulted for requirements regarding the water quality during chiller operation. The appropriate chiller manufacturer's service literature shall be available to the operator and/or service contractor and consulted for guidelines concerning preventative maintenance and off-season shutdown procedures.

3.07 WATER TREATMENT REQUIREMENTS

- .1 Supply water for the chilled water circuit shall be analyzed and treated by a professional water treatment specialist who is familiar with the operating conditions and materials of construction specified for the chiller's heat exchangers, headers and associated piping. Cycles of concentration shall be controlled such that recirculated water quality for modular chillers using 316 stainless steel brazed plate heat exchangers and carbon steel headers is maintained within the following parameters:

.1	pH	Greater than 7 and less than 9
.2	Total Dissolved Solids (TDS)	Less than 1000 ppm
.3	Hardness as CaCO ₃	30 to 500 ppm
.4	Alkalinity as Ca CO ₃	30 to 500 ppm
.5	Chlorides	Less than 200 ppm
.6	Sulfates	Less than 200 ppm

3.08 FIELD QUALITY CONTROL

- .1 Manufacturer's Field Services:
 - .1 Have manufacturer of products supplied under this Section review work involved in handling, installation/application, protection and cleaning of its product/s, and submit written reports, in acceptable format, to verify compliance of work with Contract.
 - .2 Provide manufacturer's field services, consisting of product use recommendations and periodic site visits for inspection of product installation, in accordance with manufacturer's instructions.
 - .3 Schedule site visits to review work at stages listed:
 - .1 After delivery and storage of products and when preparatory Work, or other Work, on which the Work of this Section depends, is complete but before installation begins.
 - .2 Twice during progress of Work at 25% and 60% complete.
 - .3 Upon completion of the Work, after cleaning is carried out.
 - .4 Obtain reports, within 3 days of review and submit, immediately, to the Consultant
- .2 Upon completion of work, after cleaning is carried out.
- .3 Performance Verification:

- .1 General: Perform performance verification in accordance with Division and Sections 20 05 05 and 20 05 10 - General Commissioning (Cx) Requirements, supplemented as specified.
- .4 Verification requirements in accordance with Division 01 and include:
 - .1 Materials and resources.
 - .2 Storage and collection of recyclables.
 - .3 Construction waste management.
 - .4 Resource re-use.
 - .5 Recycled content.
 - .6 Local/regional materials.
 - .7 Low-emitting materials.

3.09 DEMONSTRATION

- .1 Training: Provide training in accordance with Division 01 and Sections 20 05 05 and 20 05 10 - General Commissioning (Cx) Requirements, supplemented as specified.

3.10 EQUIPMENT START UP

- .1 Follow manufacturer's instructions and have manufacturer's representative present to certify the installation.
- .2 Check each item of equipment to ensure proper electrical connections, etc., and to verify proper operation.

3.11 CLEANING

- .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

END OF SECTION 23 64 30

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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Mechanical Work General Instructions Section 20 05 05 and Basic Mechanical Materials and Methods Section 20 05 10.
- .3 Comply with the requirements of Section 23 05 00 Common Work Results for HVAC.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Section Includes:
 - .1 Materials and installation for self-contained multi-zone and single zone, gas, electric, hot water and refrigeration packaged rooftop HVAC units.
 - .2 Sustainable requirements for construction and verification.
- .2 Related Sections:
 - .1 Division 01
 - .2 Division 02

1.03 REFERENCES

- .1 American National Standards Institute (ANSI)/Air Conditioning and Refrigeration Institute (ARI)
 - .1 ANSI/ARI 210/240, Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
 - .2 ARI 270, Sound Rating of Outdoor Unitary Equipment.
- .2 ANSI/UL, Standard for Heating and Cooling Equipment.
- .3 Canadian Standards Association (CSA International)
 - .1 CSA B52, Mechanical Refrigeration Code.
 - .2 CSA C22.1 HB-, Canadian Electrical Code Handbook.
- .4 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).
- .5 National Fire Protection Association
 - .1 NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.

1.04 QUALITY ASSURANCE

- .1 Materials in accordance with Section 20 05 05 and 20 05 10.
- .2 Pre-Installation Meetings:
 - .1 Convene pre-installation meeting one week prior to beginning work of this Section and on-site installations in accordance with Division 01, to suit Construction Progress Schedules.
 - .1 Verify project requirements.
 - .2 Review installation and substrate conditions.
 - .3 Co-ordination with other building subtrades.
 - .4 Review manufacturer's installation instructions and warranty requirements.
- .3 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Division 01, to suit Health and Safety Requirements.

- .4 Construction requirements: In accordance with Division 01, to suit Sustainable Requirements.
- .5 Verification: Contractor's verification in accordance with Division 01, to suit Sustainable Requirements.

1.05 SUBMITTALS

- .1 Provide manufacturer's printed product literature and datasheets and include product characteristics, performance criteria, physical size, finish and limitations in accordance with Section 20 05 01. Shop Drawings to include:
 - .1 Equipment, piping, and connections, together with valves, strainers, control assemblies, thermostatic controls, auxiliaries and hardware, and recommended ancillaries which are mounted, wired and piped ready for final connection to building system, its size and recommended bypass connections.
 - .2 Piping, valves, fitting shipped loose showing final location in assembly.
 - .3 Control equipment shipped loose, showing final location in assembly.
 - .4 Dimensions, internal and external construction details, recommended method of installation with proposed structural steel support, mounting curb details, sizes and location of mounting bolt holes; include mass distribution drawings showing point loads.
 - .5 Detailed composite wiring diagrams for control systems showing factory installed wiring and equipment on packaged equipment or required for controlling devices of ancillaries, accessories, and controllers.
 - .6 Pump and fan performance curves.
 - .7 Details of vibration isolation.
 - .8 Estimate of sound levels to be expected across individual octave bands in dB referred to A rating.
 - .9 Type of refrigerant used.
- .2 Test Reports: Submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.
- .3 Certificates: Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .4 Manufacturer's Field Reports: Manufacturer's field reports specified.
- .5 Closeout Submittals
 - .1 Refer to Section 20 05 05.
 - .2 Include:
 - .1 Description of equipment giving manufacturers name, type, model year, capacity.
 - .2 Start-up and commissioning procedures.
 - .3 Details of operation, servicing and maintenance.
 - .4 Recommended spare parts list.
- .6 Spares:
 - .1 Provide maintenance materials in accordance with Division 01 and Section 25 05 01.
 - .2 Provide one spare set of filters for each filter unit or filter bank.
 - .3 Furnish spare parts data for each different item of equipment specified, after approval of detail drawings.

- .4 Include with data complete list of parts and supplies, with current unit prices, source of supply, recommended spare parts list for 1 year of operation and list of parts recommended by manufacturer to be replaced on routine basis.

1.06 DELIVERY, STORAGE AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

1.07 WARRANTY

- .1 Warranty periods for air handling equipment to start on the date of verification of acceptance issued in writing by the Consultant.
- .2 The date of verification of acceptance is independent of Substantial Performance of the Work and may occur after certification of Substantial Performance.
- .3 Air handling equipment will be accepted after start up, a minimum of six hours of logged operation and submission of written verification of same by manufacturer's representative. The Consultant may also witness a portion of any of these this procedure.
- .4 Include verification of acceptance certificates with the maintenance and operating manuals in the appropriate sections.
- .5 Provide warranties as outlined in Section 20 05 05.

PART 2 - PRODUCTS

2.01 GENERAL

- .1 The contractor shall furnish and install package rooftop unit(s) as shown and scheduled on the contract documents. The unit(s) shall be installed in accordance with this specification and perform at the specified conditions as scheduled. The unit shall include the following options: Stainless Steel Heat Exchanger, Advanced controls and BACnet capability, Tool-less condenser hail guard, a programmable zone sensor.
- .2 Packaged rooftop units cooling, heating capacities, and efficiencies are AHRI Certified within scope of AHRI Standard 210-240 for 3 to 25 Tons and ANSI Z21.47 and 10 CFR Part 431 pertaining to Commercial Warm Air Furnaces (all gas heating units).
- .3 Rooftop unit shall be factory assembled, internally wired, fully charged with R-454B, and 100 percent run tested to check cooling operation, fan and blower rotation, and control sequence before leaving the factory.
- .4 All units, 3-25T shall have field convertible airflow.
- .5 Internal wiring must be colored and numbered for simplified identification.
- .6 Symbio controls operating range shall be between 0°F and 125°F in cooling mode.
- .7 Acceptable manufacturers: Trane or equal.

2.02 UNIT CASING

- .1 Cabinet: Galvanized steel with baked enamel finish.
- .2 Rooftop unit casing shall be zinc coated, heavy gauge, steel. Casing panels are weather resistant pre-painted metal with galvanized substrate and meet ASTM B117, 672 hour salt spray test.
- .3 Cabinet top cover shall be one piece construction or where seams exists, it shall be double-hemmed and gasket-sealed.
- .4 Unit shall include a removable single side maintenance access panels. Lifting handles in maintenance access panels can be removed and reinstalled by removing fasteners while providing a water and air tight seal.

- .5 Unit's base pan shall have a raised 1 1/8 inch high lip around the supply and return openings for water integrity.
- .6 Exposed vertical panels and top covers in the indoor air section are insulated with a cleanable foil-faced, fire-retardant permanent, odorless glass fiber material.
- .7 Base pan shall have no penetrations within the perimeter of the curb other than the raised 1 inch high downflow supply/return openings to provide an added water integrity precaution, if the condensate drain backs up.
- .8 Base of the unit is insulated with 1/8 inch, foil-faced, closed-cell insulation.
- .9 Provide openings either on side of unit or through the base for power, control, condensate, and gas connections.
- .10 Unit base shall contain provisions for forklift and/or crane lifting on three sides of unit.

2.03 PANELS AND FILTERS

- .1 2-inch MERV 13 filters with Hinged Panels.

2.04 FANS AND MOTORS

- .1 Supply fan shall be either a direct drive plenum fan with backward-curved fan wheel with an external rotor direct drive variable speed motor, or a variable direct propeller forward curved centrifugal fan.
- .2 Supply fan speed adjustments can be made using the control user interface or mobile app.
- .3 Provide Fan Fail indication. The indication will be registered at the on-board user interface, mobile service app., or building management system.
- .4 Variable speed direct drive motors are premium efficiency – 3 to 25 tons.
- .5 Motors are thermally protected.
- .6 Outdoor fans shall be direct drive, statically and dynamically balanced, draw through in the vertical discharge position. Outdoor motors shall be 3 phase.
- .7 Provide shafts constructed of solid hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.

2.05 GAS FIRED HEATING SECTION

- .1 The heating section shall have a progressive tubular heat exchanger with corrosion-resistant aluminized steel tubes and stainless steel burners throughout.
- .2 On initial call for heat, the combustion blower shall purge the heat exchanger for 20 seconds before ignition.
- .3 Completely assembled and factory installed heating system shall be integral to unit, UL or CSA approved specifically for outdoor applications for use downstream from refrigerant cooling coils. Threaded connection with plug or cap provided.
- .4 Heating section shall be factory run tested prior to shipment.
- .5 Induced draft combustion blower shall be used to pull the combustion products through the firing tubes. System shall use direct spark ignition (DSI).
- .6 After three unsuccessful ignition attempts, entire heating system shall be locked out until manually reset at the thermostat/zone sensor.
- .7 Induced draft blower to pull the gas mixture through the burner tubes.
- .8 Compact cabinet features a tubular heat exchanger in low, medium and high heat capacities. Corrosion-resistant aluminized steel tubes and burners are standard on all models.
- .9 Limit controls: High temperature limit controls will shut off gas flow in the event of excessive temperatures resulting from restricted indoor airflow or loss of indoor airflow.

- .10 Units shall be suitable for use with natural gas or propane (field-installed kit).

2.06 EVAPORATOR COIL

- .1 Heat pump evaporators shall be 5/16" copper tubes mechanically bonded to a configured aluminum plate fin.
- .2 Provide a removable, reversible, cleanable double sloped drain pan for base of evaporator coil constructed of PVC.
- .3 Coil shall be leak tested to 600psig.

2.07 CONDENSER SECTION

- .1 Provide vertical discharge, direct drive fans with aluminum blades. Fans shall be statically balanced. Motors shall be permanently lubricated, with integral thermal overload protection in a weather tight casing.
- .2 Heat pump condensers shall be 5/16" copper tubes mechanically bonded to a configured aluminum plate fin.
- .3 Provide tool-less factory installed corrosion resistant louvered hail/vandalism guards to protect condenser coils from hail or physical damage.

2.08 REFRIGERATION SYSTEM

- .1 All units have direct-drive, hermetic, scroll type compressors with centrifugal type oil pumps. Suction gas-cooled motor with voltage utilization range of plus or minus 10 percent of unit nameplate voltage. Internal overloads standard with scroll compressors. Crankcase heaters are standard on all compressors.
- .2 Compressors shall have thermostatic temperature motor winding control for protection against excessive temperatures caused by over/under voltage operation or loss of charge. Also provide high and low pressure switches.
- .3 Thermal Expansion valves are standard for all models.
- .4 All units have dual compressors.
- .5 Units shall have cooling capabilities down to 0 degree F as standard. For field-installed low ambient accessory, the manufacturer shall provide a factory-authorized service technician that will assure proper installation and operation.
- .6 For heat pump units, provide reversing valve, discharge muffler, flow control check valve, and electronic temperature initiated demand defrost.
- .7 Three stages of cooling available on 6 to 17.5 tons units and four stages of cooling available on 20 and 25 ton units.

2.09 EXHAUST/RETURN SECTION

- .1 Provide barometric relief gravity type dampers to operate in conjunction with a dry bulb economizer to provide exhaust.

2.10 OUTDOOR AIR SECTION

- .1 Units shall be available with barometric relief.
- .2 Barometric relief shall provide a pressure operated damper that shall be gravity closing.
- .3 Barometric relief shall prohibit entrance of outside air during the equipment "off" cycle.
- .4 Motorized outside air damper, once set, when indoor fan starts, outdoor air dampers shall open to set position. When indoor fan shuts down, damper shall close to the full closed position.
- .5 Provide spring return motor for outside air damper closure during unit shut down or power interruption.

- .6 Provide microprocessor unit-mounted control which when used with a wireless zone sensor provides proportional integral room control. This UCM shall perform all unit functions by making all heating, cooling and ventilating decisions through resident software logic.
- .7 Provide factory-installed indoor evaporator defrost control to prevent compressor slugging by interrupting compressor operation.
- .8 Provide a anti-cycle timing and minimum on/off between stages timing in the microprocessor.

2.11 SYSTEM CONTROL

- .1 Multi-Speed Indoor fan System- unit shall be provided with indoor fan system designed for use in applications for meeting the minimum requirements of CA Title 24. This system incorporates a multi-speed fan control to change speed of the fan to 66% of full airflow based off of compressor stages.
- .2 RTUs to come with advanced controls, capable of communicating to a building automation system, and zone sensor wirelessly.

2.12 BUILDING MANAGEMENT SYSTEM

- .1 Connection to Building Management System to be furnished by rooftop unit manufacturer. Through this interface, all Building Management functions (specified in Building Management Section) shall be performed. See Building Automation and Automatic Temperature Control System Specifications. The only field connection to Building Management System shall be a single communication link.
- .2 Control Functions: Include unit scheduling, occupied/unoccupied mode, start-up and coast-down modes, nighttime free-cool purge mode, demand limiting, night setback, discharge air set point adjustment, timed override and alarm shutdown.
 - .1 Leak Detection Sensors
- .3 Unit shall be furnished with a leak detection system from the factory when a circuit refrigerant charge exceeds 3.91 lbs. The leak detection system shall consist of one or more refrigerant detection sensors. When the system detects a leak, the unit controller shall initiate mitigation actions.

PART 3 - EXECUTION

3.01 MANUFACTURER'S INSTRUCTIONS

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

3.02 INSTALLATION

- .1 Install as per manufacturers' instructions on roof curbs.
- .2 Manufacturer to certify installation, supervise start-up and commission unit.
- .3 Run drain line from cooling coil condensate drain pan to discharge.

3.03 FIELD QUALITY CONTROL

- .1 Manufacturer's Field Services:
 - .1 Have manufacturer of products, supplied under this Section, review Work involved in the handling, installation/application, protection and cleaning, of its product/s and submit written reports, in acceptable format, to verify compliance of Work with Contract.
 - .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
 - .3 Schedule site visits, to review Work, at stages listed:

- .1 After delivery and storage of products and when preparatory Work, or other Work, on which the Work of this Section depends, is complete but before installation begins.
- .2 Twice during progress of Work at 25% and 60% complete.
- .3 Upon completion of the Work, after cleaning is carried out.
- .4 Obtain reports, within 3 days of review and submit, immediately, to the Consultant
- .2 Verification requirements in accordance with Division 01 and include:
 - .1 Materials and resources.
 - .2 Storage and collection of recyclables.
 - .3 Construction waste management.
 - .4 Resource re-use.
 - .5 Recycled content.
 - .6 Local/regional materials.
 - .7 Certified Wood.
 - .8 Low-emitting materials.
- .3 Verify accessibility, serviceability of components including motorized dampers, filters coils, fans, motors, operators, humidifiers, sensors, electrical disconnects.
- .4 Verify accessibility, cleanability, drainage of drain pans for coils, humidifiers.
- .5 Performance Verification:
 - .1 General:
 - .1 In accordance with Section 20 05 70 - Water Treatment, supplemented as specified herein.
 - .2 Rooftop Air Handling Units:
 - .1 Set zone mixing dampers for full cooling, except that where diversity factor forms part of design set that % of zone dampers to full heating.
 - .2 Set outside air and return air dampers for minimum outside air.
 - .3 Set face and bypass dampers so face dampers are fully open and bypass dampers are fully closed.
 - .4 Check for smooth, vibration less correct rotation of supply fan impeller.
 - .5 Measure supply fan capacity.
 - .6 Adjust impeller speed as necessary and repeat measurement of fan capacity.
 - .7 Measure pressure drop each component of air handling unit.
 - .8 Set outside air and return air dampers for the % of outside air required by design and repeat measurements of fan capacity.
 - .9 Reduce differences between fan capacity at minimum and maximum outside air less than 5%.
 - .10 Set face and bypass dampers to full bypass and repeat measurement of fan capacity.
 - .11 Reduce difference between fan capacity with F&BPD fully closed to bypass and fully open to bypass to less than 5%.

- .12 Reduce difference between fan capacity at full cooling and fan capacity at full heating to less than 5%.
- .13 OAD: verify for proper stroking, interlock with RAD.
- .14 Measure DBT, WBT of SA, RA, EA.
- .15 Measure air cooled condenser discharge DBT.
- .16 Measure flow rates (minimum and maximum) of SA, RA, EA, relief air.
- .17 Simulate maximum cooling load and measure refrigerant hot gas and suction temperatures and pressures.
- .18 Use smoke test to verify no short-circuiting of EA, relief air to outside air intake or to condenser intake.
- .19 Simulate maximum heating load and:
 - .1 Verify temperature rise across heat exchanger.
 - .2 Perform flue gas analysis. Adjust for peak efficiency.
 - .3 Verify combustion air flow to heat exchanger.
 - .4 Simulate minimum heating load and repeat measurements.
- .20 Measure radiated and discharge sound power levels under maximum heating demand and under maximum cooling demand with compressors running.
- .21 Verify operating control strategies, including:
 - .1 Heat exchanger operating and high limit.
 - .2 Early morning warm-up cycle.
 - .3 Freeze protection.
 - .4 Economizer cycle operation, temperature of change-over.
 - .5 Alarms.
 - .6 Voltage drop across thermostat wiring.
 - .7 Operation of remote panel including pilot lights, failure modes.
- .22 Set zone mixing dampers for full heating and repeat measurements.
- .23 Measure leakage past zone mixing dampers by taking temperature measurements. Reduce leakage to less than 5%.
- .24 Measure return fan capacity.
- .25 Adjust impeller speed as necessary and repeat measurement of return fan capacity.
- .26 Check capacity of heating unit.
- .27 Measure DX refrigeration system performance as specified Section.
- .28 Refer to other sections of these specifications for PV procedures for other components.
- .3 Start-Up:
- .4 Verify accessibility, serviceability of components including motorized dampers, filters coils, fans, motors, operators, humidifiers, sensors, electrical disconnects.
- .5 Verify accessibility, clean ability, drainage of drain pans for coils, humidifiers.
- .6 Commissioning Reports:

- .1 In accordance with Division and Sections 20 05 05 and 20 05 10 - General Commissioning (Cx) Requirements, supplemented as specified herein. Include:

- .1 Report Forms and Schematics.

3.04 DEMONSTRATION

- .1 Training: Provide training in accordance with Division 01 and Sections 20 05 05 and 20 05 10 - General Commissioning (Cx) Requirements, supplemented as specified.

3.05 CLEANING

- .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

END OF SECTION 23 74 00

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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Mechanical Work General Instructions Section 20 05 05 and Basic Mechanical Materials and Methods Section 20 05 10.
- .3 Comply with the requirements of Section 23 05 00 Common Work Results for HVAC.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Section Includes:
 - .1 Materials and installation for self-contained, belt driven energy recovery ventilator.
 - .2 Sustainable requirements for construction and verification:
- .2 Related Sections:
 - .1 Division 01
 - .2 Division 02

1.03 REFERENCES

- .1 American National Standards Institute (ANSI)/Air Conditioning, Heating and Refrigeration Institute (AHRI)
 - .1 ANSI/AHRI 1060, Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment.
 - .2 ANSI/AHRI 270, Sound Rating of Outdoor Unitary Equipment.
- .2 American National Standards Institute (ANSI)/Air Movement and Control Association (AMCA)
 - .1 ANSI/AMCA 204, Balance Quality and Vibration Levels for Fans.
- .3 American Society of Heating, Refrigeration and Air Condition Engineers (ASHRAE)
 - .1 ANSI/ASHRAE 90.1, (I-P) Energy Standard for Buildings Except Low-Rise Residential Buildings.
 - .2 ANSI/ASHRAE 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
- .4 Canadian Standards Association (CSA International)
 - .1 CSA C22.1 HB, Canadian Electrical Code Handbook.
- .5 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).
- .6 National Fire Protection Association
 - .1 NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.

1.04 QUALITY ASSURANCE

- .1 Materials in accordance with Section 20 05 05 and 20 05 10.
- .2 Pre-Installation Meetings:
 - .1 Convene pre-installation meeting one week prior to beginning work of this Section and on-site installations in accordance with Division 01, to suit Construction Progress Schedules.
 - .1 Verify project requirements.
 - .2 Review installation and substrate conditions.

- .3 Co-ordination with other building subtrades.
- .4 Review manufacturer's installation instructions and warranty requirements.
- .3 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Division 01, to suit Health and Safety Requirements.
- .4 Construction requirements: In accordance with Division 01, to suit Sustainable Requirements.
- .5 Verification: Contractor's verification in accordance with Division 01, to suit Sustainable Requirements.

1.05 SUBMITTALS

- .1 Provide manufacturer's printed product literature and datasheets and include product characteristics, performance criteria, physical size, finish and limitations in accordance with Section 20 05 01. Shop Drawings to include:
 - .1 Equipment and connections, together with control assemblies, thermostatic controls, auxiliaries and hardware, and recommended ancillaries which are mounted, wired and piped ready for final connection to building system.
 - .2 Control equipment shipped loose, showing final location in assembly.
 - .3 Dimensions, internal and external construction details, recommended method of installation with proposed structural steel support, mounting curb details, sizes and location of mounting bolt holes; include mass distribution drawings showing point loads.
 - .4 Detailed composite wiring diagrams for control systems showing factory installed wiring and equipment on packaged equipment or required for controlling devices of ancillaries, accessories, and controllers.
 - .5 Fan performance curves.
 - .6 Details of vibration isolation.
 - .7 Estimate of sound levels to be expected across individual octave bands in dB referred to A rating.
- .2 Test Reports: Submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.
- .3 Certificates: Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .4 Manufacturer's Field Reports: Manufacturer's field reports specified.
- .5 Closeout Submittals
 - .1 Refer to Section 20 05 05.
 - .2 Include:
 - .1 Description of equipment giving manufacturers name, type, model year, capacity.
 - .2 Start-up and commissioning procedures.
 - .3 Details of operation, servicing and maintenance.
 - .4 Recommended spare parts list.
- .6 Spares:
 - .1 Provide maintenance materials in accordance with Division 01 and Section 25 05 01.

- .2 Provide one spare set of filters for each filter unit or filter bank.
- .3 Furnish spare parts data for each different item of equipment specified, after approval of detail drawings.
- .4 Include with data complete list of parts and supplies, with current unit prices, source of supply, recommended spare parts list for 1 year of operation and list of parts recommended by manufacturer to be replaced on routine basis.

1.06 DELIVERY, STORAGE AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

1.07 WARRANTY

- .1 Warranty periods for air handling equipment to start on the date of verification of acceptance issued in writing by the Consultant.
- .2 The date of verification of acceptance is independent of Substantial Performance of the Work and may occur after certification of Substantial Performance.
- .3 Air handling equipment will be accepted after start up, a minimum of six hours of logged operation and submission of written verification of same by manufacturer's representative. The Consultant may also witness a portion of any of these this procedure.
- .4 Include verification of acceptance certificates with the maintenance and operating manuals in the appropriate sections.
- .5 Provide warranties as outlined in Section 20 05 05.

PART 2 - PRODUCTS

2.01 GENERAL

- .1 Provide commercial energy recovery ventilator (ERV) consisting of fans and an enthalpy core with capacities and characteristics as described in the Equipment Schedules and in the following:
 - .1 Bolted construction utilizing corrosion resistant fasteners.
 - .2 Minimum 22 gauge galvanized steel, bolted to a minimum 18 gauge galvanized roof curb with insulation.
 - .3 Unit shall be painted with white baked enamel outside finish, removable access panels and supply and exhaust hoods with bird screens.
 - .4 Top, side, and interior panels insulated utilizing 1" thick, three-pound density foil faced insulation, manufactured and tested to meet NFPA 90A and UL 181 requirements.
 - .1 Insulation to be fastened to the panels with weatherproof adhesive and weld pins.
 - .5 Separate blower and motor for supply and exhaust air streams.
 - .2 Assemblies to be mounted on rubber vibration isolators.
 - .6 Two inch (2") thick, 30 percent efficient pleated filters in supply and exhaust air streams.
 - .7 Removable side panels for easy access to motors, blowers, filters and energy recovery wheel.
 - .8 Engrave aluminum nameplate indicating design CFM, static pressure, and maximum fan RPM.
 - .9 MERV 8 filters on exhaust and MERV 13 on supply.
 - .10 Provide integral Fresh air bypass damper.
- .2 Other acceptable manufacturers: VanEE, Cook.

2.02 FAN

- .1 Fan wheel shall be DWDI centrifugal forward curved type, constructed of painted steel. Wheel shall be balanced in accordance with AMCA Standard 204-05, Balance Quality and Vibration Levels for Fans.
- .2 Motor shall be NEMA design B with Class B insulation rated for continuous duty and furnished at the specified voltage, phase and enclosure.
- .3 ECM motor shall be provided.
- .4 Bearings shall be permanently lubricated, sealed ball type selected for a minimum L50 life in excess of 200,000 hours at maximum catalogued operating speed.

2.03 CONTROLS AND ELECTRICAL

- .1 All internal electrical components shall be pre-wired for a single point power connection.
- .2 Internal control panel shall be UL listed with hinged access door and interlocking NEMA 3R disconnect switch.
- .3 Each motor shall have a motor starter combination providing fuseless disconnect, over-current, overload and motor starting functions.
- .4 A 24V circuit shall be provided to allow remote on/off control of ERV by building control system.
- .5 Short circuit protection shall be provided on primary and secondary of control power transformer.

PART 3 - EXECUTION

3.01 MANUFACTURER'S INSTRUCTIONS

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

3.02 INSTALLATION

- .1 Install as per manufacturers' instructions on roof curbs as indicated.
- .2 Manufacturer to certify installation, supervise start-up and commission unit.

3.03 FIELD QUALITY CONTROL

- .1 Manufacturer's Field Services:
 - .1 Have manufacturer of products, supplied under this Section, review Work involved in the handling, installation/application, protection and cleaning, of its product/s and submit written reports, in acceptable format, to verify compliance of Work with Contract.
 - .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
 - .3 Schedule site visits, to review Work, at stages listed:
 - .1 After delivery and storage of products and when preparatory Work, or other Work, on which the Work of this Section depends, is complete but before installation begins.
 - .2 Twice during progress of Work at 25% and 60% complete.
 - .3 Upon completion of the Work, after cleaning is carried out.
 - .4 Obtain reports, within 3 days of review and submit, immediately, to the Consultant
- .2 Verification requirements in accordance with Division 01 and include:
 - .1 Materials and resources.
 - .2 Storage and collection of recyclables.

- .3 Construction waste management.
- .4 Resource re-use.
- .5 Recycled content.
- .6 Local/regional materials.
- .7 Certified Wood.
- .8 Low-emitting materials.
- .3 Verify accessibility, serviceability and cleanability of components including motorized dampers, filters, fans, motors, operators, sensors, and electrical disconnects.
- .4 Performance Verification:
 - .1 Rooftop Energy Recovery Ventilators:
 - .1 Check for smooth, vibration less correct rotation of supply fan impeller.
 - .2 Measure supply fan capacity.
 - .3 Adjust impeller speed as necessary and repeat measurement of fan capacity.
 - .4 Measure pressure drop each component of air handling unit.
 - .5 Verify operating control strategies, including:
 - .1 Heat wheel operating and high limit.
 - .2 Early morning warm-up cycle.
 - .3 Freeze protection.
 - .4 Alarms.
 - .5 Voltage drop across thermostat wiring.
 - .6 Operation of remote panel including pilot lights, failure modes.
 - .6 Measure exhaust fan capacity.
 - .7 Adjust impeller speed as necessary and repeat measurement of exhaust fan capacity.
 - .8 Refer to other sections of these specifications for PV procedures for other components.
 - .5 Commissioning Reports:
 - .1 In accordance with Division and Sections 20 05 05 and 20 05 10 - General Commissioning (Cx) Requirements, supplemented as specified herein. Include:
 - .1 Report Forms and Schematics.
- 3.04 DEMONSTRATION
 - .1 Training: Provide training in accordance with Division 01 and Sections 20 05 05 and 20 05 10 - General Commissioning (Cx) Requirements, supplemented as specified.
- 3.05 CLEANING
 - .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

END OF SECTION 23 74 20

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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Comply with Requirements of Division 01, General Requirements and all documents referred to therein.
- .2 Comply with requirements of Mechanical Work General Instructions Section 20 05 05 and Basic Mechanical Materials and Methods Section 20 05 10.
- .3 Comply with the requirements of Section 23 05 00 Common Work Results for HVAC.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Section Includes:
 - .1 Materials and installation for self-contained air and water source heat pumps.
 - .2 Sustainable requirements for construction and verification.
- .2 Related Sections:
 - .1 Division 01
 - .2 Division 02

1.03 REFERENCES

- .1 Air-Conditioning and Refrigeration Institute (ARI)
 - .1 ARI 210/240, Standard for Unitary Air Conditioning and Air-Source Heat Pump Equipment.
 - .2 ARI 325, Standard for Ground Water - Source Heat Pumps.
- .2 American National Standards Institute/Air-Conditioning and Refrigeration Institute (ANSI/ARI)
 - .1 ANSI/ARI 320, Standard for Water-Source Heat Pumps.
- .3 American National Standards Institute/National Fire Protection Association (ANSI/NFPA)
 - .1 ANSI/NFPA 90A, Installation of Air Conditioning and Ventilating Systems.
- .4 American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)
 - .1 ASHRAE Standard 15, Safety Standard for Refrigeration Systems.
- .5 Canadian Standards Association (CSA International)
 - .1 CAN/CSA-C13256-1-03 (R2016), Water-Source Heat Pumps - Testing and Rating for Performance.
 - .2 CAN/CSA-C656-14, Performance Standard for Single Package Central Air Conditioners and Heat Pumps.
- .6 Environment Canada, (EC)/Environmental Protection Services (EPS)
 - .1 EPS 1/RA/2, Code of Practice for Elimination of Fluorocarbons Emissions from Refrigeration and Air Conditioning Systems.
 - .2 Environment Canada, Ozone-Depleting Substances Alternatives and Suppliers List.

1.04 QUALITY ASSURANCE

- .1 Heat pumps: EPS 1/RA/2, CSA approved and carry AHRI certification.
- .2 Materials in accordance with Section 20 05 05 and 20 05 10.
- .3 Pre-Installation Meetings:
 - .1 Convene pre-installation meeting one week prior to beginning work of this Section and on-site installations in accordance with Division 01, to suit Construction Progress Schedules.
 - .1 Verify project requirements.

- .2 Review installation and substrate conditions.
- .3 Co-ordination with other building subtrades.
- .4 Review manufacturer's installation instructions and warranty requirements.
- .4 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Division 01, to suit Health and Safety Requirements.
- .5 Construction requirements: In accordance with Division 01, to suit Sustainable Requirements.
- .6 Verification: Contractor's verification in accordance with Division 01, to suit Sustainable Requirements.

1.05 SUBMITTALS

- .1 Provide manufacturer's printed product literature and datasheets and include product characteristics, performance criteria, physical size, finish and limitations in accordance with Section 20 05 01. Shop Drawings to include:
 - .1 Capacities.
 - .2 ARI Ratings.
 - .3 Sound Power levels.
 - .4 Installation instructions.
 - .5 Start-up Instructions.
 - .6 O&M, Instructions.
- .2 Test Reports: Submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.
- .3 Certificates: Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .4 Manufacturer's Field Reports: Manufacturer's field reports specified.
- .5 Closeout Submittals
 - .1 Refer to Section 20 05 05.
 - .2 Include:
 - .1 Description of equipment giving manufacturers name, type, model year, capacity.
 - .2 Start-up and commissioning procedures.
 - .3 Details of operation, servicing and maintenance.
 - .4 Recommended spare parts list.
- .6 Spares:
 - .1 Provide maintenance materials in accordance with Division 01 and Section 25 05 01.
 - .2 Provide one spare set of filters for each filter unit or filter bank.
 - .3 Furnish spare parts data for each different item of equipment specified, after approval of detail drawings.
 - .4 Include with data complete list of parts and supplies, with current unit prices, source of supply, recommended spare parts list for 1 year of operation and list of parts recommended by manufacturer to be replaced on routine basis.

1.06 DELIVERY, STORAGE AND HANDLING

- .1 Do Delivery, Storage and Handling in accordance with Section 20 05 05 - Mechanical Work General Instructions.

1.07 WARRANTY

- .1 Warranty periods for air handling equipment to start on the date of verification of acceptance issued in writing by the Consultant.
- .2 The date of verification of acceptance is independent of Substantial Performance of the Work and may occur after certification of Substantial Performance.
- .3 Air handling equipment will be accepted after start up, a minimum of six hours of logged operation and submission of written verification of same by manufacturer's representative. The Consultant may also witness a portion of any of these this procedure.
- .4 Include verification of acceptance certificates with the maintenance and operating manuals in the appropriate sections.
- .5 Provide warranties as outlined in Section 20 05 05.

PART 2 - PRODUCTS

2.01 HEAT PUMPS – WATER SOURCE

- .1 Furnish and install Trane or approved equal, Horizontal Water Source Heat Pumps as indicated on the plans and Equipment Schedules. Equipment shall be completely assembled, piped and internally wired, and in accordance with the following Specifications
- .2 Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - .1 Trane
 - .2 Or approved equal
- .3 Description: Packaged water-source heat pump with temperature controls; factory assembled, tested, and rated according to ASHRAE/AHRI/ISO-13256-1.

Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.
 - .1 Products shall be designed, rated, and certified in accordance with ISO-AHRI 13256-1. Units shall meet the efficiency standards of the ASHRAE 90.1 – 2016.
 - .2 Products shall be designed, rated and certified in accordance with ETL, CETL and ISO-AHRI 13256-1. Units shall meet the efficiency standards of the ASHRAE 90.1 2016 standard.
- .4 GENERAL UNIT DESCRIPTION
 - .1 The unit frame shall be constructed of zinc coated, heavy-gauge, galvanized steel. The panels are acoustically insulated with ½ inch matte faced glass fiber insulation [option: foil faced insulation with no exposed edges to prevent glass fiber in the airstream]. The insulation shall be UL listed and meets NFPA-90A and UL 181 standards.
 - .2 The manufacturer's maintenance instructions shall describe the proper cleaning procedure for the unit. Access for inspection and cleaning of the unit drain pan, coils and fan section shall be provided. The unit shall be installed for proper access. Procedures for proper access, inspection and cleaning of the unit shall be included in the maintenance manual.
 - .3 All units shall be factory test operated prior to shipping.
 - .4 Horizontal units shall be arranged for back, left, or right discharge. The discharge must also be capable of being changed in the field.
 - .5 Vertical units shall have either Top or Back supply-air with Left or Right return-air.

- .6 Units shall be provided with 2" MERV13
 - .1 Vertical units: A ducted filter rack shall be factory mounted for the use of 1 or 2 inch filters and shall provide easy access to the filters from the side of the filter rack through a door that does not require a tool. Duct collars will be built into the filter rack to provide an easy means to connect the duct work to the unit.
 - .2 Horizontal unit: A ducted filter rack shall be factory mounted for the use of 1 or 2 inch filters and shall provide easy access to the filters from the top or bottom of the filter rack through a door that does not require a tool. Duct collars will be built into the filter rack to provide an easy means to connect the duct work to the unit.
- .7 Drain Pan
 - .1 A stainless steel unit drain pan shall be provided. The stainless steel material shall meet the requirements of ASTM A480/A480M and comply with the chemical composition requirements of ASTM A240 - 304. The drain pan shall be insulated to prevent moisture accumulation on the drain pan material. The drain pan insulation material shall be suitable to be used in the airflow and consists of closed cell elastomeric insulation, complying with flammability requirements of UL94-5V
 - .2 The unit as standard will ship with a solid state electronic switch or manufacturer's standard condensate overflow switch complying with UL 508.
- .8 Sound attenuation shall be applied as a standard feature in the product design.
 - .1 A sound reduction package shall include vibration isolation to the compressor and water-to-refrigerant coil, compressor blanket, unit base stiffeners, insulated metal compressor enclosure, and a second stage of vibration isolation to the compressor and water-to-refrigerant base pan.
 - .2 Acoustical data obtained in accordance with AHRI 260. Sound power data must be provided at jobsite operating conditions, including CFM and total external static pressure.
- .5 COMPRESSOR
 - .1 The unit shall have a have Two-Stage high efficiency scroll type compressor. The compressor shall be dually isolated. External vibration isolation is provided by rubber mounting devices located underneath the mounting base of the compressor. A second isolation of the refrigerant assembly shall be provided under the compressor mounting base. Internal thermal overload protection shall be provided. Protection against excessive discharge pressure is provided by means of a high-pressure switch. Protection against a loss of charge is provided by low-pressure safety.
- .6 SUPPLY AIR FAN AND MOTOR ASSEMBLY
 - .1 Fan shall be a forward-curved centrifugal wheel style constructed of corrosion resistant galvanized material. The fan is placed in a draw-thru configuration and is arranged for top, back or side supply air. This assembly shall attach the wheel and motor to the fan housing providing single side service access.
 - .2 All fan motors shall be ECM variable speed motors with electronic overload protection. The motor shall be programmed to provide soft starting and a constant torque over a range of static pressures and airflows. The motor shall contain a quick disconnect plug.
 - .3 Removal of the motor and fan wheel shall be made with the assistance of a factory provided orifice ring assembly. This assembly shall attach the wheel and motor to the fan housing providing single side service access.
 - .4 The fan assembly on horizontal units shall be arranged for back, left, or right discharge. The discharge must also be capable of being changed in the field.

- .5 Removal of the motor and fan wheel shall be made with the assistance of a factory provided orifice ring assembly. This assembly shall attach the wheel and motor to the fan housing providing single side service access.
- .7 REFRIGERANT CIRCUIT
 - .1 All units shall have a sealed refrigerant circuit that is charged with R-454B refrigerant. The unit will have a bi-directional thermostatic expansion valve that allows equipment operation between 25- and 120-degrees F entering fluid temperature.
 - .2 The water-to-refrigerant heat exchanger shall be of a high quality co-axial coil for maximum heat transfer. Brazed plate heat exchanger type shall not be acceptable. The copper coil shall be deeply fluted to enhance heat transfer and minimize fouling and scaling. The coil shall have a working pressure of 600 psig on the refrigerant side and 400 psig on the water side.
 - .1 Insulated water to refrigerant heat exchanger and suction line. The water-to-refrigerant heat exchanger, water lines, and refrigerant suction lines shall be insulated to prevent condensation at low temperatures below 60F degrees.
 - .3 The air-to-refrigerant coil shall contain copper tubes mechanically expanded into evenly spaced aluminum fins. All coils are to be leak tested. The proof must be performed at 650 psig operating pressure and the leak test at 450 psig operating pressure with helium. In addition, the tubes are to be completely evacuated of air prior to shipment. The refrigerant coil distributor assembly shall be of orifice style with round copper distributor tubes. The tubes shall be sized consistently with the capacity of the coil. Suction headers shall be fabricated from rounded copper pipe.
 - .4 Access ports shall be factory supplied within the refrigerant circuit on the high- and low-pressure sides for easy refrigerant pressure or temperature testing. A filter drier shall be provided and factory installed within the refrigerant circuit. Protection against excessive discharge pressure and loss of charge shall be provided.
 - .5 Units shall come standard with a reversing valve for heating and cooling operation. The reversing valve is a pilot operating sliding piston type with replaceable encapsulated magnetic coil. This valve shall be energized in cooling. Refrigerant Metering shall be accomplished with a Bi-directional thermal expansion valve (TXV) as standard. Capillary tubes are not acceptable.
 - .6 All water lines that are located in the indoor air stream shall be insulated with 3/8-inch-thick elastomeric insulation. The refrigerant lines that are located in the indoor air stream that are not directly over the drain pan area shall be insulated with 3/8-inch-thick elastomeric insulation.
- .8 ELECTRICAL
 - .1 The factory tested and installed control panel shall contain all necessary devices to allow heating and cooling operation of the equipment to occur from a remote wall thermostat or zone sensor. These devices shall be as follows:
 - .1 24 Vac energy limiting class II [50 VA (minimum) transformer.
 - .2 24 Vac compressor contactor for compressor control
 - .3 Field thermostat connections shall be provided for ease of hook-up to terminal locations located in the unit's control box.
 - .4 Lockout function controls excessive cycling of the compressor shall be provided to protect
 - .5 the compressor during adverse operating conditions. The device may be reset by interrupting

- .6 power to the 24 Vac control circuit. Reset may be done either at a remote thermostat or
 - .7 through a momentary main power interruption for units with thermostat controls. For units
 - .8 with DDC controls, the reset can be reset at the zone sensor (with an off switch) or a service
 - .9 tool.
 - .10 A high-pressure switch shall protect the compressor against operation at refrigerant system
 - .11 pressures exceeding 600 psig.
 - .12 Factory installed wire harness shall be available for the Deluxe 24 or Symbio 400(B) control packages.
 - .13 A Disconnect Switch shall be unit-mounted and easily accessed from the front of the unit. The disconnect switch can be locked in the off position with one padlock. The disconnect switch is UL508 listed.
 - .2 A single point power connection shall be provided which will power the entire unit including the controls, compressor, blower motor and all installed options.
- .9 **CONTROLS**

Unit control box shall contain necessary devices to allow heating and cooling operation to occur from a remote mounted zone sensor. Devices shall be as follows:

- .1 A microprocessor based terminal unit controller that provides accurate, pressure independent control through the use of a proportional integral control algorithm and direct digital control (DDC) technology. The controller shall be factory-wired, factory tested, and factory-commissioned. Each WSHP unit shall have control logic for standalone control or BAS integration via the BACnet™ MS/TP protocol. Control of the compressor and supply air fan motor shall be provided by the unit controller to optimize energy efficiency and comfort.
 - .1 The controller shall have the ability to control to four set points:
 - .1 Occupied
 - .2 Occupied standby
 - .3 Occupied bypass
 - .4 Unoccupied
 - .2 Controller shall also provide anti-short cycle compressor protection, random start delay, filter maintenance timer, timed override, isolation valve control (two position), condensate overflow protection, high- and low-pressure protection, low water temperature sensor, diagnostics, test mode for troubleshooting, and dehumidification mode (if specified or scheduled).
 - .3 At a minimum a 75 VA transformer will be provided with a fuse for component safety.
 - .4 Brownout protection will protect the unit from a low voltage condition. Once low voltage has occurred, the anti-short cycle timer will become energized. The voltage will continue to be monitored until it increases. The compressors will be enabled at this time if all start-up time delays have expired, and all safeties have been satisfied.

- .5 Provide a wireless communications interface that enables wireless communications between system controls, unit controls, and wireless sensors that control products that use the BACnet® protocol. The Interface shall replace the need for communications wire in all system applications.
- .10 Hose Kits
 - .1 Standard Hose Kit Flow Balancing Systems
 - .1 Provide two ball valves per unit. One for the supply line and one for the return line. Valve assembly shall be constructed of a brass ball and cast bronze body. Ball valve shall be seated in a Teflon seal.
 - .2 Provide two hoses per unit in 3-foot lengths. Hoses shall be made of stainless-steel outer braid and a thermoplastic rubber inner lining. Hoses shall have a NPT fitting at the ends.

PART 3 - EXECUTION

3.01 INSTALLATION

- .1 Install where indicated and in accordance with manufacturer's instructions.
- .2 Install outdoor units at ground level on RC housekeeping pad.
- .3 Install outdoor units on roof with vibration isolation providing 95% isolation efficiency. For flashing, roofing, weatherproofing.
- .4 Secure with hold-down bolts.
- .5 Make duct connections through flexible connections.
- .6 Level unit with fans running. Align ductwork. flexible connections. Misalignment with fan stopped not to strain or damage flexible connection.
- .7 Make piping connections.
- .8 Nothing to obstruct ready access to components or to prevent removal of components for servicing.

3.02 EQUIPMENT INSTALLATION

- .1 Heat pumps (water source): Install all components and equipment to Manufacturer's instructions. Central panel supplier to install and wire panel and test and commission entire system. A complete commissioning and test report to be provided as a condition of acceptance by the Consultant.

3.03 DRAIN PANS

- .1 Install so that no water can accumulate and arrange for easy access for cleaning.

3.04 FIELD QUALITY CONTROL

- .1 Manufacturer's Field Services:
 - .1 Have manufacturer of products, supplied under this Section, review Work involved in the handling, installation/application, protection and cleaning, of its product/s and submit written reports, in acceptable format, to verify compliance of Work with Contract.
 - .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
 - .3 Schedule site visits, to review Work, at stages listed:
 - .1 After delivery and storage of products and when preparatory Work, or other Work, on which the Work of this Section depends, is complete but before installation begins.
 - .2 Twice during progress of Work at 25% and 60% complete.

- .3 Upon completion of the Work, after cleaning is carried out.
- .4 Obtain reports, within 3 days of review and submit, immediately, to the Consultant
- .2 Verification requirements in accordance with Division 01 and include:
 - .1 Materials and resources.
 - .2 Storage and collection of recyclables.
 - .3 Construction waste management.
 - .4 Resource re-use.
 - .5 Recycled content.
 - .6 Local/regional materials.
 - .7 Certified Wood.
 - .8 Low-emitting materials.
- .3 Commissioning Reports:
 - .1 In accordance with Division and Sections 20 05 05 and 20 05 10 - General Commissioning (Cx) Requirements, supplemented as specified herein. Include:
 - .1 Report Forms and Schematics.
- 3.05 DEMONSTRATION
 - .1 Training: Provide training in accordance with Division 01 and Sections 20 05 05 and 20 05 10 - General Commissioning (Cx) Requirements, supplemented as specified.
- 3.06 CLEANING
 - .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

END OF SECTION 23 81 40

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PART 1 - GENERAL

1.01 DESCRIPTION

- .1 Division 01, General Requirements, is part of this Section and shall apply as if repeated here.
- .2 Comply with requirements of Mechanical General Provisions Section 20 05 05 and Mechanical Basic Materials and Methods, Section 20 05 10.
- .3 Comply with all the requirements outlined in the City of Toronto Standard Building Automation System (BAS) owner requirements.
- .4 General: The control system shall consist of a high-speed, peer-to-peer network of DDC controllers and an operator workstation. The operator workstation shall be a personal computer (PC) with a monitor, mouse, keyboard, and printer. The DDC Application Software shall allow operators to interface with system via dynamic color graphics. Depict each mechanical system and building floor plan by a point-and-click graphic. Furnish a modem or network interface card for remote access to the network and for paging operators when an alarm occurs. The DDC system shall be accessed by both a Web Browser application (MS IE6) and PC PTP application. Provide the latest versions of all controllers.
- .5 The system shall directly control all HVAC equipment, and mechanical devices for all systems as indicated on the drawings or described herein including: dampers, valves, sensors./ Refer to Part 3 – Sequences of Operation or to the attached control drawings, if available.
- .6 The system shall use the BACnet protocol for communication to the operator workstation and for communication between control modules. Schedules, set points, trends, and alarms specified (Sequences of Operation) shall be BACnet objects.

1.02 WORK PERFORMED BY THIS SECTION

- .1 Provide a complete direct digital control (DDC) Energy Management Controls Systems (EMCS) with all required software, host computer, monitor, keyboard, printers, field processing units, thermostats, controllers, dampers, valves, operators, switches, wiring and other accessory equipment, in accordance with the Drawings and as required by description of sequences of operation which shall include, but not be limited to:
 - .1 Air supply, return, exhaust and relief systems.
 - .2 Hydronic heating and cooling and humidifying systems.
 - .3 Major mechanical equipment and auxiliary components.
- .2 Electronic static pressure sensors and electric actuators for variable inlet guide vanes on Air Handlers, supply, return and exhaust fans.
- .3 Electronic/electric actuators for all dampers.
- .4 Electronic control and actuation for terminal units.
- .5 Wiring and installation of pressure differential switches and humidistats supplied with packaged humidifiers.
- .6 A complete dynamic color graphics package including all necessary programming.
- .7 Assistance in balancing of all hydronic systems, air systems and terminal equipment.
- .8 Attendance during startup of major controlled equipment.

1.03 QUALITY ASSURANCE

- .1 Qualifications: Contractor for Section 25 is to be a contractor whose core business is the design, installation and maintenance of DDC systems for buildings. The Contractor is to have at least five years successful Greater Toronto Area experience in the installation of DDC systems for large commercial and condominium buildings. Contractor must have factory trained engineers on staff to handle the preparation of shop drawings, programming and commissioning. Wholesalers and contractors reliant on suppliers or others for engineering are not acceptable.
- .2 All systems hardware and associated equipment shall be standard OEM items regularly manufactured for this and/or other systems, and not custom designed especially for this project. All components shall have been thoroughly tested and proven in actual use. All BACnet devices, including programmable controllers must be BACnet Testing Laboratory-Listed.
- .3 Design scope documents establish minimum system and component capability. They are not all inclusive. All additional construction, equipment, interfaces and software required for a complete and operating system are to be provided.
- .4 The fire/life safety system (F/LS) shall have priority with respect to control of equipment that is subject to control by both the F/LS and BMS.
- .5 Freeze stats and other safety controls shall have priority with respect to control of equipment that is also controlled by the BMS. Coordinate installation of the BMS to ensure that interfacing and connection of the BMS and H-O-A switched to such equipment shall not by-pass or interfere with freeze-stats or other safety controls, or the fire alarm system.
- .6 Systems shall be fully modular, permitting point expansion by adding computer memory, remote terminal units or applications software without obsolescence of existing communication or processing equipment.
- .7 All electrical and electronic components shall be CSA, ULC or cUL approved.
- .8 Acceptable Firms: Delta Controls, Reliable Controls, Schemirder Electric SmartX Series, Distech Controls, Johnson Controls Facility Explorer, Honeywell CIPer Series, Spyder models 5 or 7.

1.04 SUBMITTALS

- .1 Submit control shop drawings and wiring diagrams with I/O points, written sequences of operation and components description.
- .2 Submit catalogue cuts and specifications on all EMCS front end equipment, i.e. monitor/keyboard, printers, modem.
- .3 Submit DDC data by systems, i.e. chilled water control, S1 air handling unit, etc., whereby schematics, panel terminal wiring, sequences of operation, hardware and component lists are grouped together without requiring cross reference to other parts of the data.
- .4 Submit descriptions of the operating system and operator communication protocols and a complete list of point and controller names.
- .5 Submit sample print-outs of all points (hardware only) listing, alarms, demand and energy logging.
- .6 With reference to Architectural, Mechanical and Electrical Drawings, submit a layout of the Building Operator's room showing the most practical arrangement of the EMCS front end equipment. Show all dimensions and power requirements. Co-ordinate installation with other equipment i.e. fire alarm and security monitoring.
- .7 Submit points list complete with built-in commissioning checklist identifying make and model of field device for each point organized by controller along with the testing and commissioning plan.

- .8 Submit shop drawings for review in sufficient quantities to satisfy contractual requirements. Where shop drawings consist of printed catalogue sheets, submit at least ten (10) copies. Shop drawings pertain to each particular item as specified; show project and component name, item reference number, certified physical and performance data; and clearly indicate all applicable parts and accessories. Affix Contractor's "Approved" stamp on all copies of all shop drawings prior to their submittal to the Engineer for review. Approval stamp shows name of firm, date the approval was made and the checker's signature or initials. Should the above requirements not be adhered to, shop drawings submitted will be returned for proper re-submittal.
- .9 Shop drawing review by the Engineer is for the sole purpose of ascertaining conformance with general design concept. This review means that the Engineer does not approve the detail design inherent in the shop drawings, responsibility for which remains with the Contractor submitting same, and such review shall not relieve the Contractor of his responsibility for errors or omission in the shop drawings or of his responsibility for meeting all requirements of the Contract Documents. The Contractor is responsible for dimensions to be confirmed and correlated at the job site, for information that pertains solely to fabrication processes or to techniques of construction and installation and for co-ordination of the work of all subtrades.
- .10 With reference to Architectural, Mechanical and Electrical Drawings, submit a layout showing the wiring system routing from EMCS front end equipment to all Field Processing Units (FPU), Local Control Units (LCU) and remote control devices of equipment supplied under Divisions 20, 21, 22, 23, and 25. Co-ordinate installation with other contractors to avoid interference of their equipment.
- .11 Shop drawings (Adobe "PDF" format) shall show the following:
 - .1 Total Energy Management System communication diagram showing all EMCS components and layout of equipment.
 - .2 System Architectural schematics: Provide a complete drawing(s) which details all components of the monitoring and control system. Identify the individual type of controllers, communication buses and speeds, power sizes and distribution etc by location and name. Field devices need not be shown. Schematics must be integrated with the central operator's computer for future reference.
 - .3 Schematic of Central Equipment showing sources of power, peripherals and connections, leased lines and connections, modems and connections, etc.
 - .4 Communication link diagram showing location of each FPU, LCU, power sources, systems connected, POT location, trunk conductors, modem location, etc.
 - .5 List of connected data points (input/output summaries) including FPU's to which they are connected and input/output devices (sensors, transducers, etc.).
 - .6 Drawings of each HVAC system showing all connected devices, all wiring connections between all components with terminal numbers, all data point addresses (connected and calculated) and operator notations. Wiring diagrams shall clearly designate between Divisions 23, 26 and Section 25 01 01 work. Provide a colour printed out of each graphic screen display for review and final written approval by the Owner.
 - .7 Documentation of all maintenance procedures for each system components including inspection, periodic preventive maintenance, fault diagnosis and repair or replacement of defective module. This shall include calibration, maintenance and repair of sensors, transmitters, transducers and panels plus diagnostics and repair or replacement of all system hardware.
 - .8 Damper schedules with construction details and dimensions. Identify dampers in accordance with specification and drawings.
 - .9 Specifications and data sheets for all control system components including relays, switches, thermostats, controllers, dampers, indicators, flow switches, sensors and similar components.

- .10 Valve schedules with construction details, pressure drops and flows.
- .11 Submit three (3) complete sequences of operation of the DDC systems in both program and written format.
- .12 Data file assignments of each connected and calculated I/O point in both the ASC and PC work station.
- .13 Energy management program parameters along with the I/O points assigned to each program.
- .14 Technical specification data sheets of each system component and software module.
- .15 Descriptive data, source codes and sequence of operation of all operating, user, and application software.
- .16 Detail drawing showing dimensions and mounting techniques of both wall-mounted and free-standing versions of FPU's with built-in operator terminal pads.
- .17 Detail drawings showing typical mounting methods for all sensors, transmitters and status indicators.
- .18 Submit diskettes (including backup diskettes) containing up-to-date copies of the programs in each controller.
- .12 Shop Drawing must be approved before any materials are delivered or installed at site.
- 1.05 **GUARANTEE**
 - .1 Guarantee the control system and all components thereof free from defects in operating sequences, materials and workmanship for a period of [one] year of normal use and service from the date of certified acceptance by the Consultant - refer to warranties Section 20 05 05.
- 1.06 **ACCEPTANCE**
 - .1 Acceptance by the Consultant will be granted when:
 - .1 All components installed, operating and calibrated.
 - .2 DDC programming complete and operating personnel have received a minimum 4 hrs. of instructions.
 - .3 As-built drawings and operating instructions submitted.
- 1.07 **INSTRUCTION, TRAINING, ADJUSTMENT, AND "AS BUILT" DRAWINGS**
 - .1 On completion of the work, the Contractor shall submit one soft copy in PDF format and three hard copies of all Operating and Maintenance Manuals for equipment and materials, including the operator's manual for the OWS software and available technical/maintenance literature for each control component including all necessary users and passwords and processes required to create or remove users.
 - .2 Provide a copy of all "as-built" shop drawings in each of the Manuals specified. Provide an Operator's manual consisting of instructions, program listings and control sequences.
 - .3 Revised points list, panel schedule and sequences of operation and all other information submitted with the original shop drawings, reflecting the "as built" condition, taking into consideration all Addenda and Site Instructions.
 - .4 The "as-built" documentation must include:
 - .1 An Information sheet that contains:
 - .1 Project Name and address
 - .2 A brief description of the control details. i.e. total # of points, list of equipment controls and which panels they are connected to.

- .3 Panel's information i.e. part numbers for panels used and there serial numbers and revision # (if applicable)
- .4 Software version
- .5 Modem telephone number
- .6 Warranty start date and duration
- .7 BAS contractor Name, address, and Phone number
- .2 Detailed sequence of operation for each controlled system.
- .3 Control schematics for each system. Including a System Architecture indicating the type and model number for all BAS components, the proposed interconnection and location of all panels, network connection and key peripheral devices (workstations, modems, printers, repeaters, etc.)
- .4 BAS Points List indicating the panel ID, panel location, hardware address, point acronym, point description, field device type, point type (i.e. AO/DO/AI/DI), end device fail position, end device manufacture and model number and wire tag ID.
- .5 Floor plan with the location of all field mounted control devices.
- .6 Programming code for all DDC controllers
- .7 Wiring diagrams including complete power system, interlocks, control and data communications.
- .8 Manufacturers' data/specification sheets and catalogue cuts for all material and equipment supplied including the workstation PC and any equipment (e.g. valves, starters, VFDs, etc.) supplied under the mechanical scope of work. This section shall include a summary sheet that indicates all BAS Device, Manufacturers', model number, and quantity of each used on this job.
- .9 Automatic control valve and damper, VAV box and terminal unit schedules where required.
- .10 Electrical Authority Inspection Certificates – General Inspection and Product Approval Inspection.
- .11 Commissioning list including the name of the Commissioning agent of the BAS Contractor, his signature and the date of commissioning.
- .12 Licensed BAS workstation software.
- .13 BAS programming database stored on a USB drive.
- .14 Workstation PC documentation, original Windows operating system/recovery disks, licenses, and warranty.
- .5 Training shall be provided after successful commissioning. Training shall be site specific; on site, using installed systems.
- .6 The Contractor shall supply qualified, experienced personnel familiar with the project for operator training.
- .7 The Contractor shall utilize the working automation system for the workshop.
- .8 The operator training program shall include the following:
 - .1 Overview of HVAC systems provided in the project;
 - .2 General familiarization with the automation system & safety circuits.
 - .3 Logging in and navigating displays.
 - .4 Commanding setpoints and outputs for day to day operations and testing;
 - .5 Use of alarms and trends.

- .9 Include for a total of 24 hours of training in 4 daily sessions of 4 hours for building operators and two call back sessions of 4 hours each.

1.08 EMCS OPERATION SUMMARY

- .1 The EMCS Operation Summary is a supplement to the drawings and the written sequence of operation.
 - .1 It is intended as a guide and clarification of requirements.
 - .2 It is not an I/O summary, but only a brief description of requirements for each type of system and unit component. The quantities of systems and components are shown on the drawings.
 - .3 It is the responsibility of this Section to determine quantities.

1.09 EMCS LIMITATIONS

- .1 The use of Owner inaccessible software with or without proprietary EPROM or ROM CHIPS in field processing panels where EPROM burners are required and for which software agreements need be signed will not be accepted.

1.10 RELATED WORK SPECIFIED ELSEWHERE

- .1 Power wiring for all electric motors will be by Division 26 unless indicated otherwise.
- .2 Electromagnetic starters with required number of ancillary contactors will be supplied and installed by Division 26 unless supplied as an integral part of equipment.
- .3 Installation of control valves will be by Division 23, Heating, Ventilating and Air Conditioning. Supply will be by this Section unless supplied as an integral part of mechanical equipment i.e. humidistats.
- .4 Supply and installation of control dampers will be by Division 23. The actuator shall be provided by this Division in coordination with the dampers being provided by Division 23. Note that some air handling equipment may have factory supplied motor operated dampers. Refer to Divisions 20, 23, 25 and Mechanical Equipment Schedules. Co-ordinate with Equipment suppliers of Divisions 20, 23, and 25.
- .5 Division 25 shall supply controllers and actuators of terminals to the manufactures for installation. Cost of factory installation of controller will be the terminal unit manufacturers. Refer to Division 23 for the requirement of unit controllers.

PART 2 - PRODUCTS

2.01 GENERAL

- .1 Building Management System (BMS) shall be fully integrated and installed as a complete package of controls and instrumentation. System shall be stand-alone energy management using direct digital control (DDC) solid state technology of modular construction with high reliability and simple user friendly operation. Intelligent controllers shall be fully integrated with BMS and BTL listed.
- .2 Components shall not require any customizing other than setting of jumpers and switches, adding of firmware modules or software modules or any software programming to perform required functions. System shall be a true distributed processing system without any form of network management device used. All software functions shall be performed by intelligent field panels and intelligent terminal unit controllers as appropriate
- .3 All equipment, unless specified otherwise, shall be fully proportioning, modulating in operation.
- .4 Local equipment cabinets shall be provided for each controller or group of controllers. Cabinets to be free standing or wall mounted units. Respective controllers and transducers shall be mounted within the cabinet. Relays, transformers and other devices using a voltage above 24VAC must be housed in a separate enclosure from the controllers. Cabinets shall be located where shown or as later directed and may be grouped per mechanical room.

- .5 Provide integral or supplementary power conditioning equipment for all hardware so as to ensure that power line noise or electrical spikes, noise, bursts, sags or surges shall not damage equipment or software or cause erroneous computations.
- .6 Provide engraved black and white lamacoid plastic nameplates or waterproof, oil proof Brady labels at all duct mounted instruments, rest controls, thermometers and panels, so as to clearly indicate service of particular device. All manual switches shall be similarly labelled, unless they come with standard nameplate. Field Controllers for BMS system shall also be labelled by both function and BACnet MS/TP address, Network Number and Baud Rate.
- .7 In the case of terminal equipment, supply and install a lamacoid plate on each thermostat AND on the ceiling grid to indicate the service access for each terminal unit, indicating the consultants designation for the device, and its MAC address on the BACnet MS/TP network.

2.02 DAMPERS

- .1 Motorized Dampers are specified in Dampers, Section 23 33 10. Actuators are specified below.

2.03 ACTUATORS

- .1 Electric/Electronic Sized to provide adequate power for opening, closing and modulating dampers or valves in specified time.
- .2 Provide each actuator with a bracket for attaching to ductwork, building structure, or equipment. Do not install actuators in ducts or fresh air intakes.
- .3 Provide electric low temperature protected actuators in unheated areas such as parking garages, ventilation shafts and transformer rooms and on any equipment located outdoors.
- .4 Wherever possible, actuators to be provided to the original equipment manufacturer for factory installation (i.e. VAV terminal and fan manufacturers). Provide actuators to equipment manufacturer's specifications.
- .5 All damper and valve actuators to be provided with spring return to normal position.
- .6 For combination fire smoke dampers provide relays adjacent to the actuators for interface to fire alarm system by Division 26 Subcontractor. Wire relays to actuators. Co-ordinate with Division 26 subcontractor and provide instructions on wiring to achieve full open and full closed damper operation.
- .7 Unless shown otherwise on drawings, actuators to be provided and set up such that all heating valves and return air dampers are normally open and cooling valves, exhaust and outdoor air dampers are normally closed.
- .8 Actuators for Valves:
 - .1 Each automatic control valve shall be fitted with a "fail-safe" operator capable of tight shut-off against the differential imposed by the system.
 - .2 Valve actuators on valves 3 in. dia. and larger shall be provided with a manual position override.
 - .3 Floating point control of valves is not acceptable under any circumstances.
 - .4 The standard of acceptance shall be Belimo.
- .9 Actuators for Dampers:
 - .1 All actuators for control dampers shall be electric type and be powered by a single phase AC 24V overload-proof synchronous motor.
 - .2 All actuators shall be direct-coupled type for both modulating and two position control dampers.
 - .3 All damper actuators shall be selected to operate maximum damper loads of 28 sq.ft. (2.6 sq.m.).

- .4 Each actuator shall be "fail safe", complete with external adjustable stops to limit the length of stroke in either direction and mounted on an adjustable bracket. Operating arms shall have double yoke linkages and double set of screws for fastening to the damper shaft.
- .5 The standard of acceptance shall be Belimo.

2.04 AUTOMATIC CONTROL VALVES

- .1 Properly sized and selected by the manufacturer in accordance with load requirements and characteristics of the systems to which they are applied. Do not provide, under any conditions, valves smaller than 20mm (¾").
- .2 Select valves for full shut off application (i.e. two position valves) on the basis of full line size.
- .3 Water pressure drop through all two-way modulating control valves: 18 kPa (2.5 PSI) Water pressure drop through all three-way modulating major system valves; 35 kPa (5 PSI).
- .4 Ensure the bursting pressure ratings of all valves selected are sufficient for the location of the valve taking into the height of the building into consideration. Control valves for heating application to be spring return to open flow port in power off condition.
- .5 Select valves with characteristics to suit the application. Straight through two port water valves shall be single seated with equal percentage flow characteristics.
- .6 Three port valves shall be linear for each port to give constant total flow. Butterfly valves are not acceptable, except for "full shutoff" applications and modulating valves greater than 100mm diameter (4").
- .7 All valves shall be equipped with stainless steel stems.
- .8 Valves 50mm and smaller shall be Belimo characterized ball valves with stainless steel stems, stainless steel balls, and stainless steel plated screwed bronze bodies suitable for a working pressure of 1200Pa. Do not select models without characterizing discs for modulating applications. Models with chrome plated brass balls are not acceptable.
- .9 Valves 65mm and larger shall be complete with flanged cast iron bodies suitable for a maximum working pressure of 1400Pa and may be globe type.
- .10 Valves shall be equipped with fully modulating Belimo electronic actuators with sufficient torque for the application. All actuators for valves 65mm and smaller must be spring return or battery failsafe type, except for reheat valves exposed to outside air, radiation and pressure differential valves. Controls to be 2-10VDC.
- .11 Where feedback is specified in the points list or implied by the sequence of operation, provide Belimo actuators with feedback potentiometers.
- .12 Valves for radiator and reheat applications shall have manual opener and position indicator for use in event of actuator failure and during maintenance operations.
- .13 All valves shall be fully modulating under DDC control, except for self-contained valves.
- .14 Any valve body that will handle potable water must be lead free NSF 61 rated.

2.05 THERMOSTATS AND/OR SPACE SENSORS

- .1 Space and duct sensors shall be electronic suitably located for the specific application.
- .2 Space sensing units shall be mounted 1500mm from floor to center unless otherwise agreed to by the Engineer/Architect.
- .3 All setpoints shall be fully adjustable from OWS and remote terminals via the graphic displays. Sensors to be equipped with a port to allow connection of portable local command and display device for programming, set point adjustment and calibrating.

- .4 Sensors to have pushbuttons in the housing which will allow the occupant to override time programs and automatically switch to occupied/unoccupied mode. The override time available shall be programmed via the operator terminal. The operator terminal to display the override time remaining.
- .5 Override pushbuttons to be software configurable in such a manner that one sensor can be assigned to initiate a schedule override for one or more. Configure override zones as directed by the Owners representative.
- .6 Provide a log of all overrides for each sensor override push button showing date and time of each override occurrence and duration.
- .7 All sensors to be provided with local set point adjust. The occupant to have the ability to adjust the pre-programmed set point within pre-programmed limits, (2°C). The adjustment shall be performed using Increase/decrease pushbutton sensor controls. The resulting set point shall be visually displayed on the sensor. The default sensor display value shall be the zone temperature or set point as selected by the User. The display shall be User programmed to "BLANK" after a period of time if selected.

2.06 SENSORS AND CONTROL DEVICES

- .1 A general guideline requires all new only devices to be supplied/ installed as specified. Sensors must provide responses which deliver accurate, reliable control of HVAC equipment.
- .2 Sensors and control devices are to be industry standard products that can be purchased by the Owner from the manufacturer.
- .3 Temperature Sensors.
 - .1 10 k NTC @ 25 °C Thermistor. Encapsulated to protect against moisture and permit an acceptable TC for the application.
Acceptable products:
All DOC based temperature sensors as supplied by:
 - .1 MAMAC
 - .2 Greystone
 - .3 Enercorp.
 - .2 Each sensor shall be provided with a custom label which indicates the model, manufacturer, specifications, and DDC point I.D.
 - .3 Duct mounted sensors shall be S.S. probe type or Cu averaging element type as specified. Probe sensors are suitable for any duct as preferred.
 - .4 Space sensors shall be provided with ventilating conductive protective covers, mounted 1.2 metres from the floor level.
 - .5 Provide space sensors as specified.
 - .6 Stainless Steel (S.S.) plate sensors are specified for use in the GP rooms and as specified.
 - .7 Smart programmable Display (LCD) Sensors (SDT) shall be installed for all DDC VAV terminal boxes. The SDT power shall originate from the respective B-(A)ASC panel.
 - .8 Submit samples to Owner for final approval with shop drawings.
 - .9 Liquid immersion sensors shall be spring loaded tip sensitive devices mounted in brass wells rated for the working temperature and pressure of the fluid.

- .10 Outdoor air sensor shall be weather proof and properly shielded from direct solar radiation. Only the probe shall be externally mounted on the building skin and properly sealed to eliminate the effect of internal air temperatures. Wiring connections shall be made inside the building for easy testing/access service. Sensors located in the fresh air intake duct of air systems will not be permitted.
- .4 Duct Temperature Sensors:
 - .1 Provide duct mounted temperature sensors (DTS) with the following minimum characteristics:
 - .1 Sensor encapsulated in a 200mm long, 6mm OD copper or stainless steel probe.
 - .2 Operating range 0-60 degrees C.
 - .3 End-to-end accuracy +/- 0.3 °C.
 - .4 Assembly complete with wiring housing and mounting flange.
 - .2 Standard of Acceptance:
Enercorp TS-D-12-T-10K
- .5 Duct Averaging Temperature Sensors:
 - .1 Provide plenum mounted mixed air temperature averaging type sensors with the following minimum characteristics:
 - .1 Constructed of FT6 plenum rated cable incorporating a minimum of 9 temperature sensors encapsulated at equal distances along the 24 foot length of the element. The assembly acts as a single sensor reporting the average temperature from all individual sensors.
 - .2 End-to-end accuracy +/- 0.3 °C.
 - .3 Mount in a zigzag manner to provide continuous coverage of the entire duct cross-sectional area.
 - .4 The use of thermister type sensors is acceptable.
 - .2 Standard of Acceptance:
Enercorp TS-FC-24-9-T-RTD
- .6 Outdoor Air Temperature Sensors:
 - .1 Provide outdoor air temperature sensors with the following minimum characteristics:
 - .1 Each sensor shall be a 6", 10K thermistor probe
 - .2 Minimum two sensors shall be installed for each site.
 - .3 Both sensors shall be mounted inside a heavy-duty (blow-proof) solar shield.
 - .4 Provide a heavy-duty, metal, wire guard.
 - .2 Standard of Acceptance:
Enercorp TS-O-T-10K
- .7 Immersion Temperature Sensors:
 - .1 Use immersion temperature sensors with thermowells for all applications where a temperature of a fluid in a pipe is being sensed.
 - .2 Provide well-mounted water temperature sensors with the following minimum characteristics:
 - .1 The sensors shall be 10k ohm thermistor encapsulated in a 6mm OD, 50m long probe, with screw fitting for insertion into a standard thermowell.

- .2 Operating range -10 to +100 degrees C.
- .3 End-to-end accuracy +/- 0.3 °C over the entire operating range.
- .4 The sensors shall be complete with brass thermowell. Provide a stainless steel thermowell where exposed to corrosive liquids.
- .5 Use conductive gel when mounting the sensor in the thermowell. The sensors to be mounted on insulated piping shall be installed clear of the insulation.
- .3 Standard of Acceptance:
Enercorp TS-P-4-T-10K

2.07 WIRING

- .1 Provide all electrical wiring and components required (of any voltage) within the temperature control system such as low limit protection, thermostats, alarms, refrigeration system components, relays and interlocks as required to achieve the control function specified in the schematic drawings and sequences of operation. This work to include wiring into prefabricated control circuits (as co-ordinated with the appropriate sub trade or supplier) of boilers, chillers, air cooled condensers, pump sets and fire alarm panels. Also provide suitably rated relays for single phase motors wired in series with manual starters where EMCS start/stop operation is required. Provide "Hand-Off-Auto" switch on relays.
- .2 Provide all power and interconnecting wiring to EMCS field panels and terminal devices. Co-ordinate with Division 26 Subtrade for appropriate locations of all power outlets for head-end equipment (monitor/keyboard, printers, clock). Do not wire any EMCS components into emergency power supply.
- .3 Refer to Electrical Division drawings for locations of all power outlets for electric actuators, sensors and control devices or panels. Provide all wiring from these locations to the above devices as necessary and provide all low voltage control wiring between devices. Refer to Electrical Division for wiring and conduit requirements. 24 volt voltage wiring to room thermostats, VAV terminals and radiation valves may be routed in enclosed ceiling spaces utilizing approved plenum cable, provided that this Contractor checks acceptability of such cable with ALL applicable authorities.

2.08 OCCUPANCY SENSORS

- .1 The Occupancy Sensor system shall sense the presence of human activity within the desired space and fully control the on/off function of the loads automatically. Sensors shall turn on the load within 2 feet of entrance and shall not initiate on outside of entrance.
- .2 Approved manufacturer shall be Sensor Switch, Inc. or pre-approved equal.
- .3 Sensing technologies shall be completely passive in nature, in that the occupancy sensor system shall not emit or interfere with any other electronic device, or human characteristic. Acceptable known technologies are Passive Infrared (PIR), or Microphonic.
- .4 Upon detection of human activity by the detector, a Time Delay shall be initiated to maintain the light on for a pre-set period. The Time Delay setting shall be factory preset for typical applications, and field adjustable from 30 seconds to 20 minutes. The timing circuit shall be analog providing adjustment by simple rotation only.
- .5 All sensors shall have non-adjustable factory calibrated sensitivity for maximum performance. Time Delay and Photocell field adjustments shall be provided as needed.
- .6 The installing contractor shall be responsible for a complete and functional system. Satisfactory performance shall be determined by the owner and the engineer. Proper coverage of the area for all types of human activity, and any necessary relays or miscellaneous devices is the responsibility of the contractor.
- .7 System installation shall be in accordance with all national and local electrical codes.

- .8 Installation shall be warranted for a period of one year from completion, and product shall be warranted for 5 years.
- .9 All sensors, power packs, and relays shall be UL Listed under either Industrial Control Equipment, or Energy Management Equipment. Appliance Control listing shall not be accepted.

2.09 BOILER ROOM GAS DETECTOR

- .1 Provide gas detector system incorporating the E3 Point detector as manufactured by Honeywell complete with remote sensor for natural gas/Methane.
- .2 Detector shall be connected to the Building Automation System.
- .3 Detector to include:
 - .1 On board 85 Db @10ft Buzzer
 - .2 LCD Screen
 - .3 LED Indicators
 - .4 2DPDt relays

2.10 FLOW SWITCHES

- .1 Select the flow switch for pipe size and flow rate
- .2 The flow switch shall have a paddle with 3 segments for selecting optimum size suited for pipe sizes from 20mm to 150mm:
 - .1 Temperature rating – 121C
 - .2 Pressure rating – 1030Pa
 - .3 Contact rating – 8 amps at 120VAC
 - .4 Switch shall be CSA approved
- .3 Flow switch to be DPDT to facilitate BMS monitoring
- .4 Standard of acceptance: McDonnell Miller; Johnson Controls

2.11 TIMERS

- .1 Rex (Davis Controls) Maxirex BDI single channel digital type with a minimum of 4 separate switch on switch off programs for each day of the week with LCD continuous display of program status, 1 minute shortest switching period, rechargeable 100 HR reserve battery back up, automatic or manual on off operation and suitable for cut out panel mounting.

2.12 FREEZE PROTECTION

- .1 Electronic manual reset, with adjustable set point within a range, adjustable time delay and averaging RTD of suitable length. Kit to be complete with 22mm amber LED for "Fz Tripped" 22mm momentary reset push button, 22mm H-O-A rotary switch, flexible temperature sensor
- .2 Each pilot device to be complete with suitable lamacoid.
- .3 Kit to be complete with wiring diagram corresponding to the best practices for safety circuits. Provide one thermostat for each 1sq,m of coil face or part thereof.
- .4 Mount the sensing element rigidly and as close as possible to the downstream face of the coil being protected or where shown on schematic drawings. Freeze controls shall have 6m capillary arranged in ducts for maximum protection. Provide freeze stat for each 5.5 sq. m. of duct area, wired in series.

2.13 DIFFERENTIAL PRESSURE TRANSMITTERS

- .1 The transmitter shall have an operating range to suit the application such that the controlled value is mid-range. (Typically 0 – 50 psi)

- .2 The transmitter output shall have a linear proportional signal over the full operating range for 0 to 10VDC.
 - .3 Provide each transmitter with the optional 3-VB manifold.
 - .4 The transmitter must handle 2 times the operating pressure and 20 times the operating pressure for the burst rating.
 - .5 Standard of acceptance: Greystone DP-3VB Series, suitable range and complete with manifold.
- 2.14 FILTER BANK STATUS DIFFERENTIAL PRESSURE SWITCHES
- .1 To be complete with setpoint adjustment and pitot tubes.
 - .2 Standard of acceptance: Belimo AFS with suitable range.
- 2.15 SWITCHES
- .1 Pressure electric switches shall have diaphragm operated SPDT snap acting contacts with electrical rating suitable for applications as specified. Pressure electric switches shall withstand up to 25 psig and be provided with adjustable cut-in and cut-out settings between 3 and 20 psig.
 - .2 Water flow switches shall be general purpose with a paddle actuated, snap acting SPDT switch rated at 16 amp 120/1/60 AC full load.
 - .3 Air proving (differential pressure) switches shall utilize a differential pressure activated, diaphragm actuated, snap acting SPDT switch rated at 9.8 amp 120/1/60 AC full load. Differential pressure range shall be selected to suit the application, set point shall be adjustable. Mount switches with diaphragm in a vertical plane. Switches shall be CSA approved.
 - .4 Minimum positioning switches shall be installed inside local cabinets. After system balancing, switches shall be locked.
 - .5 Damper status switches shall be lever operated, activated by damper blade movement and mounted securely on damper frame. Switches shall have a contact rating of 5A to 120 VAC and shall be CSA approved.
- 2.16 RELAYS
- .1 Relays shall be solid state, heavy duty type. Supply, install and wire all relays for outside lighting circuit control, and for other line voltage applications. All equipment controlled by ECMS shall be provided with H.O.A. Switch by same manufacturer as equipment motor control starter mounted on front of panel and wired as follows:
 - .1 AUTO: Equipment shall be controlled by EMCS in series with all limits and other protective devices.
 - .2 OFF: No operation.
 - .3 HAND: Equipment shall be operated independently of EMCS, but still in series with all limits and other protective devices.
 - .2 Standard of acceptance: Mamac CT800 Series
- 2.17 SWITCHES AND RELAY
- .1 Current Sensing Status Switch, ON/OFF
 - .1 Current sensing relays shall be solid state, two wire, now powered devices.
 - .2 Acceptable products:
 - .1 Veris Industries, USA
Hawkeye model H-800 N.O. contact @ 0.5-200 A as supplied
 - .2 Air Pressure Switches, ON/OFF

- .1 Switches shall be field adjustable over the operating pressure range and provide snap-acting Form C contacts.
- .3 Hydronic Pressure Transducers
 - .1 Pressure transducers shall be S.S. devices matched to the operating pressure of the application. Provide 2x over pressure protection c/w a new brass snuber, pressure gauge and isolation brass valve for service.
Provide a 4-20 ma signal for the working pressure range.
 - .2 Acceptable products by:
 - .1 ITT
 - .2 Other by approval
- .4 Electronic-to-Pneumatic Transducers
 - .1 The device shall be sufficient to provide full scale operation of the pneumatic operator. The transducer shall provide linearity of 1% of full scale. Hysteresis and repeatability of 0.75% full scale or less. A 1-5V d.c. output feedback signal, proportional and linear to the 21-138 kPa output signal shall be provided. A gauge tap shall be provided to mount a pressure gauge for pressure output indication.
 - .2 Acceptable products:
 - .1 Kreuter manufacturing Company, Kreuter Marketing Canada E/I-P Transducer, with mounting hardware, and 0-20 psig pressure gauge.
- .5 Control Relays
 - .1 Control relays are SPDT for control of electrical starters and equipment where shown on the control diagrams.
 - .2 Coil voltage matches the ASC. Contacts are rated a 5A to 120 VAC.
 - .3 Control relay contacts shall be rated for 150% of the loading application, Form C double pole contacts. The relay shall provide a minimum, one million operations and contain coil transient suppression devices and DDC output LED pilot. All relays shall be mounted on a separate relay base and in ventilated indoor locations.
 - .4 Acceptable products:
 - .1 CARLO GAVAZZI.
 - .2 FEME. Model Series M15, Pilot.
 - .3 Omron, HP rated, starter rated.
- .6 Solid State Relays (SSR)
 - .1 SSR with opto-electronic coupler for 3-32 V d.c. turn on/off input control shall be provided. Relays shall be rated for the application and mounted on a properly sized heat sink in order to regulate relay temperatures below 25°C continuously.
 - .2 Acceptable products:
 - .1 Crydom.
- 2.18 ELECTRICAL LINE VOLTAGE THERMOSTAT
 - .1 Provide heavy duty type. Include backplate and bracket for mounting on standard size outlet box where required.
 - .2 Provide heating/cooling type thermostat where sequencing of heating and cooling/ventilation is required.
- 2.19 ELECTRICAL LOW VOLTAGE THERMOSTAT

- .1 Provide complete with heat anticipator, and backplate and bracket for mounting on standard size outlet box where required. Include sub-base with fan On-Off-Auto switch with each thermostat where summer ventilation is required. Include modulating heating or cooling stage where used in conjunction with control valves; step controllers; SCR's; or similar equipment requiring modulation, and mercury switches where On-Off control is required.

2.20 NAMEPLATES

- .1 Provide Lamicoid nameplates, 25mm x 550mm (1" x 22") at all control system devices to clearly indicate the service of a particular device. All manual switches, unless they come with standard nameplates, are labelled. All thermostats, thermometers and switches installed on all local panels shall be similarly labelled. Permanent painted stencil labels may be used on all controllers and relays mounted inside local panels, if so desired. Tape labels are not acceptable.
- .2 All duct and pipe mounted sensors, ASC's, etc. are to be similarly labelled.

2.21 ACCESS DOORS

- .1 Refer to Section 20 05 10 for access door requirements.

2.22 ENERGY MANAGEMENT CONTROL SYSTEM (EMCS)

- .1 Refer to City of Toronto Building Automation System (BAS) Owner requirements.

PART 3 - EXECUTION

3.01 GENERAL

- .1 The DDC controls project shall be performed in such a manner as to limit disruption of the normal daily operation of the building HVAC equipment. The work shall occur while the control system remains on-line in order to maintain a minimum level of comfort within the building. The Owner shall be notified about situations in which equipment will be off-line for extended periods of time during the project. The Contractor shall conduct all on-site work in conjunction with building operating staff to streamline the new system startup.

3.02 COMPONENTS

- .1 Mount all controllers and relays within control panel cubicles. Mount exposed components for easy access and protect from damage.
- .2 Cut-out mount switches and timers on control panel fronts.
 - .1 Identify all exposed components and equipment mounted on the control panel front with lamacoid nameplates screwed or pop-riveted in place. Identify instruments inside the cabinet with Dymo tape labels.
 - .2 Provide, on all equipment operated by EMCS, 50 x 100mm red lamacoid tags with white lettering held with screws or pop rivets, reading: "Warning This equipment may start at any time. Do not service without disconnecting power."
 - .3 Locate all local control panels as shown on the drawings or as directed by the Consultant.
 - .4 Provide electric freeze protection thermostats with averaging elements capable of sensitivity on any 300mm (12") portion. Mount element across coil face approximately 150mm (6") downstream of coil in rows 400mm (16") OC. Locate lowest row no higher than 1500 mm (6") above bottom of coil. Mount thermostats side-by-side 1500mm (60") above floor on service side of unit.

Provide relay such that on low temperature shut-down, one button will reset control circuit. Label and locate button on service side of equipment.
 - .5 Mount CO detectors between 900 to 1200mm (3'- 0" to 4'- 0") above floor. Provide a lockable wire guard enclosure over unit. Provide field calibration by manufacturer's designated representative.

3.03 CO-ORDINATION

- .1 Attend and assist in testing, start-up and commissioning of the major mechanical equipment and pumping systems.
- .2 Attend and assist in testing and commissioning air handling and distribution systems.
- .3 Set outdoor air dampers to minimum positions as verified by the air balancing specialist.
- .4 Calibrate air volumes and temperatures at each terminal unit as verified by the air balancing specialist.
- .5 Attend and assist in commissioning, start-up and testing of fans and dampers.

3.04 WIRING

- .1 Rules and Regulations: all of the installation requirements, be it temporary or permanent shall comply with the Canadian Electrical Code and all Provincial and local codes.
- .2 Conduits and Wiring: The contractor shall supply, install and connect all conduits, boxes and wires between the different components related to the centralized control system, including all required line voltage to the equipment. All power shall be provided from appropriately sized new circuits, at the nearest electrical panel with breakers provided by Section 26 contractor.
- .3 Install all wiring in conduit and conform to CSA, ULC and local Code requirements as well as requirements as specified in Division 26 except as stipulated in following paragraph .2.
- .4 EMCS 24 Volt Wiring:
 - .1 In ceiling spaces, approved plenum cable to be installed neatly clipped to structure in 8 foot intervals and run parallel and at right angles to building structural members. Plenum cable to be installed clear of any electrical or mechanical components requiring access or servicing.
 - .2 All EMCS wiring installed within walls and where exposed to be installed in conduit conforming to requirements of Division 26.
- .5 All wiring in connection with the control system shall be furnished by the Contractor.
- .6 Grounding:
 - .1 Contractor shall comply with manufacturer's recommendations for network wiring and grounding.
- .7 All wiring shall conform to governing codes and shall be inspected by request of the Contractor for approval. The Contractor shall obtain and purchase all necessary permits as required.

3.05 MAJOR MECHANICAL EQUIPMENT

- .1 Co-ordinate with the manufacturers and provide all required wiring and components as required to achieve specified sequences of operation.

3.06 VARIABLE FREQUENCY DRIVES

- .1 Co-ordinate with variable frequency drives manufacturers and provide all required wiring and components as required to achieve specified sequences of operation.

3.07 MOTORIZED DAMPERS

- .1 Co-ordinate with Division 23 Contractor.

3.08 DDC SYSTEM

- .1 Install the entire DDC system under supervision of factory trained engineers and technicians fully capable of providing instruction, routine maintenance, programming and emergency maintenance service on all system components.

- .2 During the training period and at no extra cost, make any required program changes to enable optimum system operation as directed by the Consultant.
- .3 Provide "status" confirmation by using auxiliary starter contacts for pumps. Use load side activated relays or auxiliary relay contacts for single phase motors. Use pressure differential switches for fans.
- .4 For stop/start operation wire only to starter "Auto" circuit. Failure to stop and start to register as an alarm.
- .5 In the event of a DDC control system failure from any cause, provide for normally "on" sequence for equipment such as boilers, boiler pumps, heating pumps and coil circulation pumps and normally open to heating for scheduling valves and other 3 port valves to prevent coil and equipment freeze-up.
- .6 Provide a minimum of two spare input and two spare output points on each DDC controller (FPU).
- .7 Do not control more than 3 air handling units on one FPU.
- .8 Provide complete graphics package, as indicated in the EMCS Operation Summary, installed in the EMCS and ready for the Owner's use.
- .9 Where motor operation is specified to provide enable/disable, permissive or sequential operation, use DDC software wherever possible or provide hard wire interlocks.
- .10 For air handling systems with mixed air control, EMCS to compute return and outdoor temperatures for required mixed air temperature to provide minimum outdoor air quantity.
- .11 Occupied/Unoccupied Mode of Operation:
 - .1 Provide all controls and application programs for time of day scheduling, night set-back, duty cycling, load shedding etc. Provide and independent operating schedule for each tenant or Amenities Area and for each floor;
 - .2 Provide mode over-ride for all zones. Mode over-ride to be accomplished by pushbuttons on all adjustable DDC thermostats. For areas controlled by non-adjustable DDC temperature sensors, mode override shall be accomplished through the Operator Console.
 - .3 During unoccupied mode, all fans serving the zone shall be off and temperature setpoints will revert to heating setback/cooling set up settings.
 - .4 If the mode is overridden in a heating zone, the temperature setpoint reverts to the occupied setpoint for a period of two hours (adjustable at Operator Console within the 1 to 8 hour range). If half the zones in an area served by an air handling unit are over-ridden, operation of the air handling unit resume until the over-ride has ended.
- .12 Trend Graphing
 - .1 System shall support trending and graphing.
- .13 Trends and Reports:
 - .1 Provide point trending capabilities for any system of operating point. Generate reports based on specific point or group of points (e.g. status, room temperature, etc.). Write the trend logged data to a file for screen review by the operator.
 - .2 Implement trends on all physical points in the central plant and all space temperatures and for all "mode" variables for all systems. See points list for minimum requirements.
 - .3 Digital points on major equipment shall be trended using Change of State trending.
 - .4 Analogue points on major equipment shall be trended using Change of Value trending
- .14 Alarms:

- .1 Provide alarming capabilities on all points by assigning a maximum or minimum values, incorrect state or error state status. Generate alarm message as 25 character alpha/numeric text.
- .2 Provide interlock and time delay functions so that alarms shall be locked out.
- .3 No alarm shall be reset until acknowledged or unless status of point returns to normal condition.
- .4 Provide for emailing sending of alarms as specified elsewhere.
- .5 Implement alarms and dial outs (actual email) for all logical conditions that can be supported by specified DDC points. Examples include HWST out of range; Flame failure; space too cold; pump failed to start, fan failed to start, bad thermostat, etc. Alarms dialed out shall be identified as CRITICAL and MAINTENANCE. A CRITICAL alarm indicates a condition serious enough to justify the Owner attending the site during off hours to effect repairs and/or mitigate the conditions.

3.09 LABELLING

- .1 All control equipment is to be labelled with lamacoid plates with a designation corresponding to the specific system point description/label. All lamacoids shall be mechanically fastened to surfaces. Submit samples to the Owner for approval.

3.10 COMMISSIONING – DDC SYSTEMS

- .1 Check the installation of each sensor, actuator and controlled device.
- .2 Verify and record in as built OEM drawings the wiring of each I/O sensor and device as installed.
- .3 Calibrate each sensor as required.
- .4 Manually operate each output for every system with a portable Display Terminal supplied by the contractor for commissioning.
- .5 Tune each control loop and print the response of trends for hard copy record. Identify correct PID parameters on all print outs.
- .6 Verify all start/stop operations, e.g. “schedule control”, “Optimized control”, “unoccupied mode” setback.
- .7 Verify all custom control programs and alarm functions.
- .8 Perform end-to-end checks from an operator terminal to all sensors and actuators to verify system communications and control.

3.11 FAIL STATE POSITION OF OUTPUTS

- .1 Unless specified otherwise, configure BAS output points for the following fail state (e.g. device position upon panel failure):

All Fans	OFF
Heating Valves	Full heat to terminal device
Mixing Dampers	Full recirculation air
Face/Bypass Dampers	Full heat
Zone Dampers	Full heat
Heating Pumps	ON (except boiler belly pumps)
Boiler Belly Pumps	OFF
Variable Frequency Drives	ON, minimum programmed speed
Lighting Relays	Last State

Boilers (1 stage)	ON
Boilers (Multi-stage)	LOW ON, HIGH OFF
Cooling Equipment	OFF
Electric Heating	OFF
Domestic Hot Water Pumps	OFF
Roof-top Gas Burners	OFF

3.12 SEQUENCES OF OPERATION

- .1 Refer to schematics on the drawings and the EMCS Operation Summary at the end of this section.
- .2 Room Temperature Set Points (adjustable):

Unless otherwise noted, the following are temperature set-points for conditioned spaces of general areas:

 - .1 "Occupied" heating: 22.2°C
 - .2 "Unoccupied" heating: 16.0°C
 - .3 "Occupied" cooling: 23.9°C
 - .4 "Unoccupied" cooling: 29.0°C

Unless otherwise noted, the following are temperature set-points for conditioned spaces of classroom areas with displacement diffusers and hot water piping:

 - .1 "Occupied" heating: 21.0°C
 - .2 "Unoccupied" heating: 18.3°C
 - .3 "Occupied" cooling: 25.0°C
 - .4 "Unoccupied" cooling: 26.6°C
- .3 Boiler Room Temperature Control: (Separate Loop) A sensor/controller will, on a temperature drop, cycle on the unit heater. On a space temperature rise it will open the relief damper.
- .4 Heating Night Setback:
 - .1 Any one designated space temperature sensor on each floor to, through the DDC panel, cycle on heating pumps on sensing a temperature below set point (15.5°C) during night mode and heating mode. The heating pumps to run until all night set back space temperature sensors are satisfied.
- .5 Packaged Energy Recovery Units
 - .1 The BAS shall implement time of day scheduling with night set-backs, cooling set up and mode override. During Occupied mode, fans run continually.
 - .2 Packaged heat recovery unit supplier shall provide the units complete with safety and operating controls. The terminal strip shall be the interface between the BAS and the unit and shall be the means for the BAS to:
 - .1 Directly control the inputs to any variable speed drives;
 - .2 Monitor status of clogged filter sensors.
 - .3 Monitor CO2 levels.
- .6 Packaged HVAC Units
 - .1 Packaged air conditioning equipment shall operate on their own electromechanical or electronic controls. This Section shall wire all thermostats and interlocks. All controls components are to be provided by the equipment manufacturer.

- .7 Low Temperature Alarm
 - .1 Should any of the space sensors senses space temperature below critical temperature set point, send a critical alarm to the security panel.
- .8 Loss of Power Alarm
 - .1 Provide two sensors for loss of power alarms. Should any of the sensors detects a loss of power, send a critical alarm to the security panel.
 - .2 When the power is restored, start-up all equipment in sequence
- .9 Electrical Consumption
 - .1 The electric utility meter will be provided with a pulse transmitter. This transmitter signal is to be totalized at the EMCS.
- .10 Gas Consumption
 - .1 The Consumer Gas meters to be fitted with a Solid State or Dry Contact pulse transmitter. Transmitter signal to be totalized at the EMCS.
- .11 Water Consumption
 - .1 The water meter to be fitted with a Dry Contact pulse transmitter. Transmitter signal to be totalized at the EMCS.
- .12 Resumption of Power
 - .1 EMCS controllers and front end will restart on resumption of power without human intervention.
 - .2 In the event of a power outage, upon restoration of power, the EMCS shall stage on controlled equipment to prevent avoidable power surges
 - .3 Equipment and systems must be restored in a logical order. For example, in the case of a central heating system, the pumps should be restored first, followed by the boiler, supply and return fans and finally the cooling tower and chiller.
 - .4 The time between stages shall be sufficient to permit the first piece of equipment to startup, come up to speed, and settle down to drawing normal "run" amperage before starting up the next piece of equipment.
 - .5 Specify in the shop drawing submittals the order in which controlled equipment shall be restored to normal operation after resumption of power.

3.13 CLEANING

- .1 Do Cleaning in accordance with Section 20 05 05 - Mechanical Work General Instructions.

END OF SECTION 25 01 01