



INSTRUCTIONS TO BIDDERS

Date: APRIL 19, 2016

BID PACKAGE #: 629-CP1605

1. BID SUBMISSION

The St. Clair Catholic District School Board (Board) is seeking mechanical contractors to replace the hot water boiler at St. Elizabeth Catholic School, 1350 Bertha St., Wallaceburg, ON.

Bids from invited bidders shall be submitted on the Bid Form provided and submitted in an envelope clearly marked:

Bid Package #: 629-CP1605 – St. Elizabeth Boiler Replacement Tender

The envelope shall be sealed and delivered to: St. Clair Catholic District School Board
420 Creek St.
Wallaceburg, ON
N8A 4C4

Attention: Mr. Tony Prizio, Procurement Specialist

Bids will be accepted at the Board's Catholic Education Centre office not later than **May 10, 2016 @ 2:00:00 p.m. (No extensions to Bid Closing date are anticipated. Bidders are encouraged to act immediately to prepare their submissions!)**

Bids shall be filled out in ink or typed, signed in longhand by a duly authorized company official (having authority to bind). One original of the fully completed Bid Form must be submitted. **Failure to provide all of the requested information on the Bid Form may result in disqualification of the bid.**

Unsolicited bids will not be accepted.

Bids by telephone, fax or email will **not** be accepted.

After bid closing, sealed envelopes will be opened by the Board's Procurement Specialist (Tony Prizio) and a representative from Corporate Services' department.

Suppliers Quote, Instruction to Bidders, Scope of Work, Specifications, Drawings, Incentive Documentation Requirement and CCDC 2-2008e Order will form the agreement.

2. SCOPE OF WORK

The Instructions to Bidders identifies the work to be performed in the Contract and takes priority if there is a conflict within the Bid Documents. **Refer to Scope of Work in Appendix A for detailed description of work to be carried out by the successful proponent.**

3. BID DOCUMENTS

The following Bid Documents form the basis of this Bid Package and shall be examined by bidders:

- 3.1** Instructions to Bidders dated April 19, 2016
- 3.2** Bid Form dated April 19, 2016.
- 3.3** **Prime Contract** – The Contract CCDC 2-2008, Stipulated Price Contract.
- 3.2** The Board assumes no responsibility for the bidder's failure to examine **all** of the Bid Documents.
- 3.4** Incentive Documentation Requirements - **Appendix B.**



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BID PACKAGE #: 629-CP1605

4. BID ACCEPTANCE

It shall be understood by all bidders, that the bid shall be valid and subject to acceptance by the Board, and that no adjustments shall be made to the Bid amounts for a period of up to and including sixty (60) days from the Bid Closing Date.

The Board reserves the right to determine the successful bidder by any combination of base bid, separate prices, requested alternate prices and voluntary alternate prices submitted with the bid. The Board is not obligated to select the bid with the lowest price and may cancel a bid prior to award without liability to any bidder.

The successful bidder shall be required to enter into a formal contract with the Board, which will include the terms and conditions of the Instructions to Bidders, Bid Form, and all other applicable documents.

5. AWARD

The Board has the right to reject any or all bids. The lowest Bid will not necessarily be accepted. The invitation to bid does not constitute an offer by the Contractor to enter into a contract.

6. PAYMENT

The Board shall pay within forty-five (45) days after receipt of the invoices which are received and approved by the Board.

7. TAXES

Include in Bid all Taxes and all other Customs Duties and Excise Taxes which are in force at Bid date as detailed in General Conditions. Harmonized Sales Tax (H.S.T.) is **not** to be included in the bid. The H.S.T. amount and the Bidder's **H.S.T. Registration Number** are to be indicated on the Bid Form in the spaces provided.

8. ADDENDA

Bidders finding discrepancies, ambiguities or omissions in the bid documents or having doubt as to the meaning or intent thereof, shall immediately notify the Procurement Specialist who may issue instructions and/or clarifications by Addendum to all Bidders. Bidders may also, during the Bidding Period, be advised by Addendum of any additions, deletions or alterations to bid documents. All such Addenda shall become part of the Bid Documents.

All questions to be addressed in writing to: Mr. Tony Prizio, Procurement Specialist
St. Clair Catholic District School Board
E-mail: tony.prizio@st-clair.net
Copy: marcie.butler@st-clair.net

No later than 48 hours prior to bid closing date.

9. CHANGE NOTICES, CHANGE ORDERS

The following fee percentage and overhead charges shall be applied to additional work ordered by the Board:

- For work carried out by the Contractor's own forces – 10% Overhead & Profit
- For work involving a subcontractor, the subcontractor may charge a maximum 10% fee. The



INSTRUCTIONS TO BIDDERS

Date: APRIL 19, 2016

BID PACKAGE #: 629-CP1605

General Contractor may charge a maximum of 5% in addition to subcontractor's fee.

10. BONDING

BONDING NOT REQUIRED FOR THIS PROJECT.

~~On bids exceeding \$ 50,000.00, submit with the Bid an Agreement to Bond for a 50% Performance Bond, and a 50% Labour & Material Payment Bond. Upon request, the successful Bidder will be required to provide the 50% Performance Bond and 50% Labour and Material Payment Bond from a bonding company acceptable to the Board. The cost of the bond is not to be included in the bid sum, the amount of which is to be identified on the Bid Form.~~

11. VOLUNTARY ALTERNATE AND SEPARATE PRICES

The bid amounts are to be based on the bid documents. Where there is any conflict within the bid documents, the bid amount shall include the higher cost alternative. Alternative proposals are encouraged and must be identified in the bid. Submit complete information including any impact on schedule to allow a full evaluation of the proposal including, as applicable, any particulars in which the alternate proposal is at variance with or unable to meet the specifications. Note also any impact on other trades if the alternative is accepted. Alternative proposals may be made without limitation, including for items specified as single sourced.

12. EXAMINATION OF SITE & SITE VISIT

In submitting a bid, it will be assumed that the bidders have carefully examined the site and surrounding properties of the work and have informed themselves as to the existing conditions, access, storage areas and limitations, and have included in the bid price the complete cost of the work contemplated by the drawings and specifications and other bid documents.

A mandatory site visit has been scheduled for **April 25th, 2016 at 2:00 p.m.** Interested parties shall meet at the office of **St. Elizabeth Catholic School, 1350 Bertha St., Wallaceburg, ON.** The contact for this site visit is Tony Montanino (Cell: 519-381-1777).

13. TIMING OF PROJECT

A letter of Intent is expected to be issued by May 13th 2016. Work must take place during the months of July 4th and August and completed no later than **August 21, 2016.**

14. PROJECT SPECIFIC REQUIREMENTS

Contractor's employees shall use only those toilet and washroom facilities designated by the Owner or provide their own facilities. In the event that the contractor elects to use Board facility washrooms, the contractor will be responsible for the maintenance, stocking and cleaning of the designated washroom. The designated washroom shall be returned to the Board in the same condition as received by the contractor. Any and all damages to facilities while under the control of the contractor shall be repaired at the contractor's cost.

Please be advised that the Owner has a No Smoking Requirement on the Owners' property. Contractors are requested to ensure that employees and suppliers are advised of the Requirement. Contractor shall remove rubbish and debris from the site on a daily basis or as directed by the Board. On completion of the work, all debris shall be removed; the floor shall be thoroughly cleaned and swept; the site shall be left in a tidy condition (construction clean). Do not use the Board's equipment or facilities for cleaning or for any reason.



INSTRUCTIONS TO BIDDERS

Date: APRIL 19, 2016

BID PACKAGE #: 629-CP1605

15. INSURANCE

Contractor must maintain, at the Contractor's expense for the entire term of the Contract or as otherwise required, all insurance as set out below:

- The successful Contractor shall provide the Board with proof of insurance for Comprehensive General Liability and Property Damage with a limit of not less than \$2,000,000.00 (two million dollars) inclusive prior to commencing work.
- The successful Contractor shall provide the Board with proof of insurance for Motor Vehicle Public Liability and Property Insurance on all owned and rented equipment with a limit of not less than **\$2,000,000.00 (two million dollars)** inclusive prior to commencing work.
- The Contractor agrees to indemnify, hold harmless, and defend the Board from and against any and all liability for loss, damage and expense, which the Board may suffer or for which the Board may be held liable by reason of injury (including death) or damage to any property arising out of negligence on the party of the proponent or any of its representatives or employees by way of ownership or operation of an automobile.
- The successful Contractor shall provide the Board with a complete certified copy of all policies.
- The successful Contractor must name the St. Clair Catholic District School Board as additional insured on their insurance policies.

16. WORKPLACE SAFETY INSURANCE BOARD (WSIB)

Contractor must furnish a copy of Workplace Safety and Insurance Board Clearance Certificate of good standing, "Section 748" of the Workplace Safety and Insurance Act with its bid documents.

17. PERMITS

Contractor shall apply and pay for any permits and approvals required for the completion of their work.

18. MEETINGS

A Post Bid Meeting may be convened and chaired by the Board who will invite Contractor and his major Subcontractors to review the Contract Documents and Bid submitted. This meeting will be prior to the Board issuing a Letter of Intent or Contract. This meeting does not constitute or infer any contract award to the proposed contractor or any other contractor, nor that will the project proceed.

During the course of Work, scheduled progress meetings may be required at the call of the Project Leader.

19. GUARANTEE

The guarantee shall be for a period identified in the general specifications.

The Contractor's guarantee shall cover all work under the Contract whether or not any portion or trade has been sublet.

The Contractor agrees to correct promptly, at the Contractor's own expense, defects or deficiencies in the Work which appear prior to and during the period of guarantee, or such longer periods as may be specified for certain products or work.



INSTRUCTIONS TO BIDDERS

Date: APRIL 19, 2016

BID PACKAGE #: 629-CP1605

If the Contractor fails to make any replacements or repairs required hereunder, after notice from the Board and reasonable opportunity to do so, the Board may have such work done at Contractor's expense, including all necessary labour costs in connection therewith. Board shall inform Contractor in advance of the approximate cost of such work to be done by the Board.

20. SCHEDULE

The Contractor will be required to perform the work in accordance with the Schedule dates provided in 13. Timing of Project. Ordering of major and long delivery items shall begin immediately upon successful bidder's receipt of contract award. The Contractor will provide a construction schedule within five (5) days of being awarded the project.

Time is of the essence. Bidders are to include adequate manpower, overtime and shift work necessary to meet or improve the schedule, and to make up any time lost to weather or normal delays. Include travel, room and board costs for out of town workers, shop overtime and other premiums to expedite material and equipment, shipping premiums and any incentive costs required to meet the schedule.

21. CONTRACTED SERVICES PROGRAM

Contractors performing work on Board property must complete the Contracted Services Program. This program has three basic components that **must** be met before the bid is awarded. Contractors who cannot meet the minimum requirements of this program will not be awarded this tender. Program information can be found on the Board's web site at www.st-clair.net or through the Board contact identified previously in this document.

22. HEALTH and SAFETY

The Occupational Health and Safety Act describes the responsibilities of an employer. The Board requires Contractors to maintain procedures, training, and enforcement so that the responsibilities are carried out in the workplace. The Contractor shall abide by and strictly adhere to the regulations and conditions set out and laid down by the most current versions of the Occupational Health and Safety Act. All staff employed or hired by the Contractor and working on the Board's premise **MUST** be trained in WHMIS in accordance with Occupational Health and Safety Act and Regulations. They **MUST** adhere to all of the Board's Health and Safety Procedures and Guidelines and to Municipal By-Laws.

Contractor will submit proof of its health and safety program, procedures and training as detailed above upon request by the Board.

The Contractor shall appoint a Competent Person as the Supervisor of this project. The Competent Person shall be as defined in Section 1 of the Occupational Health and Safety Act.

The successful Contractor shall conform to the Ontario "Occupational Health and Safety Act" and all regulations made under said act and assume full responsibility for contraventions of same.

All workplace injuries or accidents on Board property **MUST** be reported by the Contractor to the Board's representative within 24 hours.

Any workplace injury that is defined under the Occupational Health and Safety Act as a "Critical Injury" must be reported to the Board's representative **IMMEDIATELY**.



ST. CLAIR CATHOLIC
DISTRICT SCHOOL BOARD

Lighting the Way ~ Rejoicing in Our Journey

BOILER REPLACEMENT TENDER

INSTRUCTIONS TO BIDDERS

Date: APRIL 19, 2016

BID PACKAGE #: 629-CP1605

23. SAFE SCHOOL PROCEDURES

Contractor's staff is required to report to the main office of each school during regular school hours and notify the school office staff of the purpose of the visit. The Contractor is required to adhere to all school specific procedures if applicable.

It is the responsibility of the Contractor's staff to sign in and sign out of the Log Book, which is located in the main office area, while performing their duties.

The following information must be recorded in a legible manner:

- Date
- Company Name
- Employee Name
- Employee Signature
- Reason for Visit
- Time Entering Building
- Time Leaving Building

24. PARKING

Contractors must park within the designated areas and allow for provisions to and from the designated parking area onto the job site.

25. TIE BID

In the event there of a tie. A coin flip conducted by the Procurement Specialist with a minimum of one other Board staff will determine the successful proponent.

END OF INSTRUCTIONS TO BIDDERS



ST. CLAIR CATHOLIC
DISTRICT SCHOOL BOARD

Lighting the Way ~ Rejoicing in Our Journey

**BOILER REPLACEMENT TENDER
ST. ELIZABETH CATHOLIC SCHOOL WALLACEBURG**

BID FORM

Date: APRIL 19, 2016

Project #: 629-CP1605

NAME OF BIDDER

ADDRESS

BID PRICE

I/We the undersigned, having carefully examined the Bid Documents, having received, carefully examined and incorporated Addenda No. _____ to No. _____ inclusive, the General Conditions of the contract as amended by the Supplementary General Conditions, having complied with the Instructions to Bidders, having visited and investigated the Place of the Work, and having examined all conditions, circumstances and limitations affecting the Work, offer to enter into a Contract with the Owner to perform the Work required by the Bid Documents for the price of

_____ CANADIAN DOLLARS (\$ _____). The price offered **excludes** all Harmonized Sales Tax (HST) but includes all other eligible taxes.

HST

The HST amount **not** included in the BID PRICE: \$ _____

ACCEPTANCE

In submitting this bid, we recognize the right of the Owner to accept any bid at the price submitted, to reject any and all bids, or to negotiate contract terms with various bidders, at the Owner's sole

DECLARATIONS

I/We the undersigned declare that:

1. I/We agree to perform the Work in compliance with the Contract Documents and attain Substantial Performance of the Work on or before August 21st, 2016.
2. No person, firm or corporation other than the undersigned has any interest in this bid or in the proposed Contract for which this bid is made.
3. This bid is irrevocable and is open for acceptance by the Owner for a period of sixty (60) days from the date of submission.



ST. CLAIR CATHOLIC
DISTRICT SCHOOL BOARD

Lighting the Way ~ Rejoicing in Our Journey

BOILER REPLACEMENT TENDER
ST. ELIZABETH CATHOLIC SCHOOL WALLACEBURG

BID FORM

Date: APRIL 19, 2016

Project #: 629-CP1605

AUTHORIZATION

Signature (Signing Officer)

Name (Print)

Date

END OF DOCUMENT

APPENDIX A

MECHANICAL & ELECTRICAL

SPECIFICATIONS

FOR

**ST. ELIZABETH CATHOLIC SCHOOL BOILER
REPLACEMENT**

**ISSUED FOR
TENDER**

VANDERWESTEN RUTHERFORD MANTECON
Consulting Structural, Mechanical, Electrical & Civil Engineers
7242 Colonel Talbot Road
London, ON N6L 1H8

Date: April 18, 2016

VRM Project No. 15-199

TABLE OF CONTENTS

Pages

Division 20 - Common to Division 23 and 25

Section 20 01 01 - General Requirements	9
Section 20 01 05 - Demolition and Renovations	4
Section 20 05 00 - Common Work Results	19
Section 20 05 16 - Piping Expansion Control	4
Section 20 05 30 - Supports and Anchors	4
Section 20 05 93 - Testing, Adjusting and Balancing	7
Section 20 07 19 - Piping Insulation	5
Section 20 90 50 - Mechanical-Electrical Equipment Schedule	1

Division 23 - Heating, Ventilating and Air Conditioning (HVAC)

Section 23 00 01 - Supplementary Bid Form	2
Section 23 05 14 - Variable Frequency Drives	6
Section 23 21 13 - Hydronic Piping	8
Section 23 21 16 - Hydronic Specialties	3
Section 23 21 23 - Hydronic Pumps	3
Section 23 25 13 - HVAC Chemical Treatments	4
Section 23 51 00 - Breeching, Chimneys and Stacks	3
Section 23 52 16 - Boilers, Condensing	3
Section 23 82 00 - Terminal Heat Transfer Units	2

Division 25 - Integrated Automation

Section 25 05 00 - Common Work Results	13
Section 25 30 00 - Controls and Instrumentation	54
Section 25 90 00 - Sequences of Operation	2

Division 26 - Electrical

Section 26 00 01 - Electrical Supplementary Bid Form	1
Section 26 03 00 - Electrical Work General Requirements	12
Section 26 03 05 - Basic Electrical Materials and Methods	10
Section 26 03 10 - Demolition and Revisions	2
Section 26 04 25 - Conductor (0-1000 Volts)	3
Section 26 05 33 - Conduit Systems	2
Section 26 05 55 - Motor Starters	2
Section 26 05 60 - Disconnect Switches	1
Section 26 05 66 - Wiring for Mechanical Work	1
Section 26 06 25 - Boxes	2
Section 26 06 35 - Wiring Devices	2
Section 26 06 40 - Branch Circuit Panelboards	2
Section 26 90 50 - Mechanical-Electrical Equipment Schedule	1

END OF TABLE

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Read and conform to:
 - .1 The Contract CCDC 2-2008, Stipulated Price Contract as amended,
 - .2 Division 1 requirements and documents referred to therein.
- .2 Section 20 01 01 applies to and governs the work of all Sections of Divisions 21, 22, 23 and 25.
- .3 The technical Sections of this Division are generally divided into units of work for the purpose of ready reference. The division of the work among subcontractors is not the Consultant's responsibility and the Consultant assumes no responsibility to act as an arbiter and/or to establish subcontract limits between any Sections of the work.
- .4 The specifications are integral with the drawings which accompany them. Neither is to be used alone. Any item or subject omitted from one but implied in the other is fully and properly required.
- .5 Wherever differences occur in the tender documents, the most onerous condition governs. Base the bid on the most costly arrangement.
- .6 ~~**Spec Note:** Ensure Sub-contractors undertaking the work of Divisions 20, 21, 22, 23, 25 provide a 50% performance bond and a 50% labour and materials payment bond. In addition, ensure Sub-contractors employed to undertake any part of the work of afore mentioned Divisions that is \$50,000.00 or greater in contract value provide a 50% performance bond and a 50% labour and materials bond to the party they are in contract with.~~

1.2 WORK INCLUDED

- .1 Products and methods mentioned or shown in the Contract Documents complete with incidentals necessary for a complete operating installation. Provide all tools, equipment and services required to do the work.
- .2 Cutting and patching of new or existing work
- .3 Identification of equipment, piping, ductwork, and valves and controllers
- .4 Concrete equipment bases, housekeeping pads, sump pits and trenches.
- .5 Motors required for equipment supplied under Divisions 20, 21, 22, 23.
- .6 Variable frequency drives for motors and equipment supplied under Divisions 20, 21, 22, 23.
- .7 Internal wiring, relays, contactors, switches, transformers, motor starters, and all controls necessary for the intended operation, furnished with terminals and external controls suitable for connection to power source at a single easily accessed location for equipment items that are supplied with motors and/or electrical or electronic components under Divisions 20, 21, 22, 23.
- .8 Disconnect switches for exhaust fans located on the roof complete with;
 - .1 EEMAC 1 enclosure if housed within a weatherproof cabinet,
 - .2 EEMAC 3 enclosure if exposed to weather
- .9 Take such measures and include in Bid Price for the proper protection of the existing building and its finishes at all times during alterations and construction of the new addition. Coordinate this protective work with all trades.
- .10 Refer to Mechanical/Electrical Equipment Schedule for extent of wiring and electrical characteristics.
- .11 Verify the correct operation of each equipment item provided and/or altered and each system in total and obtain the Owner's approval prior to starting and/or returning to operation.

1.3 RELATED WORK

- .1 Power wiring, conduit and connections for motors under Divisions 21, 22, 23 will be by Division 26.
- .2 Power wiring, conduit and connections to variable frequency drives for motors under Divisions 21, 22, 23, 25 will be by Division 26. Wiring and connections from VFD to motors under Divisions 21, 22, 23, 25 will be by Division 26.
- .3 Flashings for mechanical equipment and services located on or passing through roofs will be provided. Supply counter flashings, and integral flashing collars on equipment and piping under Divisions 21, 22, 23, 25.

1.4 SUBMITTALS

- .1 Approval Drawings: Prepare and submit drawings necessary for approval to any authority having jurisdiction, and obtain two (2) copies of approved drawings for retention by Consultant prior to commencement of work under Divisions 20, 21, 22, 23, 25.
- .2 Shop Drawings: Prepare and submit one (1) electronic copy of shop drawings of major equipment items (including those items specifically indicated under Part 1: General of each Section), to the Consultant for review. The Consultant will return one electronic copy, marked with comments and his review stamp as he deems appropriate. Prepare the necessary number of copies of the returned set and distribute to the Owner, the Prime Consultant, the General Contractor, the site, and to subcontractors and suppliers.
 - .1 Clearly indicate manufacturer's and supplier's names, catalogue model numbers, details of construction, accurate dimensions, capacities and performance. Prior to submission check and certify as correct, shop drawings and data sheets. Do not order equipment until a copy of the shop drawings, reviewed by Consultant, has been returned to Contractor.
 - .2 Clearly indicate the weight, location, method of support and anchor point forces and locations for each piece of equipment on shop drawings.
 - .3 The Consultant will not review shop drawings that fail to bear the Contractor's stamp of approval or certification.
 - .4 Read the following in conjunction with the wording on the shop drawing review stamp applied to each and every drawing submitted:
"This review by the Consultant is for the sole purpose of ascertaining conformance with general design concept. This review shall not mean that the Consultant approves the detail design inherent in the shop drawings, responsibility for which shall remain with the Contractor submitting same, and such review shall not relieve the Contractor of his responsibility for errors or omissions in the shop drawings or of his responsibility for meeting all requirements of the Contract Documents. The Contractor is responsible for dimensions to be confirmed and correlated at the job site, for information that pertains solely to fabrication processes or to techniques of construction and installation and for coordination of the work of all sub trades."
- .3 Directories & Schematics
 - .1 Include one (1) copy of a neat typewritten directory indicating the valve number, related service, and location of each valve under Divisions 20, 21, 22, 23 with close out documents.
 - .2 Enclose one (1) copy of each directory/schematic under glass in a neat polished 18" x24" (460 mm x 610 mm) metal frame, complete with mounting clips.
- .4 Maintenance Data and Operating Instructions
 - .1 Submit one (1) copy of Operation and Maintenance Manual in PDF format on DVD disc clearly marked and labelled accordingly.
 - .2 Ensure the binder spines have typewritten lettering as follows:
OPERATION & MAINTENANCE MANUAL
for
SCCDSB - St. Elizabeth- Boiler Replacement
[Insert date of submission]
[Insert Division Title]
 - .3 Provide a list of names, addresses and telephone numbers of equipment suppliers, installing contractors, general contractors and Consultant.
 - .4 Provide descriptive literature (shop drawings) of each manufactured item.
 - .5 Include PDF copies of Boiler Manufacturer's Fire Test and Start-up Reports and TSSA Certificate of Boiler Inspection.
 - .6 Ensure operating instructions include the following:
 - .1 General description of each mechanical system.
 - .2 Step by step procedure to follow in putting each piece of equipment into service.
 - .3 Schematic control diagrams for each separate mechanical system, control thermometers, freezestats, firestats, pressure gauges, automatic valves, and refrigeration accessories. Mark correct operating settings for each control device on these diagrams.
 - .7 Ensure maintenance instructions include the following:
 - .1 Manufacturer's maintenance instructions for each item of mechanical equipment installed under this Division. Instructions shall include installation instructions, parts numbers and lists, name of supplier and maintenance and lubrication instructions.

- .2 Summary list of each item of mechanical equipment requiring lubrication, indicating the name of the equipment item, location of all points of lubrication, type of lubricant recommended, and frequency of lubrication.
- .3 Equipment directory indicating name, model, serial number and nameplate data of each item of equipment supplied, and system with which it is associated.
- .4 Balancing and testing reports including Chemical Treatment O&M Manual.
- .5 Valve Tag chart directory.
- .6 Boiler Maintenance Schedule
- .5 As-Built Records: Prepare and submit complete as-built records prior to Substantial Performance of the Contract. Refer to Division 1 for requirements.
- .6 Requests for Shut-Down: Obtain permission for systems shut-down and/or service interruption from the Owner prior to disruption of any system or service in use by the Owner. Employ the Owner's standard form of request where available. Refer to Division 1 and section 3.4 for additional requirements.
- .7 Requests for Start-up: Obtain permission from the Owner to start-up or to return to service any item of equipment, system or service installed new or previously shut-down. Refer to Division 1 for additional requirements.
- .8 Warranties: Include descriptions of all equipment and performance warranties (1, 2, 5 and 10 years) and include with close out documents.

1.5 QUALITY ASSURANCE

- .1 Conform to minimum requirements or better of provincial and local codes, where existing, and to requirements of local inspection authorities for execution of work under this Division.
- .2 Ensure materials supplied under this Division conform to minimum requirements and recommendations or better of applicable standards of the following:
 - .1 AABC Associated Air Balance Council
 - .2 AMCA Air Moving and Conditioning Association
 - .3 ANSI American National Standards Institute
 - .4 ASA American Standards Association
 - .5 ASHRAE American Society of Heating, Refrigerating, and Air Conditioning Engineers
 - .6 ASME American Society of Mechanical Engineers
 - .7 ASSE American Society of Sanitary Engineers
 - .8 ASPE American Society of Plumbing Engineers
 - .9 ASTM American Society of Testing and Materials
 - .10 AWWA American Water Works Association
 - .11 CAN2 National Standard of Canada (Published by CGSB)
 - .12 CAN3 National Standard of Canada (Published by CSA)
 - .13 CGSB Canadian General Standards Board
 - .14 CSA Canadian Standards Association
 - .15 EEMAC Electrical & Electronic Manufacturer's Association of Canada
 - .16 NBC National Building Code of Canada
 - .17 NEBB National Environmental Balancing Bureau
 - .18 NFPA National Fire Protection Association
 - .19 NEMA National Electrical Manufacturers Association
 - .20 OBC Ontario Building Code
 - .21 OFC Ontario Fire Code
 - .22 OFM Ontario Fire Marshall
 - .23 SMACNA Sheet Metal & Air Conditioning Contractors National Association
 - .24 TIAC Thermal Insulation Association of Canada
 - .25 ULC Underwriter's Laboratories of Canada Ltd.
 - .26 UL Underwriter's Laboratories (including cUL)
- .3 Use latest editions and amendments in effect on date of Bid call subject to requirements of OBC.
- .4 Arrange and pay for permits and inspections by authorities having jurisdiction, required in the undertaking of this Division. Make modifications required by authorities.
- .5 All tradesmen employed on the project shall hold valid trade certificates/licenses and shall make a copy available for review by the Consultant and/or Owner when requested.

- .6 All welding and brazing shall be executed by certified welders in accordance with registered procedures.
- .7 All refrigeration work shall be executed only by mechanics with valid ODP cards.

1.6 PRODUCT DELIVERY, HANDLING AND STORAGE

- .1 Immediately after letting of contract, review material and equipment requirements for this work, determine supply and delivery dates for all items, and notify Consultant of any potential delays in completion of this project in order that remedial action may be taken.
- .2 Store neatly out of the way and protected from damage and theft, materials and equipment supplied under Divisions 20, 21, 22, 23, 25 that are received at the site by respective Division.

1.7 JOB CONDITIONS

- .1 Visit site and examine existing conditions which may affect work of this Divisions 20, 21, 22, 23, 25.
- .2 Examine all Contract Documents to ensure that work of respective Division may be satisfactorily completed.
- .3 Notify Consultant upon discovery of conditions which adversely affect work of Mechanical Divisions 20, 21, 22, 23, 25. No allowance will be made after letting of contract for any expenses incurred through failure to do so. No extras will be granted due to lack of a thorough preliminary investigation of the site.
- .4 Remove and replace existing ceiling tile to inspect ceiling space for existing Mechanical, Electrical and Structural obstructions. Include cost of all necessary changes in Bid Price. No extras will be granted due to lack of a thorough preliminary investigation of accessible ceiling spaces. Obtain permission from the Owner before removing any ceiling tiles.
- .5 Submission of a bid confirms that the Contract Documents and site conditions are accepted without qualifications, unless exceptions are specifically noted in the Bid.

1.8 WARRANTY

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

1.9 DEFINITIONS

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

1.10 INTERRUPTIONS

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

2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- .1 Ensure materials and equipment provided under Mechanical Divisions 20, 21, 22, 23, 25 are new and free from defects and bear labels of approval as required by codes referred to in this Division and/or by inspection authorities.
- .2 Ensure apparatus and equipment provided under Divisions 20, 21, 22, 23, 25 bears manufacturer's nameplate indicating name of manufacturer, model number or type, size, capacity, CRN, and other pertinent information. Ensure nameplates are easily read and clearly visible, with openings provided where equipment is insulated.
- .3 Ensure manufacturers and suppliers of equipment or materials under Divisions 20, 21, 22, 23, 25 determine if their products are composed of any hazardous materials. If they are, the products are suitably labeled and supplied with Material Safety Data sheets. Obtain the Owner's approval in writing to bring hazardous materials onto the site prior to doing so.
- .4 When utilizing any products that are hazardous, keep Material Safety Data sheets on file at the job site and present them to anyone requesting this information. When transferring hazardous materials from original container into other containers, provide Workplace Labels on such containers.

2.2 ACCEPTABLE PRODUCTS

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

2.3 EQUIVALENTS AND ALTERNATIVES

- .1 Suppliers wishing approval for additional equipment items as equivalent to those specified must submit complete description, technical and performance data to Consultant at least ten (10) working days prior to Bid closing date. Such equivalent equipment, if accepted, to conform to specifications with regard to all details, accessories, modifications, features and performance. Deviations from specifications must be stated in writing at time of submission for approval.
- .2 Bid Prices shall include only products specified or approved equivalents. Contractors may propose unsolicited alternatives to the products specified. Alternative proposals shall be submitted in sealed envelope at time of general contract Bid submission and shall include full description and technical data, and a statement of the related increase or decrease in Bid Price should alternatives be accepted. All additional costs associated with unsolicited alternative proposals such as larger motor starters, larger power feeders, and space revisions to associated equipment, controls, etc. shall be included in alternative price. Prior approval by Consultant is not required for unsolicited alternative proposals.

- .3 Where the Contractor uses equipment other than that first named, on which the design is based, he shall be responsible for all details of installation including equipment size, arrangement, fit, and maintenance of all required clearances. Contractor shall prepare and submit revised layouts to indicate arrangement of all affected piping, ductwork, conduit, lighting, equipment, etc. Failure by Contractor to provide such drawings will be considered indication that original arrangements and space allocations are adequate. All additional costs associated with equivalent equipment such as larger motor starters, larger power feeders, space revisions to associated equipment, controls, etc. shall be included in Bid Price.

2.4 SUBSTITUTIONS DURING PROGRESS OF WORK

- .1 If during the progress of work, specified products are not obtainable, equivalent or similar products by other manufacturers may be permitted by Consultant.
- .2 Apply, in writing, to Consultant for substitution of any products, indicating the following:
 - .1 Manufacturer's name, model number, details of construction, accurate dimensions, capacities and performance of proposed products.
 - .2 Reason for substitution.
 - .3 Any revisions to the contract price made necessary by substitution.
 - .4 Any revisions to the contract time made necessary by substitution.
 - .5 Any revisions to layout, arrangement or services made necessary by substitution.
- .3 No substitutions will be permitted without written authorization from the Consultant.

2.5 CONSULTANT'S REVIEW

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

3 EXECUTION

3.1 RELATIONSHIP WITH OTHER TRADES

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

3.2 INSTALLATION REQUIREMENTS

- .1 The Consultant's drawings and instructions govern the location of all items. Prepare fully coordinated installation drawings prior to installation.
- .2 Install equipment neatly to the satisfaction of the Consultant. Unless noted otherwise install products and services to follow building planes. Ensure installation permits free use of space and maximum headroom.
- .3 Confirm the exact location of outlets, fixtures and connections. Confirm location of outlets for equipment supplied under other Divisions.
- .4 Install equipment and apparatus to allow free access for maintenance, adjustment and eventual replacement. Verify equipment access and coordinate with equipment supplier to ensure equipment can be physically transported to installation location. Under no circumstances will any claim be allowed for extra cost to disassemble and/or assemble equipment at the final location which will be considered as part of the equipment installation.
- .5 Install metering and/or sensing devices to provide proper and reliable sampling of quantities being measured. Install instruments to permit easy observation.

- .6 Provide suitable shielding and physical protection for devices.
- .7 Install products and services in accordance with the manufacturer's requirements and/or recommendations.
- .8 Provide bases, supports, hangers and fasteners. Secure products and services so as not to impose undue stresses on the structure and systems.
- .9 Do not use power activated tools without written permission of the Consultant. Use them in accordance with the Owner's health and safety policies.
- .10 Ensure that the load onto structures does not exceed the maximum loading per square metre indicated on the structural drawings or as directed by the Consultant.

3.3 CONTRACT DRAWINGS

- .1 The drawings of Mechanical Divisions 20, 21, 22, 23, 25 are performance drawings and indicate general arrangement of the work. They are diagrammatic except where specific details are given. No allowance will be made for additional costs arising from the failure to obtain proper clarification of conflicting information before Bid.
- .2 Obtain accurate dimensions from the architectural and structural drawings, or by measurement. Location and elevation of services are approximate. Verify them before construction is undertaken.
- .3 Make changes where required to accommodate structural conditions, (beams, columns, etc.). Obtain Consultant's approval before proceeding.
- .4 Adjust the location of materials and/or equipment as directed without adjustment to contract price, provided that the changes are requested before installation and do not affect material quantity. Note that outlets and/or equipment may be relocated up to 10 feet (3 M) in any direction without a change to the contract price. The Consultant reserves the right to revise the locations of equipment and outlets within any given room without altering the Contract Price provided Notice of Change is given prior to rough-in.
- .5 Note that the layout and orientation of the ceiling outlets on the architectural reflected ceiling drawings may differ from that shown on the mechanical drawings. Make the installation in accordance with the latest architectural ceiling drawings. Provide the equipment as specified and/or shown on the documents of Mechanical Divisions 20, 21, 22, 23, 25.
- .6 The drawings of Mechanical Divisions 20, 21, 22, 23, 25 are intended for tender pricing. The quantities and quality to be included in the bid price shall be based on the layout and specifications as shown on the mechanical documents. If there is a difference in quantity between the architectural and mechanical drawings, base the contract price on the greater quantity. No adjustment to the Contract Price will be allowed to complete the work.
- .7 Prepare installation (construction) drawing to reflect the latest architectural ceiling layout.

3.4 CONSTRUCTION DRAWINGS

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

3.5 RECORD DRAWINGS

- .1 Maintain project "as-built" record drawings. Identify each set as "Project Record Copy".
- .2 Record deviations from contract documents caused by site conditions or by changes ordered by the Consultant. Record deviations in red ink clearly and accurately, using industry standard drafting procedures consistent with quality and standards of Consultants documents.
- .3 Record deviations as work progresses throughout the execution of this contract. Maintain record

drawings on site in clean, dry, legible condition, making them available for periodic review by the Consultant.

- .4 Record location of concealed services, particularly underground services. Before commencing any backfilling, obtain accurate measurements and information concerning correct location and depth of services.
- .5 Transfer records from the "Project Record Copy" to a DVD in Autocad format matching the Consultant's documents. Arrange computer file in layers to exactly match the layering system of the Consultant.
- .6 Submit the "Project Record Copy" in Autocad and PDF format on one or more DVD with one (1) hard copy of each drawing to the Consultant at the time of Substantial Performance. Include the scanned copy of marked up site copy for record purposes. Include "Project Record Copy" in all three formats with O&M manuals described under section 1.4.

3.6 USE OF EQUIPMENT

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

3.7 SPECIAL TOOLS AND SPARE PARTS

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

3.8 EXTRAS AND CREDITS

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

3.9 INSTRUCTION

- .1 Instruct and familiarize Owner's operating personnel with the various mechanical systems. Arrange instruction for each system separately.
- .2 Provide two (2) hour instruction session for systems with the Owner's staff operating schedule, in order that interested personnel may arrange to attend.

- .3 Ensure each instruction period includes, but is not limited to the following;
 - .1 instruction by the manufacturer's representative regarding the proper operating and maintenance procedures for each item of equipment,
 - .2 demonstration of the proper operating procedures for each item of equipment,
 - .3 explanation of the purpose and function of all safety devices provided,
 - .4 demonstration of all measures required for safe and proper access for operation and maintenance.

3.10 COMMISSIONING

- .1 The contractor shall start up and completely commission all equipment and systems installed and/or modified under this contract, Include start-up reports with close-out documents.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 01 01.

1.2 COMMON WORK RESULTS

- .1 Section 20 01 05 applies to and governs all work of Division 21, 22, 23 and 25.

1.3 WORK INCLUDED

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

1.4 REGULATORY REQUIREMENTS

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

1.5 JOB CONDITIONS

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

1.6 INTERRUPTIONS

- .1 Arrange execution of work to maintain present building operations, and to minimize the effect of work under this Division on existing operations. The minimizing of the effect of work within existing building shall include but not be limited to installation of new isolation valves, pipe freezing, draining of the existing system etc.
- .2 Prior to interrupting any existing service notify the Owner and Consultant, in writing, at least 7 days in advance, and obtain written authorization. Do not interrupt any existing service without Consultant's specific authorization. Refer to Division 1 for requirements.
- .3 Arrange time and duration of interruption through the Owner's Physical Plant Department. Include in Bid Price for all overtime or premium time hours necessary to minimize duration of service interruption. Where new valves are installed to replace existing valves and it is impractical to shut-down and drain the entire system, valves shall be replaced using pipe freezing techniques.

- .4 Test and verify the proper operation of existing equipment and systems that are shut down due to work of this project, prior to returning to service.
- .5 Assume responsibility for consequential costs on failure to obtain permission to shut-down and/or start-up any item of equipment, system or service.

2 PRODUCTS

Not Applicable

3 EXECUTION

3.1 PREPARATION

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

3.2 RELATIONSHIP WITH OTHER TRADES

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

3.3 PROTECTION

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

3.4 DEMOLITION

- .1 Notify all authorities of intent to demolish and schedule for the work.
- .2 All demolition work shall conform to all codes, regulations, standards and by-laws applicable to the work.
- .3 Isolate and drain systems as required to effect demolition. Disconnect, cap and make safe all mechanical services to the building including, but not limited to; sanitary sewer(s), storm sewer(s),

- water service, natural gas service, steam service, condensate return, water supply to standpipe and sprinkler systems, fire suppression systems hot water heating systems, steam and condensate systems.
- .4 Protect existing equipment and services to remain from debris and unwanted materials. Clean as necessary to maintain service during demolition period and on completion of the work.
 - .5 Coordinate all service shut downs with Owner's project coordinator. Provide notice as required by Owner and submit schedule for the work.
 - .6 Remove and dispose of all redundant mechanical services and equipment within the limits of the demolition site and where demolished systems extend beyond these limits.
 - .7 Turn over items identified for recovery by the Owner.
 - .8 All demolition work shall conform to Occupational Health & Safety and Environmental regulations.
 - .9 If during alteration work existing asbestos material, other than known asbestos, is discovered (e.g. fireproofing, acoustic or thermal insulation, tank covering), stop work in the affected area and immediately notify consultant. Follow the Ontario Ministry of Labour's Latest Requirements.
 - .10 Ensure that all parties are familiar with requirements and experienced in the work to be undertaken.
 - .11 Waste disposal shall conform to the requirements of Division 1, municipal By-Laws and Ministry of the Environment regulations and standards.
 - .12 All existing air intake and exhaust openings that may be affected by dust and/or debris from the demolition work shall be fitted with appropriate filter media to protect against entry of dust and/or debris into the building and its air distribution systems. Filters shall be closely monitored and replaced when necessary. The Contractor shall replace existing filters that become contaminated with dust and/or debris from demolition work with new filters.
 - .13 In the event that dust and debris from demolition work does penetrate the building and/or its air distribution systems, this Section shall be responsible for cleaning the affected areas and/or systems.
 - .14 Disconnect remove, cap and identify all utilities within demolition areas.
 - .15 Demolish in an orderly and careful manner. Protect existing supporting structural members.
 - .16 Remove demolished materials from site except where specifically noted otherwise. Do not burn or bury materials on site.
 - .17 Remove materials as Work progresses. Upon completion of Work, leave areas in clean condition.
 - .18 Remove temporary Work.

3.5 RENOVATIONS

- .1 Isolate and drain systems as required to effect renovations, modifications and/or repairs. On completion of renovations, modifications and/or repairs, test entire system as if new. Report repairs or replacements required of existing equipment, piping, fittings or devices that are not included in contract to Consultant and Owner for instruction. Flush, clean and refill renovated systems as specified for new.
- .2 Relocate or remove existing items so designated unless specifically indicated to be relocated or removed under other Sections.
- .3 Existing items to be relocated shall be cleaned and repaired or altered as required to suit new location. All damaged or ineffective parts shall be replaced and the item made "as new".
- .4 Existing items to be removed remain the property of the owner and shall be delivered to a location on site designated by the owner. If the owner declares no interest in the removed items, assume ownership and remove the items from the site.
- .5 Make good all surfaces and finishes in areas from which items have been removed and in which items are relocated. Cap all existing services required to be severed to effect alterations and do all other work necessary to make good such areas to satisfaction of consultant.
- .6 Openings in existing floor assemblies and vertical fire separations necessitated by installation of equipment and systems or construction in general must be temporarily sealed with fire barrier materials such as mineral wool or other noncombustible insulation.
- .7 If during alteration work existing asbestos material, other than known asbestos, is discovered (e.g. fireproofing, acoustic or thermal insulation, tank covering), stop work in the affected area and immediately notify consultant. Follow the Ontario Ministry of Labour's Latest Requirements.
- .8 Existing refrigerant indicated to be removed shall not be discharged to the atmosphere, but shall be salvaged and reclaimed or disposed of following the guidelines of the authority having jurisdiction.
- .9 All existing air intake and exhaust openings that may be affected by dust and/or debris from the

renovation work shall be fitted with appropriate filter media to protect against entry of dust and/or debris into the building and its air distribution systems. Filters shall be closely monitored and replaced when necessary. The Contractor shall replace existing filters that become contaminated with dust and/or debris from renovation work with new filters.

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

3.6 INSPECTION AND RE-CERTIFICATION

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

3.7 REFRIGERANT RECOVERY / RECYCLING

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

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 01 01.

1.2 COMMON WORK RESULTS

- .1 Section 20 05 00 applies to and governs all work of Division 21, 22 and 23.

1.3 REFERENCE STANDARDS

- .1 Provide all work in accordance with requirements of Regulatory Agencies and conform to:
 - .1 Local and district by-laws, regulations and published engineering standards.
 - .2 Ontario Building Code as amended,
 - .3 Ontario Gas Utilization Code as amended
 - .4 Regulations for Construction Projects under The Occupational Health and Safety Act.
 - .5 Fire Code made under the Fire Marshal's Act.
- .2 Conform to following CSA Standards:
 - .1 CSA W48 series Electrodes.
 - .2 CSA B51, Boiler, Pressure Vessel and Pressure Piping Code.
 - .3 CAN/CSA-W117.2, Safety in Welding, Cutting and Allied Processes
 - .4 CAN1-B149.1 Natural gas and propane installation code.
 - .5 CSA B64.1 Manual for the Selection and Installation of Backflow Prevention Devices
 - .6 CSA B64.1 Manual for the Maintenance and Field Testing of Backflow Prevention Devices.
- .3 Conform to following National Research Council Canada publications:
 - .1 National Building Code of Canada and Supplements to National Building Code of Canada
 - .2 National Fire Code of Canada.
 - .3 Canadian Plumbing Code.
 - .4 Model National Energy Code for Buildings
- .4 Conform to following American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME) Standards:
 - .1 ANSI/ASME B31.1 Power Piping.
 - .2 ANSI/ASME B31.3, Process Piping.
 - .3 ANSI/ASME Boiler and Pressure Vessel Code:
 - .1 Section 1: Power Boilers.
 - .2 Section V: Nondestructive Examination.
 - .3 Section IX: Welding and Brazing Qualifications.
 - .4 ASME A13.1 - Scheme for the Identification of Piping Systems.
 - .5 ASME B40.100 - Pressure Gauges and Gauge Attachments.
- .5 Conform to following American Welding Society (AWS) Standards:
 - .1 AWS C1.1, Recommended Practices for Resistance Welding.
 - .2 AWS Z49.1, Safety Welding, Cutting and Allied Process.
 - .3 AWS W1, Welding Inspection.
- .6 Conform to following American Society for Testing and Materials (ASTM) Standards:
 - .1 ASTM E1 - Specification for ASTM Thermometers.
 - .2 ASTM E77 - Inspection and Verification of Thermometers.
- .7 Conform to following Underwriters Laboratories (UL) Standards:
 - .1 UL 393 - Indicating Pressure Gauges for Fire-Protection Services.
 - .2 UL 404 - Gauges, Indicating Pressure, for Compressed Gas Service.
- .8 Conform to AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings.
- .9 Conform to AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
- .10 Conform to IEEE 112 - Test Procedure for Polyphase Induction Motors and Generators.
- .11 Conform to NEMA MG 1 - Motors and Generators.
- .12 The above documents or portions thereof are referenced within the work of Division 21, 22 and 23 and shall be considered part of the requirements of this document as though fully repeated herein.

1.4 QUALIFICATIONS

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

1.5 SUBMITTALS

- .1 Submit shop drawings in accordance with refer to section 20 01 01.

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 WASTE MANAGEMENT & DISPOSAL

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

1.8 WARRANTY

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

2 PRODUCTS

2.1 PIPING SPECIALTIES

- .1 Cast brass, pressure, copper to copper unions shall be used with seamless copper tubing smaller than 3" (75 mm).
- .2 Cast brass flanges shall be used with seamless copper tubing, type L for tubing 3" (75 mm) and larger.
- .3 Dart type, 125 lb. (860 kPa) black malleable iron unions shall be used with all steel pipe for piping 2-1/2" (65 mm) and smaller.
- .4 Slip-on, 150 lb. (1000 kPa) carbon steel flanges with 1/16" (4 mm) raised face shall be used with all steel pipe for piping larger than 2-1/2" (65 mm).
- .5 Gaskets for joining flanged steel pipe shall be 1/16" (4 mm) Cranite ring type gaskets.
- .6 Piping specialties including backflow preventers, strainers, valves etc. shall be line size unless indicated otherwise on drawings.
- .7 Strainers
 - .1 Manufacturers:
 - .1 Sarco SB
 - .2 S. A. Armstrong
 - .3 Crane
 - .4 Conbraco
 - .5 Colton
 - .2 In copper tubing: Class 250, wye type, bronze, screwed connection, with blind caps, and 1/32" (0.8 mm) perforated stainless steel screen.
 - .3 In Steel Piping: 2" (50mm) and smaller
 - .1 Body and cover: screwed, line size Y type strainer, semi-steel conforming to ASTM A278-85, Class 30, complete with screwed blind cap. Primary service rating of 125 psi @ 350 F (860 kPa @ 178 C). Body shall have side drain connection.

- .2 Screen: perforated type 304 stainless steel service:
 - .1 Steam 1/16" (0.4 mm)
 - .2 Water 1/32" (0.8 mm)
 - .3 Glycol 1/32" (0.8 mm)
 - .4 Water @ Pump Suction 1/8" (3.2 mm)
 - .5 Light Oil 1/16" (1.6 mm)
 - .6 Compressed Air 1/64" (0.4 mm)
- .4 In Steel Piping: 2-1/2" (65mm) and larger
 - .1 Body and cover: flanged, line size Y type strainer, cast steel, class 150, complete with flanged blow down cover. Primary service rating of 150 psi @ 500 F (1 MPa @ 260 C).
 - .2 Screen: perforated type 304 stainless steel service:
 - .1 Steam 1/32" (0.8 mm)
 - .2 Water 1/16" (1.6 mm)
 - .3 Glycol 1/16" (1.6 mm)
 - .4 Water @ Pump Suction 1/4" (6.4 mm)
 - .5 Light Oil 1/16" (1.6 mm)
 - .6 Compressed Air 1/32" (0.8 mm)
- .5 In grooved piping-where permitted refer to 21, 22, 23 Piping Sections
 - .1 Victaulic Style 730 grooved end tee-type strainer for piping 2 1/2" (65 mm) and larger or approved equivalent.
 - .2 Victaulic Style 731 suction diffuser, or approved equivalent

2.2 ADHESIVES, SEALANTS, PAINTS AND COATINGS

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

2.3 WELDING ELECTRODES

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

2.4 FIRESTOPPING COMPOUND

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

2.5 NAMEPLATES

- .1 Provide laminated plastic plates with black face and white centre of minimum size 3-1/2" x 1-1/2" x 3/32" (90 x 40 x 2 mm) nominal thickness, engraved with 1/4" (6 mm) high lettering. Use 1" (25 mm)

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

2.6 TAGS

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

2.7 STENCILS

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

2.8 PRESSURE GAUGES

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

2.9 STEM TYPE THERMOMETERS

- .1 Manufacturer: Trerice Model BX91403-1/2.
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Weiss Model 9VS3-1/2.
 - .2 Winter
 - .3 Morrison
 - .4 Taylor
- .3 Thermometer: 9" (230mm) scale, red appearing thermal fluid with black figures on white scale, calibrated in both degrees F and degrees C, accuracy to ASTM E77 of 2%, clear glass lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device,

- 3/4" (20mm) NPT brass stem.
- .4 All thermometers to include a separable well.
- .5 Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.
- .6 Flange: 3" (75 mm) outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

2.10 DIAL THERMOMETERS

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

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

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

2.11 TEST PLUGS

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

2.12 STATIC PRESSURE GAUGES

- .1 Manufacturer: Terice
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Weiss.
 - .2 Winter.

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

2.13 ACCESS DOORS

- .1 Standard Universal Flush
 - .1 Material: Up to 16" x 16" (400x400) 16 Gauge mounting frame, over 16" x 16" (400x400) 14 gauge door, 16 gauge mounting frame.
 - .2 Hinge: Continuous, concealed.
 - .3 Latch: Stainless steel screwdriver operated cam latch
 - .4 Finish: Steel: 5-stage iron phosphate preparation with prime coat of white, Alkyd Baking Enamel or stainless steel type 304, No. 4 satin polish.
 - .5 Manufacturers:
 - .1 Acudoor UF-5000
 - .2 CEB
 - .3 MIFAB
 - .4 Cendrex Contour
- .2 Recessed Access Door
 - .1 Material: Steel or stainless steel, 22 gauge door, 22 gauge mounting frame. Door -recessed 5/8"
 - .2 Hinge: Continuous, concealed.
 - .3 Latch: Stainless steel screwdriver operated cam latch
 - .4 Finish: Satin coat steel
 - .5 Manufacturers:
 - .1 Acudoor UF-5015
 - .2 CEB
 - .3 MIFAB
 - .4 Cendrex Contour

2.14 MOTOR CONSTRUCTION AND GENERAL REQUIREMENTS

- .1 Motors less than 0.33 HP (250 W), for intermittent service may be equipment manufacturer's standard and need not conform to these specifications.
- .2 Electrical Service:
 - .1 Motors 0.35 HP (0.38 kW) and Smaller: 115 volts, single phase, 60 Hz.
 - .2 Motors Larger than 0.35 HP (0.38 kW): 208 volts, three phase, 60 Hz.
- .3 Type:
 - .1 Open drip-proof except where noted otherwise.
 - .2 Design for continuous operation in 104°F (40°C) environment.
 - .3 Design for temperature rise to NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
 - .4 Motors with frame sizes 254T and larger: NEMA premium efficiency.
- .4 Motors smaller than 0.5 HP (372 W): Provide continuously rated squirrel cage induction type with capacitor start, EEMAC `N' starting characteristics and a minimum of Class `A' insulation.
- .5 Motors 0.5 HP (372 W) and over: Provide continuously rated squirrel cage induction type with EMAC `B' starting characteristics and a minimum of Class `B' insulation.
- .6 Provide drip-proof type motors with a 1.15 service factor, unless specified or required otherwise by the motor location.
- .7 Provide fan cooled totally enclosed motors having a 1.0 service factor.
- .8 Visible Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, efficiency.

- .9 Wiring Terminations:
 - .1 Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to code, threaded for conduit.
 - .2 For fractional horsepower motors where connection is made directly, provide conduit connection in end frame.
- .10 Provide motors within the 1-500 horsepower range of the "high efficiency" or "premium efficiency" as required under provincial regulations. Ensure this is indicated on the motor nameplate. Provide "T" frame (NEMA Specifications) motors approved under the Ontario Electrical Safety Code. If delivery of specified motor will delay delivery of any equipment, install an acceptable motor for temporary use. Final acceptance of equipment will not occur until the specified motor is installed.
- .11 Coordinate with Division 26 the sizing of electrical protective devices supplying new and relocated mechanical equipment that contain integral motor starters and contactors.
- .12 Motor ratings rated in watts refer to output watts.
- .13 Provide constant speed motors with reduced voltage starters where specified.
- .14 Motors for use with variable frequency drives shall be rated for inverter duty. Motors for pumps and fans shall be rated for inverter duty whether or not VFD are included at this time.
- .15 Design BHP shall not exceed 80% of nominal motor HP.

2.15 SINGLE PHASE POWER - SPLIT PHASE MOTORS

- .1 Starting Torque: Less than 150 percent of full load torque.
- .2 Starting Current: Up to seven times full load current.
- .3 Breakdown Torque: Approximately 200 percent of full load torque.
- .4 Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, pre-lubricated sleeve or ball bearings.
- .5 Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, pre-lubricated ball bearings.

2.16 SINGLE PHASE POWER - PERMANENT-SPLIT CAPACITOR MOTORS

- .1 Starting Torque: Exceeding one fourth of full load torque.
- .2 Starting Current: Up to six times full load current.
- .3 Multiple Speed: Through tapped windings.
- .4 Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, pre-lubricated sleeve or ball bearings, automatic reset overload protector.

2.17 SINGLE PHASE POWER - CAPACITOR START MOTORS

- .1 Starting Torque: Three times full load torque.
- .2 Starting Current: Less than five times full load current.
- .3 Pull-up Torque: Up to 350 percent of full load torque.
- .4 Breakdown Torque: Approximately 250 percent of full load torque.
- .5 Motors: Capacitor in series with starting winding; provide capacitor-start/capacitor-run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
- .6 Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, pre-lubricated sleeve bearings.
- .7 Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, pre-lubricated ball bearings.

2.18 THREE PHASE POWER - SQUIRREL CAGE MOTORS

- .1 Starting Torque: Between 1 and 1-1/2 times full load torque.
- .2 Starting Current: Six times full load current.
- .3 Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics.
- .4 Design, Construction, Testing, and Performance: Conform to NEMA MG 1 for Design B motors.
- .5 Insulation System: NEMA Class B or better.
- .6 Testing Procedure: To IEEE 112. Load test motors to determine free from electrical or mechanical

- defects in compliance with performance data.
- .7 Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- .8 Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors imbedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter.
- .9 Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for re-lubrication, rated for minimum AFBMA 9, L-10 life of 20,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt centre line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
- .10 Sound Power Levels: To NEMA MG 1.
- .11 Part Winding Start Where Indicated: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.
- .12 Weatherproof Epoxy Sealed Motors: Epoxy seal windings using vacuum and pressure with rotor and starter surfaces protected with epoxy enamel; bearings double shielded with waterproof non-washing grease.
- .13 Nominal Efficiency: As scheduled at full load and rated voltage when tested to IEEE 112.
- .14 Nominal Power Factor: As scheduled at full load and rated voltage when tested to IEEE 112.

2.19 SLEEVES

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

2.20 ESCUTCHEONS

- .1 Finish: Polished chrome

2.21 FLASHINGS AND COUNTERFLASHINGS

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

2.22 PENETRATION SEALS

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

3 EXECUTION

3.1 INSPECTION

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

3.2 PREPARATION

- .1 Existing services and equipment shall be relocated or removed to suit new construction and renovation work.
- .2 Services that are no longer required shall be removed or cut back and capped to the satisfaction of Consultant.
- .3 Obtain written authorization from Consultant for renovation work that is not specifically indicated.
- .4 Where modifications or connections to existing systems require shutdown of the system the

Contractor shall submit a request for system shutdown describing the system or part to be shutdown, the duration of the shutdown, the work planned and steps to be taken to reinstate the system to full operation. The request shall be submitted in the format stipulated by the Owner.

- .5 All work required to prepare systems for shutdown and/or re-instatement, such as draining, chemical treatments, and re-filling shall be included in this Bid Price.

3.3 PIPING INSTALLATION - ABOVE GROUND

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

3.4 PIPING JOINTS

- .1 Make joints in piping installed under this Division using persons familiar with the particular materials being used and in accordance with CSA B51 and CSA B52, manufacturer's instructions, and as specified herein.
- .2 Use only welder and/or brazer operators, with a valid identification card, as issued under The Boiler and Pressure Vessels Act, to make joints in Registered Piping Systems, as indicated under Section 20 01 01, and 23 05 00.
- .3 Use 95/5 Sb.Sn (tin-antimony) solder for joining copper drainage tubing smaller than 4" (100 mm), and for joining copper water tubing installed above grade, and smaller than 4" (100 mm).
- .4 Use silver solder or Silfos for joining copper tubing 4" (100 mm) and larger in size.
- .5 Carefully ream joints in threaded pipe and paint with approved graphite type joint sealer on male connections only. Make connections with proper wrench to suit pipe size. Where leaks occur, the joint shall be disassembled and corrected if possible, or replaced. Over-tightening, caulking or peening will not be acceptable.
- .6 Make joints in cast iron pipe with standard M-J joints in accordance with manufacturer's recommendations and CSA B70.
- .7 Install unions or welding flanges at connections to valves, etc. to facilitate removal.
- .8 Use butt welding and/or schedule 40 carbon steel welding fittings to join sections of steel piping with welding ends.

3.5 WELDING

- .1 Welder's Qualifications
 - .1 Welding qualifications to be in accordance with CSA B51.
 - .2 Use qualified and licensed welders possessing certificate for each procedure to be performed from authority having jurisdiction.
 - .3 Furnish welder's qualifications to Consultant and Owner.
 - .4 Each welder to possess identification symbol issued by authority having jurisdiction.
- .2 Inspector's Qualifications: qualified to CSA W178.2
- .3 Welding Procedures

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

3.6 FLUSHING AND CLEANING

- .1 Flush water mains in accordance with procedures established by NFPA 24
- .2 Thoroughly flush all piping installed by this Division.
- .3 Flush and sterilize domestic water mains in accordance with procedures established by AWWA Specification C601.
- .4 Flush new domestic water piping in accordance with Local and Provincial Codes.
- .5 Remove, clean and replace all strainers in systems after flushing.
- .6 Thoroughly clean all equipment and fixtures, and lubricate HVAC equipment, and leave all items in perfect order ready for operation.

3.7 PIPING SYSTEMS TESTING AND INSPECTION

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

3.8 EQUIPMENT TESTING AND INSPECTION

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

3.9 TESTING AND BALANCING

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

3.10 ELECTRICAL COMPONENTS AND WIRING

- .1 Conform to requirements of Division 26 for all wiring included in Division 21, 22 and 23. Includes pre-wired equipment provided by Sections under Division 21, 22 and 23.
- .2 Ensure that all pre-wired electrical equipment is CSA approved. Arrange and pay for special approval where this is not possible.
- .3 Coordinate all wiring requirements with other Divisions. Line voltage wiring from power distribution panels to starters and from starters to motors will be provided under Division 26. All the field wiring for equipment shall be included under Division 21, 22 and 23, unless specifically called for under Division 25.

3.11 PROTECTION

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

3.12 CUTTING AND PATCHING

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

3.13 SEALANTS & CAULKING

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

3.14 FIRESTOPPING

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

3.15 SLEEVES AND CURBS

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

3.16 FLASHINGS

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

3.17 ESCUTCHEONS AND PLATES

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

3.18 SUPPORT AND ATTACHMENT

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

3.19 PAINTING

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

ferrous metals.

3.20 DISSIMILAR METALS

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

3.21 EQUIPMENT BASES AND CURBS

- .1 Supply and erect structural work required for installation of mechanical equipment.
- .2 Build concrete bases 6" (150 mm) high, providing all necessary inserts, anchor bolts and other fasteners required, for floor mounted tanks, heaters, pumps, air handlers, boilers, etc. Make concrete bases 6" (150 mm) larger all around than the base of the supported equipment and trowel finish to a neat smooth finish. Anchor equipment to pads using 8" (200 mm) cast-in-place anchor bolts. Ensure concrete supplied under this Division is 2500 psi (17 MPa) compressive strength after 28 days.
- .3 Build 4" (100 mm) high concrete curbs around all openings through floors for ductwork. Make allowances for installation of ductwork and fire dampers where required. Ensure joint between curb and floor is watertight and maintains integrity of floor membrane where applicable.

3.22 SERVICE CONNECTIONS

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

3.23 BELT DRIVES AND SHEAVES

- .1 Provide belt driven equipment with V-belt drive, designed for at least 130 percent of motor nameplate horsepower rating and in accordance with manufacturer's recommendations for type of service intended. Ensure belt drives are at least 95 percent efficient. Balance and properly align drives. Provide matched sets of belts for multiple belt assemblies. Select belts to suit starting torque of driver. Do not use single belt drives only for motors larger than two horsepower.
- .2 Provide motor sheaves for one and two belt drives of variable pitch type, with Dodge key adjustments. Supply two sets of fixed drive sheaves for drives with three or more belts. Install first set of fixed motor sheaves to obtain the originally specified rpm. After initial test and preliminary adjustment, supply and install the second set of fixed sheaves if necessary, to provide the design flow quantities as established on the job. Obtain correct total flow rate for fans through speed changes and not by throttling.
- .3 Provide adjustable sheaves on motor sizes up to 2 HP (1492 w) and fixed sheaves on larger motors.

3.24 GUARDS

- .1 Provide OSHA compliant guards for exposed drives as follows;
 - .1 Expanded metal screen (both sides) welded to 1" (25 mm) steel angle frame.
 - .2 18 ga. 1" (25 mm) thick galvanized sheet metal tops and bottoms.
 - .3 Removable sides for servicing.
 - .4 1-1/2" (40 mm) dia. holes on both shaft centers for insertion of tachometer.
- .2 Provide means to permit lubrication and use of test instruments with guards in place.
- .3 Install belt guards to permit movement of motors for adjusting belt tension.
- .4 For flexible couplings, provide removable, "U" shaped, 12 ga. 1/10" (2.7 mm) thick galvanized frame and 18 ga. 1/25" (1.2 mm) thick expanded mesh face.
- .5 Provide 3/4" (20 mm) galvanized mesh wire screen on inlet or outlet of exposed fan blades such that net free area to openings is not less than 1.25 of original openings.

3.25 FIELD QUALITY CONTROL

- .1 Temporary and Trial Usage

- .1 Allow the Owner the privilege of temporary and trial usage of installed equipment, as soon as work is complete, for a period of time required to conduct a thorough test.
- .2 Do not construe such usage as evidence of acceptance of work by Owner.
- .3 Repair damage to work tested, resulting from such trial usage, by this Contractor at no cost to Owner.
- .2 Systems Verification:
 - .1 Verify the correct installation and proper operation of equipment and systems installed. Adjust and balance each system as necessary to achieve optimum operation of each system.
 - .2 Co-operate with the TAB agency as follows:
 - .1 Provide assistance when and as requested,
 - .2 Co-ordinate completion of work systematically to permit orderly verification and adherence to schedules,
 - .3 Provide additional necessary flow balancing devices as directed by agency,
 - .4 Notify TAB Agency of tests being conducted.

3.26 ADJUST AND CLEAN

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

3.27 MECHANICAL IDENTIFICATION INSTALLATION

- .1 Degrease and clean surfaces to receive adhesive for identification materials.
- .2 Prepare surfaces for stencil painting.
- .3 Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer (VOC content not to exceed 680 g/L).
- .4 Install tags with corrosion resistant chain.
- .5 Comply with standard detail drawing plate, "Detail of Piping Identification".
- .6 Apply stencil markings on all covered piping.
- .7 Install plastic tape pipe markers complete around bare pipe to manufacturer's instructions.
- .8 Label piping that is heat traced or equipped with heating cable "HEAT TRACED" in addition to other identification. Locate such labels adjacent to other identifications.
- .9 Clearly identify abandoned services left in place as "ABANDONED".
- .10 Install underground plastic pipe markers 6"-8" (150-200 mm) below finished grade, directly above buried pipe.
- .11 Identify pumps, water heating equipment, tanks, and water treatment devices with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.
- .12 Identify control panels and major control components outside panels with plastic nameplates.
- .13 Identify valves in main and branch piping with tags. Consecutively number valves in each system.
- .14 Identify piping, concealed or exposed, with stenciled painting and plastic tape pipe markers. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 6 m on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.
- .15 For each item of equipment which may be started automatically or remotely, add a red lamaroid plate, 2-3/8" x 9" (60 x 230 mm), reading: **"WARNING. THIS EQUIPMENT IS AUTOMATICALLY CONTROLLED. IT MAY START AT ANY TIME."**
- .16 Provide colour coded self-adhesive dots to locate valves or dampers above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

3.28 MECHANICAL IDENTIFICATION SCHEDULES

- .1 Consult the Owner and identify piping, ductwork and equipment as directed;
 - .1 Conforming to the Owner's existing identification practices, or

.2 Conforming to the following Pipe and Valve Identification Table:

SERVICE	COLOURS		LEGEND
	BACKGROUND	LETTERS	
City Water	Green	Black	CITY WATER
Make-Up Water	Yellow	Black	MAKE-UP WTR
Storm Water	Green	Black	STORM
Sanitary	Green	Black	SAN
Plumbing Vent	Green	Black	SAN. VENT
Natural Gas	to Building Code		
Gas Regulator Vents	to Building Code		
Hot water heating supply	Yellow	Black	HEATING SUPPLY
Hot water heating return	Yellow	Black	HEATING RETURN
Make-up water	Yellow	Black	MAKE-UP WTR
Boiler feed water	Yellow	Black	BLR. FEED WTR

3.29 MANUFACTURER'S NAMEPLATES

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

3.30 FLOW DIAGRAMS AND DIRECTORIES

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

3.31 INSTALLATION OF GAUGES AND THERMOMETERS

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

3.32 INSTALLATION OF ACCESS DOORS

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

3.33 MOTOR APPLICATIONS

- .1 Single phase motors for shaft mounted fans: Split phase type.
- .2 Single phase motors for shaft mounted fans or blowers: Permanent split capacitor type.
- .3 Single phase motors for fans: Capacitor start type.
- .4 Single phase motors for fans: Capacitor start, capacitor run type.
- .5 Motors located in exterior locations: Totally enclosed type.
- .6 Motors located in outdoors: Totally enclosed weatherproof epoxy-treated type.
- .7 Motors located in outdoors: Totally enclosed weatherproof epoxy-sealed type.

3.34 INSTALLATION OF MOTORS

- .1 Install motors to manufacturer's instructions.
- .2 Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
- .3 Check line voltage and phase and ensure agreement with nameplate.

3.35 NEMA OPEN MOTOR SERVICE FACTOR SCHEDULE

HP	kW	3600 RPM	1800 RPM	1200 RPM	900 RPM
1/6 - 1/3	0.12-0.25	1.35	1.35	1.35	1.35
1/2	0.38	1.25	1.25	1.25	1.15
3/4	0.5	1.25	1.25	1.15	1.15
1	0.75	1.25	1.15	1.15	1.15
1/6 - 150	0.1-111	1.15	1.15	1.15	1.15

3.36 PERFORMANCE SCHEDULE: THREE PHASE - ENERGY EFFICIENT, OPEN DRIP-PROOF

3 PHASE, ODP					
HP	KW	RPM(Syn)	NEMA Frame	Minimum Efficiency %	Minimum Power Factor %
1	0.75	1200	145T	81	72
1-1/2	1.1	1200	182T	83	73
2	1.5	1200	184T	85	75

3 PHASE, ODP					
HP	KW	RPM(Syn)	NEMA	Minimum	Minimum

			Frame	Efficiency %	Power Factor %
1	0.75	1800	143T	82	84
1-1/2	1.1	1800	145T	84	85
2	1.5	1800	145T	84	85

3 PHASE, ODP					
HP	KW	RPM(Syn)	NEMA Frame	Minimum Efficiency %	Minimum Power Factor %
1-1/2	1.1	3600	143T	82	85
2	1.5	3600	145T	82	87

3.37 PERFORMANCE SCHEDULE: THREE PHASE-ENERGY EFFICIENT, TOTALLY ENCLOSED, FAN COOLED

3 PHASE, TEFC					
HP	KW	RPM(Syn)	NEMA Frame	Minimum Efficiency %	Minimum Power Factor %
1	0.75	1200	145T	81	72
1-1/2	1.1	1200	182T	83	73
2	1.5	1200	184T	85	75

3 PHASE, TEFC					
HP	KW	RPM(Syn)	NEMA Frame	Minimum Efficiency %	Minimum Power Factor %
1	0.75	1800	143T	82	84
1-1/2	1.1	1800	145T	84	85
2	1.5	1800	145T	84	85

3 PHASE, TEFC					
HP	KW	RPM(Syn)	NEMA Frame	Minimum Efficiency %	Minimum Power Factor %

1-1/2	1.1	3600	143T	82	85
2	1.5	3600	145T	82	87

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 01 01.

1.2 COMMON WORK RESULTS

- .1 Section 20 05 16 applies to and governs all work of Division 21, 22 and 23.

1.3 SECTION INCLUDES

- .1 Flexible pipe connectors.
- .2 Anchors and guides

1.4 REFERENCES

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

1.5 PERFORMANCE REQUIREMENTS

- .1 Provide structural work and equipment required to control expansion and contraction of piping.
- .2 Verify that anchors, guides, and expansion joints provided, adequately protect system.
- .3 Arrange all piping so that expansion and contraction of any piping may take place without placing undue strain on the piping or connections to the equipment. Use swing joints and suitable expansion joints wherever necessary due to field conditions and where indicated on the drawings.
- .4 This Section shall analyze each section of pipe installed between constraints and shall determine the potential for expansion of the pipe based on pipe temperature at installation and pipe temperatures throughout the pipe's operating range. Where potential expansion exceeds 1" (25 mm) over the length of the pipe section, expansion compensators shall be installed. Pipe sections are constrained where they penetrate walls, partitions, floors, ceilings, roofs and movement of the pipe is restricted and where the pipe is anchored to the building structure.
- .5 Expansion Calculations:
 - .1 Safety Factor: 30 percent.
 - .2 Installation Temperature: 50°F (10°C).
 - .3 Hot Water Heating: 210°F (99°C).

1.6 SUBMITTALS

- .1 Refer to Section 20 01 01.
- .2 Product Data:
 - .1 Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face-to-face length, live length, hose wall thickness, hose convolutions per metre and per assembly, fundamental frequency of assembly, braid structure, and total number of wires in braid.
 - .2 Expansion Joints: Indicate maximum temperature and pressure rating, and maximum expansion compensation.
- .3 Design Data: Submit detailed construction drawings for expansion compensation and piping anchors, signed and sealed by a professional engineer licenced in Ontario. Provide selection criteria used.
- .4 Manufacturer's Installation Instructions: Indicate special procedures, and external controls.

1.7 QUALIFICATIONS

- .1 Manufacturer: Company specializing in manufacturing the products specified in this section with minimum ten years documented experience.
- .2 Design expansion compensating system under direct supervision of a Professional Engineer experienced in design of this work and licenced in the Province of Ontario.

1.8 DELIVERY, STORAGE, AND HANDLING

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

1.9 WARRANTY

- .1 Warranty: 5-year replacement warranty.

1.10 EXTRA MATERIALS

- .1 Section 20 01 01: Submittals for project closeout.
- .2 Provide two 340 gm containers of packing lubricant and cartridge style grease gun.

2 PRODUCTS

2.1 MANUFACTURERS

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

2.2 PIPE ALIGNMENT GUIDES

- .1 Steel Pipe:
 - .1 Radial "spider" type, minimizing piping motions in non-axial planes.
 - .2 Constructed of carbon steel with a 360-degree two-piece bolted housing, and 360-degree two-piece bolted clamps with spider type legs.
 - .3 Provide an insulation clearance of 1.5" on sizes 6" IPS and under, and 2.0" on sizes 8" IPS and over.
 - .4 Axial travel shall be 3" for sizes 2" IPS and under, and 6" for sizes 2-1/2" IPS and over.
 - .5 Refer to piping and expansion joint schedules for specific insulation and motion requirements.
 - .6 Basis of design: Hyspan Series 9500.
- .2 Copper Pipe:
 - .1 Radial "spider" type, minimizing piping motions in non-axial planes.
 - .2 Constructed of carbon steel with non-metallic coating on the tube clamps, and a 360-degree two-piece bolted housing, and 360-degree two-piece bolted clamps with spider type legs.
 - .3 Provide an insulation clearance of 1.5".
 - .4 Axial travel shall be 3" for sizes 2-1/2" and under, or 6" for sizes 3" and 4".
 - .5 Refer to piping and expansion joint schedules for specific insulation and motion requirements.
 - .6 Basis of design: Hyspan Series 9500.

2.3 FLEXIBLE PIPE CONNECTORS

- .1 Copper Piping:
 - .1 Inner Hose: Bronze
 - .2 Exterior Sleeve: Braided bronze.
 - .3 Pressure Rating: 125 psi (862 kPa) WSP and 450°F (232°C).

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

3 EXECUTION

3.1 INSTALLATION

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

3.2 MANUFACTURER'S FIELD SERVICES

- .1 Prepare and start systems to Section 20 01 01.
- .2 Provide inspection services by manufacturer's representative for final installing and certify installation is to manufacturer's recommendations and connectors are performing satisfactorily.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 01 01.

1.2 COMMON WORK RESULTS

- .1 Section 20 05 30 applies to and governs all work of Division 21, 22 and 23.

1.3 SECTION INCLUDES

- .1 Pipe and equipment hangers and supports.
- .2 Equipment bases and supports.
- .3 Sleeves and seals.
- .4 Flashing and sealing equipment and pipe stacks.

1.4 REFERENCES

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

1.5 SUBMITTALS

- .1 Section 20 01 01: Procedures for submittals.
- .2 Shop Drawings: Indicate system layout with location and detail of trapeze hangers.
- .3 Product Data: Provide manufacturers catalogue data including load capacity.
- .4 Design Data: Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.
- .5 Manufacturer's Installation Instructions: Indicate special procedures and assembly of components.

1.6 REGULATORY REQUIREMENTS

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

2 PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

- .1 Manufacturers:
 - .1 Anvil
 - .2 Myat
 - .3 Copper B-Line
 - .4 Unistrut
 - .5 Erico
- .2 Hydronic Piping:
 - .1 Conform to CSA B-51 and ASME B31.9.
 - .2 Hangers for Pipe Sizes 1/2" to 1-1/2" (13 to 38 mm): Carbon steel, adjustable swivel, split ring.
 - .3 Hangers for Cold Pipe Sizes 2" (50 mm) and Over: Carbon steel, adjustable, clevis.
 - .4 Hangers for Hot Pipe Sizes 2" to 4" (50 to 100 mm): Carbon steel, adjustable, clevis.
 - .5 Hangers for Hot Pipe Sizes 6" (150 mm) and Over: Adjustable steel yoke, cast iron roll, double hanger.

- .6 Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
- .7 Multiple or Trapeze Hangers for Hot Pipe Sizes 6" (150 mm) and Over: Steel channels with welded spacers and hanger rods, cast iron roll.
- .8 Wall Support for Pipe Sizes to 3" (76 mm): Cast iron hook.
- .9 Wall Support for Pipe Sizes 4" (100 mm) and Over: Welded steel bracket and wrought steel clamp.
- .10 Wall Support for Hot Pipe Sizes 6" (150 mm) and Over: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.
- .11 Vertical Support: Steel riser clamp.
- .12 Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- .13 Floor Support for Hot Pipe Sizes to 4" (100 mm): Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- .14 Floor Support for Hot Pipe Sizes 6" (150 mm) and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
- .15 Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

2.2 ACCESSORIES

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

2.3 EQUIPMENT ROOF CURBS

- .1 Fabrication: Welded 0.05" (1.2 mm) galvanized steel shell and base, mitred 3" (75 mm) cant, variable step to match roof insulation, factory installed wood nailer.

3 EXECUTION

3.1 INSTALLATION

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

3.2 INSERTS

- .1 Provide inserts for placement in concrete formwork.
- .2 Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- .3 Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4" (100 mm).
- .4 Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
- .5 Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.

3.3 PIPE HANGERS AND SUPPORTS

- .1 Support horizontal piping as scheduled.
- .2 Install hangers to provide minimum 1/2" (13 mm) space between finished covering and adjacent work.
- .3 Place hangers within 12" (300 mm) of each horizontal elbow.
- .4 Use hangers with 1-1/2" (38 mm) minimum vertical adjustment.
- .5 Support horizontal cast iron pipe adjacent to each hub, with 5 feet (1.5 m) maximum spacing between hangers.
- .6 Support vertical piping at every other floor. Support vertical cast iron pipe at each floor at hub.
- .7 Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- .8 Support riser piping independently of connected horizontal piping.
- .9 Provide copper plated hangers and supports for copper piping.

- .10 Design hangers for pipe movement without disengagement of supported pipe.
- .11 Prime coat exposed steel hangers and supports. Refer to Section 09. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

3.4 EQUIPMENT BASES AND SUPPORTS

- .1 Provide housekeeping pads of concrete, minimum 6" (150 mm) thick and extending 6" (150 mm) beyond supported equipment. Refer to 20 01 01.
- .2 Provide templates, anchor bolts, and accessories for mounting and anchoring equipment.
- .3 Construct supports of steel members. Steel pipe and fittings. Brace and fasten with flanges bolted to structure.
- .4 Provide rigid anchors for pipes after vibration isolation components are installed.

3.5 FLASHING

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

3.6 SLEEVES

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

3.7 SCHEDULES

- .1 Imperial Measure (IP)

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

2	3/8	10	9
2-1/2	3/8	12	10
3	3/8	12	10
4	5/8	14	12

.2 Metric Measure (SI)

Pipe Size (mm)	Rod Diameter (mm)	Support Spacing (m)	
		Steel Pipe	Copper Tube
13	10	2.1	1.8
20	10	2.1	1.8
25	10	2.1	1.8
32	10	2.1	1.8
38	10	2.7	2.4
50	10	3	2.7
65	10	3.6	3
75	10	3.6	3
100	16	4.2	3.6

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 01 01 applies to and governs all work of Division 21, 22, 23 and 25.

1.2 SECTION INCLUDES

- .1 Testing, adjustment, and balancing of air systems.
- .2 Testing, adjustment, and balancing of piping systems.
- .3 Testing, adjustment, and balancing of equipment.
- .4 Testing, adjustment, and balancing of smoke management systems.

1.3 REFERENCES

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

1.4 SUBMITTALS

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

1.5 PROJECT RECORD DOCUMENTS

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

1.6 QUALITY ASSURANCE

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

1.7 INDEPENDENT AGENCY

- .1 All work of Mechanical Testing, Adjusting and Balancing shall be undertaken by a single agency, employed under Division 21, 22, 23 and 25. Other agencies may be proposed as an Alternate only, in accordance with Section 20 01 01, paragraph
- .2 The work of the agency consists of the furnishing of all labour, materials, equipment and accessories necessary in the testing, verification and documentation of the operational performance of all equipment and systems installed under the Sections of Division 21, 22, 23, 25: Mechanical.

1.8 QUALIFICATIONS

- .1 Agency: Company specializing in the testing, adjusting, and balancing of systems under this Section with minimum five years documented experience certified by AABC or prequalified as listed below.
- .2 Work shall be performed under the supervision of an AABC certified Test and Balance Engineer, an NEBB Certified Testing, Adjusting and Balancing Supervisor or a registered Professional Engineer experienced in the performance of this work and licenced at the place where the Project is located.
- .3 Prequalified agencies include;
 - .1 (London)
 - .1 C.J. Zettler & Associates Ltd.
 - .2 D.J Troupe & Associates
 - .3 Caltab
 - .2 (Windsor)
 - .1 Accu Air

1.9 SEQUENCING

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

1.10 CO-OPERATION

- .1 Co-operate with installing Contractor(s) in advising them of specific scheduling requirements for systems verification.
- .2 Provide advice to installing Contractors regarding the location and installation of devices required to permit system balancing and measurements, prior to start of the installation work.

2 PRODUCTS

2.1 REFERENCE STANDARDS

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

3 EXECUTION

3.1 EXAMINATION

- .1 Verify that systems are complete and operable before commencing work. Ensure the following conditions:
 - .1 Systems are started and operating in a safe and normal condition.
 - .2 Temperature control systems are installed complete and operable.
 - .1 Proper thermal overload protection is in place for electrical equipment.
 - .2 Hydronic systems are flushed, filled, and vented.
 - .3 Pumps are rotating correctly.
 - .4 Proper strainer baskets are clean and in place.
 - .5 Service and balance valves are open.
- .2 Submit field reports. Report defects and deficiencies noted during performance of services which prevent system balance.
- .3 Beginning of work represents acceptance of existing conditions in the areas served.

3.2 PREPARATION

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

3.3 INSTALLATION TOLERANCES

- .1 Hydronic Systems: Adjust to within plus or minus 10 percent of design.

3.4 ADJUSTING

- .1 Ensure recorded data represents actual measured or observed conditions.
- .2 Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- .3 After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- .4 Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
- .5 At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.
- .6 Check and adjust systems approximately six months after final acceptance and submit report.

3.5 WATER SYSTEM PROCEDURE

- .1 Adjust water systems to provide required or design quantities.
- .2 Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.
- .3 Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
- .4 Effect system balance with automatic control valves fully open to heat transfer elements.
- .5 Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.
- .6 Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

3.6 SCHEDULES

- .1 Equipment requiring testing, adjusting and balancing:
 - .3 HVAC Pumps
 - .4 Terminal Heat Transfer Units

- .2 Report Forms
 - .1 Title Page:
 - .1 Name of Testing, Adjusting, and Balancing Agency
 - .2 Address of Testing, Adjusting, and Balancing Agency
 - .3 Telephone number of Testing, Adjusting, and Balancing Agency
 - .4 Project name
 - .5 Project location
 - .6 Project Architect
 - .7 Project Engineer
 - .8 Project Contractor
 - .9 Project altitude
 - .10 Report date
 - .2 Summary Comments:
 - .1 Design versus final performance
 - .2 Notable characteristics of system
 - .3 Description of systems operation sequence
 - .4 Nomenclature used throughout report
 - .5 Test conditions
 - .3 Instrument List:
 - .1 Instrument
 - .2 Manufacturer
 - .3 Model number
 - .4 Serial number
 - .5 Range
 - .6 Calibration date
 - .4 Electric Motors:
 - .1 Manufacturer
 - .2 Model/Frame
 - .3 HP/BHP
 - .4 Phase, voltage, amperage; nameplate, actual, no load
 - .5 RPM
 - .6 Service factor
 - .7 Starter size, rating, heater elements
 - .8 Sheave Make/Size/Bore
 - .5 V-Belt Drive:
 - .1 Identification/location
 - .2 Required driven RPM
 - .3 Driven sheave, diameter and RPM
 - .4 Belt, size and quantity
 - .5 Motor sheave diameter and RPM
 - .6 Centre to centre distance, maximum, minimum, and actual
 - .6 Pump Data:
 - .1 Identification/number
 - .2 Manufacturer
 - .3 Size/model
 - .4 Impeller
 - .5 Service
 - .6 Design flow rate, pressure drop, BHP
 - .7 Actual flow rate, pressure drop, BHP
 - .8 Discharge pressure
 - .9 Suction pressure
 - .10 Total operating head pressure
 - .11 Shut off, discharge and suction pressures
 - .12 Shut off, total head pressure

3.7 VERIFICATION CHECKLIST

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

3.8 EQUIPMENT VERIFICATION

- .1 Test the operation of all equipment installed under Division 21, 22, 23, 25 according to instructions in appropriate articles of this Division. Advise installing contractor of any required adjustments or replacements to ensure that equipment is operating as intended. Retest equipment after adjustment or replacement.
- .2 Ensure that the Contractor has given proper advance notification to all persons required to be present as tests are conducted.
- .3 Instrumentation: verify installation of air filter gauges, pumps, thermometers, thermometer wells, pitot traverse stations, and flow-measuring devices ensuring that:
 - .1 Location of points for readings is appropriate to measure what it is intended to measure;
 - .2 The scale range is appropriate to place the normal reading near mid-range of the scale;
 - .3 Proper positioning of instrumentation to allow reading from a convenient location, and for easy access.
- .4 Pre-start-up Inspection:
 - .1 Verify proper equipment mounting and setting.
 - .2 Verify that control, interlock, and power wiring are complete.
 - .3 Verify proper alignment of motors and drives.
 - .4 Verify proper piping connections and accessories.
 - .5 Verify that lubrication is complete.
- .5 First Run Observation:
 - .1 Verify direction of rotation.
 - .2 Verify setting of safety controls.
 - .3 Monitor heat build-up in bearings.
 - .4 Check motor loads against nameplate ratings.
- .6 Equipment Checkout:
 - .1 Verify the proper overload heater sizes.
 - .2 Verify function of safety and operating controls.
 - .3 Verify proper operation of equipment.
 - .4 Report on inspection, observation, and checkout procedures.
- .7 Stuffing Boxes and Packing Glands: verify adjustment of boxes on pump shafts and packing glands on valve stems.
- .8 Motor Rotation: visually inspect and verify the direction of motor rotation. It is possible for motor rotation to have been checked by the electrician when power connections were made on temporary electric power, then when final connections were made to the permanent transformer bank, crossed phasing may reverse the rotation of all three-phase motors on the system.
- .9 Overload Heaters: verify supply voltage to each equipment. If the applied voltage is different from the motor nameplate, determine whether the applied voltage is within the range allowed under the motor guarantee. If not, take the necessary action to have the Contractor change the motor or the applied voltage. When the voltage is off the nameplate value, but within the allowable range, compute the equivalent amperage at nameplate voltage and compare to the overload heater amperage rating range. Then, consider whether the ambient temperature of the starter is above, below, or the same as the ambient temperature are not the same. Advise the Contractor to use overload heaters of higher range for "hot area" starters or ones of lower range for "cold area" starters to compensate the heater trip point for heat gains or losses with the environment.
- .10 Alignment of Drives: verify the alignment of drives, belt and direct coupled, and the adjustment of belt tension.

- .11 Control Diagrams and Sequences: provide for coordination with work under the automatic control systems to have the control diagrams and sequences of operation corrected to "as installed", reflecting changes brought about in response to contract modifications and to the more pragmatic changes in diagrams and sequences to make the installed system control the building systems as intended by the designer.
- .12 Safety and Operating Control Setpoints: systematically verify the safety and operating controls of equipment, including an operational check of associated control sequences.
- .13 Fin Straightening: inspect finned surface heat transfer coils for damages fins and advise Contractor of repairs required.
- .14 Verify that manufacturer's start-up procedures have been performed and that equipment is installed in accordance with the manufacturer's written installation recommendations.
- .15 Where work is noted to be done in stages a complete air balance and verification report will be required at the end of each stage.

3.9 PIPING SYSTEMS VERIFICATION

- .1 Review the drawings, specifications, and installed work to ensure that systems may be properly balanced in accordance with drawings. Advise the installing Contractor of any additional requirements for effective balancing.
- .2 Complete air balance must have been accomplished before water balance is verified.
- .3 Open all valves to full position, including coil stop valves, close bypass valves, and return line balancing cocks.
- .4 Verify that all strainers are clean.
- .5 Examine water in system to determine if it has been treated and is clean.
- .6 Check and record type and concentration of glycol in systems which require freeze protection.
- .7 Check pump rotation.
- .8 Check diaphragm expansion tanks to ensure that fill pressure is adequate (re. static head of systems plus 5 psig or 12 psig minimum (35 kPa or 83 kPa minimum).
- .9 Check open expansion tanks to make sure they are not air bound and that the system is full of water.
- .10 Check all air vents at high points of water systems to make sure they are installed properly and are operating freely. Verify that all air is removed from circulating system.
- .11 Set all temperature controls so that all coils are calling for full cooling. This should close all automatic bypass valves at coil and chillers. To balance hot water coils, set systems to call for full heating.
- .12 Verify operation of automatic bypass valve.
- .13 Verify operating temperature of heat exchangers, to design requirements.
- .14 Check and record the following items at each cooling and heating element:
 - .1 Inlet water and air temperatures. Note rise or drop in temperature train source.
 - .2 Leaving water and air temperatures.
 - .3 Pressure drop and flow through each coil.
 - .4 Pump operating suction and discharge pressure and final t.d.h. and flow delivered.
 - .5 Pressure drop across bypass valve.
 - .6 All mechanical specifications of pumps.
 - .7 Rated and actual running amperage of pump motor.
- .15 Witness all piping tests.

3.10 MODIFICATIONS TO EXISTING SYSTEMS

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

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 01 01.

1.1 COMMON WORK RESULTS

- .1 Section 20 07 19 applies to and governs all work of Division 21, 22 and 23.

1.2 SECTION INCLUDES

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

1.3 REFERENCES

- .1 ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
- .2 ASTM C177 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
- .3 ASTM C195 - Mineral Fibre Thermal Insulating Cement.
- .4 ASTM C335 - Steady-State Heat Transfer Properties of Horizontal Pipe Insulation.
- .5 ASTM C449/C449M - Mineral Fibre Hydraulic-setting Thermal Insulating and Finishing Cement.
- .6 ASTM C518 - Steady-State Thermal Transmission Properties by Means of the Heat Flow Metre Apparatus.
- .7 ASTM C533 - Calcium Silicate Block and Pipe Thermal Insulation.
- .8 ASTM C534 - Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
- .9 ASTM C547 - Mineral Fibre Pipe Insulation.
- .10 ASTM C552 - Cellular Glass Thermal Insulation.
- .11 ASTM C578 - Rigid, Cellular Polystyrene Thermal Insulation.
- .12 ASTM C585 - Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
- .13 ASTM C591 - Unfaced Preformed Cellular Polyisocyanurate Thermal Insulation.
- .14 ASTM C610 - Moulded Expanded Perlite Block and Pipe Thermal Insulation.
- .15 ASTM C921 - Properties of Jacketing Materials for Thermal Insulation.
- .16 ASTM D1056 - Flexible Cellular Materials - Sponge or Expanded Rubber.
- .17 ASTM D1667 - Flexible Cellular Materials - Vinyl Chloride Polymers and Copolymers (Closed Cell Foam).
- .18 ASTM D2842 - Water Absorption of Rigid Cellular Plastics.
- .19 ASTM E84 - Surface Burning Characteristics of Building Materials.
- .20 ASTM E96 - Water Vapour Transmission of Materials.
- .21 NFPA 255 - Surface Burning Characteristics of Building Materials.
- .22 UL 723 - Surface Burning Characteristics of Building Materials.
- .23 ASHRAE 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings

1.4 SUBMITTALS

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

1.5 QUALITY ASSURANCE

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

1.6 QUALIFICATIONS

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

experience.

1.7 DELIVERY, STORAGE, AND HANDLING

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

1.8 ENVIRONMENTAL REQUIREMENTS

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

2 PRODUCTS

2.1 GLASS FIBRE

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

2.2 PHENOLIC INSULATION

- .1 Manufacturers:
 - .1 Manufacturer: Resolco International bv "Insul-Phen"
 - .2 Other Manufacturers: in accordance with 15010.2.3
- .2 Insulation: ASTM C-1126 Phenolic Foam Thermal Insulation, CFC and HCFC free, rigid moulded,

noncombustible insulation fabricated in required shapes by Resolco International approved fabricators to ASTM C-450 and C-585.

- .1 Density: 2.5-lb/ft³ (40-kg/m³)
- .2 Temperature range: -290°F to +250°F (-129°C to +107°C)
- .3 Closed cell content: 92%
- .4 Compressive strength: 29 psi (2 bar)
- .5 Thermal conductivity: 0.13 BTU-in/hr-ft²-°F (18.72 W-mm/m²-°C)
- .6 Fire resistance rating: 25/50 to ASTM E84 on plain and faced product up to 3" (75mm) thick
- .3 Joint Sealer:
 - .1 vapour barrier type, moisture and water resistant, 97% solids by weight, non-hardening, flexible in temperature range from -5°F to +200°F (-20.5°C to +93.3°C), Daxcel 161D, Fosters 30-45, Childers CP-76.

2.3 JACKETS

- .1 PVC Plastic
 - .1 Jacket: ASTM C921, One piece moulded type fitting covers and sheet material.
 - .1 Minimum Service Temperature: -31°F (-35°C).
 - .2 Maximum Service Temperature: 151°F (66°C).
 - .3 Moisture Vapour Transmission: ASTM E96; 0.03 perm inches.
 - .4 Maximum Flame Spread: ASTM E84; 25 or less.
 - .5 Maximum Smoke Developed: ASTM E84; 50 or less.
 - .6 Thickness: 20 mil (0.4 mm) minimum.
 - .2 Colour: standard off-white OR coloured to suit pipe identification.
 - .3 Covering Adhesive Mastic
 - .1 Compatible with insulation, maximum VOC content of 50 g/L.
 - .4 Manufacturer;
 - .1 Ceel-Co 300 series
 - .2 Speedline Smoke Safe

2.4 REMOVABLE / REUSABLE INSULATION COVERS

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

2.5 ACCESSORIES

- .1 Adhesives and finishes shall be as recommended by the insulation manufacturer and shall comply with Section 20 05 00 Accessories such as adhesives, mastics and cements shall have the same properties as listed above and shall not detract from any of the system ratings specified.
- .2 Vapor retarder lap adhesive shall be water based, fire retardant
- .3 Tapes shall be of cloth reinforced aluminum, soft adhesive with minimum 2" (50 mm) width.
- .4 Tie wire shall be of 1/16" (1.5 mm) Ø stainless steel.
- .5 Fasteners shall be of 1/8" (4 mm) Ø pins, with 35 mm square clips. Clip length to suit insulation thickness.
- .6 Bands shall be 1/2" (12 mm) wide 1/4" (6mm) thick galvanized steel.
- .7 Facing shall be of 1" (25 mm) galvanized steel hexagonal wire mesh attached on both faces of insulation

3 EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

- .1 Install piping insulations to TIAC National Installation Standards.
- .2 Apply insulation materials, accessories, jackets and finishes in accordance with manufacturer' written instructions and as specified.
- .3 On exposed piping locate insulation and cover seams in least visible locations.
- .4 For insulated pipes conveying fluids above ambient temperature:
 - .1 Provide standard jackets, with or without vapour barrier, factory applied or field applied.
 - .2 Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe.
 - .3 Finish with glass cloth and adhesive.
 - .4 PVC fitting covers may be used.
 - .5 For hot piping conveying fluids 140°F (60°C) or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
 - .6 For hot piping conveying fluids over 140°F (60°C), insulate flanges and unions at equipment.
- .5 Inserts and Shields:
 - .1 Application: Piping 1-1/2" (40 mm) diameter or larger.
 - .2 Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
 - .3 Insert Location: Between support shield and piping and under the finish jacket.
 - .4 Insert Configuration: Minimum 6" (150 mm) long, of same thickness and contour as adjoining insulation; may be factory fabricated.
 - .5 Insert Material: hydrous calcium silicate insulation.
- .6 Finish insulation at supports, protrusions, and interruptions.
- .7 Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapour barrier cement.
- .8 Provide integral vapour barrier jacket on insulation on pipe and fittings for exterior applications.
- .9 Provide PVC jacket and fitting covers for pipe in mechanical equipment rooms and where exposed in finished spaces.

3.3 PIPE INSULATION

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

RIGID PIPE INSULATION (I-P)			
Service	Operating Temperature Range °F	Pipe Diameter in.	Insulation Thickness in.
Hydronic heating (hot water & glycol/water)	105 to 140	4 and smaller	1
		5 and larger	1-1/2
	141 to 200	All sizes	1-1/2
Sanitary drainage	40 to 55	All sizes	1
Storm drainage	40 to 55	All sizes	1
FLEXIBLE INSULATION			
Service			Insulation Thickness

Horizontal storm and sanitary drainage	1"
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RIGID PIPE INSULATION (SI)			
Service	Operating Temperature Range °C	Pipe Diameter (mm)	Insulation Thickness (mm)
Hydronic heating (hot water & glycol/water)	41 to 60	100 and smaller	25
		125 and larger	40
	61 to 93	All sizes	40
Sanitary drainage	4 to 13	All sizes	25
Storm drainage	4 to 13	All sizes	25
FLEXIBLE INSULATION			
Service			Insulation Thickness
Horizontal storm and sanitary drainage			25mm

- .2 Phenolic insulation may be used in place of rigid fibreglass pipe insulation, thickness to provide equivalent thermal resistance.
- .3 Insulate valves, flanges and pipe connections with removable / reusable insulation covers.
- .4 Wrap butt joints with a 4" (100 mm) strip of fire resistant vapour barrier jacket cemented with lagging adhesive.
- .5 Where the pipe hanger is around the insulation, provide an insulation protection shield within the pipe saddle. Coordinate with installation of hangers.
- .6 Insulate all fittings, flanges and valves on pipes to provide equivalent insulation to that on adjoining pipe.
- .7 Continue insulation through sleeves including specified finish.
- .8 Cut back covering on strainers and finish off to expose removable head insulation.
- .9 Cover expansion joints first with 24 gauge (0.7 mm) galvanized metal sleeve and then insulate to provide equivalent thickness to that on adjoining pipe.
- .10 Protect insulation with protection saddles where insulated pipe is supported by rollers.
- .11 Extend pipe insulation and covering through walls, floors, ceilings, and concrete beams, unless indicated otherwise on drawings. Protect exposed insulation extending through floors with 4" (100 mm) wide strip of 18 gauge (1.3 mm) galvanized iron.
- .12 Pack annular space between pipe sleeves and piping or pipe covering with glass fibre insulation or rockwool insulation. In fire rated assemblies use Dow Silicon RTV or other ULC listed materials. Seal exposed insulation with mastic.
- .13 Recover exposed surfaces of insulated piping installed in exposed areas, mechanical rooms, and equipment rooms with PVC jacketing and PVC fitting covers installed in accordance with manufacturers instructions.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

.1 Comply with General Requirements of Section 20 01 01.

1.2 COMMON WORK RESULTS

.1 Section 20 90 50 applies to and governs all work of Division 21, 22, 23 and 25.

1.3 MECHANICAL-ELECTRICAL EQUIPMENT SCHEDULE

- .1 The following Mechanical-Electrical Equipment Schedule is provided to assist the Contractor in coordinating the efforts of sub-trades. The assignment of work among subcontractors is the Contractor's responsibility and the Contractor is free to amend the schedule as he sees fit.
- .2 The Mechanical-Electrical Equipment Schedule also describes work that is required and may or may not be described elsewhere. All work indicated in the Mechanical-Electrical Equipment Schedule shall be included in the Bid Price.
- .3 The Mechanical-Electrical Equipment Schedule shall not limit the extent of the Contract in any way. Work indicated elsewhere or otherwise needed for a complete and functioning installation shall be provided whether or not shown in the Mechanical-Electrical Equipment Schedule.

1.4 RESPONSIBILITY CODES

- .1 Responsibility Codes in the Mechanical Equipment Schedule shall be interpreted as follows:
 - .1 "Supplied by Div." means that the equipment is to be supplied to the site under the division described by number.
 - .2 "Installed by Div." means that the equipment is to be received from the supplier, handled, set in place and installed at the site under the Division described by number.
 - .3 "Wired and connected by Div." means that the equipment and its associated devices are to be wired and connected to the various electrical systems in accordance with the equipment manufacturer's installation instructions and wiring diagrams under the Division described by number.

No.	Equipment			Controls			Responsibility			
	Item	Characteristics	Location	Type	Location	Manufacturer's Reference	Supplied by Div.	Installed By Div.	Wired & Connected by Div.	
1	B-1A HOT WATER BOILER	HP	FHP	MECHANICAL ROOM	Disconnect	At Unit	See Elec Spec	26	26	26
		Voltage	120		Starter	At unit	See Mech Spec	23	23	26
		Phases	1		Boiler Controls	At Boiler	See Mech Spec	23	23	25
		Freq.	60		BAS		See Mech Spec	25	25	25
					Control wiring from boiler control panel to boiler circ. pump by Div. 25. Boiler disconnect at +5'-0". Do not gang with light switch. Clearly identify with red lamacoid label.					

No.	Equipment			Controls			Responsibility			
	Item	Characteristics	Location	Type	Location	Manufacturer's Reference	Supplied by Div.	Installed By Div.	Wired & Connected by Div.	
2	B-1B HOT WATER BOILER	HP	FHP	MECHANICAL ROOM	Disconnect	At Unit	See Elec Spec	26	26	26
		Voltage	120		Starter	At unit	See Mech Spec	23	23	26
		Phases	1		Boiler Controls	See Dwgs.	See Mech Spec	23	23	25
		Freq.	60		BAS		See Mech Spec	25	25	25
					Control wiring from boiler control panel to boiler circ. pump by Div. 25. Boiler disconnect at +5'-0". Do not gang with light switch. Clearly identify with red lamacoid label.					
3	BOILER PUMP BP-1A	HP	FHP	MECHANICAL ROOM	Disconnect	At Pump	In starter	26	26	26
		Voltage	120		Starter	Near Unit	AB 512 Series	26	26	26
		Phases	1		Other Controls	See mech spec	See mech spec	23	23	25
		Freq.	60							
4	BOILER PUMP BP-1B	HP	FHP	MECHANICAL ROOM	Disconnect	At Pump	In starter	26	26	26
		Voltage	120		Starter	Near Unit	AB 512 Series	26	26	26
		Phases	3		Other Controls	See mech spec	See mech spec	23	23	25
		Freq.	60							
5	BUILDING HEATING LOOP PUMP CP-1A	HP	1 1/2	MECHANICAL ROOM #2	VFD c/w Disconnect	See Drawings.	See Mech. Spec	23	23	26
		Voltage	208		Other Controls	See mech spec	See mech spec	23	23	25
		Phases	3		BAS	See mech spec	See mech spec	25	25	25
		Freq.	60							
6	BUILDING HEATING LOOP PUMP CP-1B	HP	1 1/2	MECHANICAL ROOM	VFD c/w Disconnect	See Drawings.	See Mech. Spec	23	23	26
		Voltage	208		Other Controls	See mech spec	See mech spec	23	23	25
		Phases	3		BAS	See mech spec	See mech spec	25	25	25
		Freq.	60							
7	PORTABLES' HEATING LOOPCP-2	HP	1	MECHANICAL ROOM	VFD c/w Disconnect	See Drawings.	See Mech. Spec	23	23	26
		Voltage	208		Other Controls	See mech spec	See mech spec	23	23	25
		Phases	3		BAS	See mech spec	See mech spec	25	25	25
		Freq.	60							

No.	Equipment				Controls			Responsibility		
	Item	Characteristics		Location	Type	Location	Manufacturer's Reference	Supplied by Div.	Installed By Div.	Wired & Connected by Div.
8	CABINET UNIT HEATER	HP	1/2	PORTABLES CORRIDOR EXIT DOOR	Disconnect/Starter	At Unit	See Spec.	23	23	26
		Voltage	120							
		Phases	1		Thermostat	See mech drawings	See mech spec	23	26	26
		Freq.	60							

END OF SECTION

1 GENERAL

1.1 SUBMITTAL

- .1 Each bidder for the work of Division 23: Heating, Ventilating and Air Conditioning (HVAC) shall submit this Supplementary Bid Form to the consultant within two (2) hours of tender closing to the Consultant.
- .2 This document, on acceptance by the Consultant, will be included in the Contract Documents and shall govern the work of Division 23: HVAC.

1.2 SUBCONTRACTORS

- .1 List the trade Subcontractors that have been included in the bid proposal.

TRADE	OWN FORCES	SUBCONTRACTOR
Steam Fitting	<input type="checkbox"/>	
Gas Fitting	<input type="checkbox"/>	
Hydronic Piping	<input type="checkbox"/>	
Welding	<input type="checkbox"/>	
Insulation	<input type="checkbox"/>	
Testing, Adjusting & Balancing	<input type="checkbox"/>	

1.3 LABOUR RATES

- .1 Indicate the unit labour rate required for additional work and/or work to be deleted in changes to the Contract under Part 6 of the General Conditions of the Stipulated Price Contract. Rates indicated shall include all allowances for foremen, supervision and office support but shall not include the Division 23 Sub-Contractor's overhead and profit margins and shall be based on regular working hours.
- .2 Labour rates for changes must be negotiated with the Owner prior to acceptance and use in pricing.

TRADE	HOURLY RATE
Steam Fitting	
Gas Fitting	
Hydronic Piping	
Welding	
Insulation	
Testing, Adjusting & Balancing	

1.4 PRODUCTS

- .1 Indicate the name of the manufacturer of equipment items included in the Bid Price by submitting a copy of the appended Equipment List marked to indicate choices. Failure to indicate a specific manufacturer will be taken to mean that products of the first manufacturer named in the specifications are included in the Bid Price. This list shall in no way limit the extent of the Contract.
- .2 The Division 23 Bidder may propose the name of an alternative manufacturer for any equipment item in accordance with Section 20 01 01, Part 2, Article 2.3.

Section	Product	Specified Product Included in Bid	Proposed Alternative
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20 05 00	Adhesives & Sealants- Low VOC		
	Firestop Systems & Sealants		
	Gauges		
	Thermometers		
	Automatic Temperature & Pressure Relief Valves		
	Access Doors		
20 05 14	Pipe Expansion Control		
20 05 30	Pipe Hangars and Supports		
	Pipe Support Systems		
20 07 19	Rigid Pipe Insulation		
	Flexible Pipe Insulation		
	Phenolic Pipe Insulation		
	PVC Pipe Covering		
23 05 14	Variable Frequency Drives		
23 21 13	Valves		
	Circuit Balancing Valves		
23 21 16	Expansion Tanks		
	Air Separators		
	Strainers		
	Pump Suction Fittings		
	Relief Valves		
23 21 23	Circulators		
	Vertical In-Line		
	Suction Guides		
	Triple Duty Valves		
23 35 13	HVAC Chemical Treatment		
23 51 00	Breeching, Chimneys and Stacks		
23 82 00	Terminal Heat Transfer Units		

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 01 01 applies to and governs all work of Division 21, 22 and 23.

1.2 SECTION INCLUDES

- .1 Variable Frequency Drives.

1.3 SUBMITTALS

- .1 Section 20 01 01: Procedures for submittals.
- .2 Product Data: Provide wiring diagrams with electrical characteristics and connection requirements.
- .3 Manufacturer's Installation Instructions: indicate setting, mechanical connections, lubrication, and wiring instructions.
- .4 Submit manufacturer's performance data including dimensional drawings, power circuit diagrams, installation and maintenance manuals, warranty description, VFD's FLA rating, certification agency file numbers and catalog information.
- .5 The specification lists the minimum VFD performance requirements for this project. Each supplier shall list any exceptions to the specification. If no departures from the specification are identified, the supplier shall be bound by the specification.
- .6 Harmonic filtering. The seller shall, with the aid of the buyer's electrical power single line diagram, providing the data required by IEEE-519, perform an analysis to initially demonstrate the supplied equipment will meet the IEEE standards after installation. If, as a result of the analysis, it is determined that additional filter equipment is required to meet the IEEE recommendations, then the cost of such equipment shall be included in the bid. A harmonic analysis shall be submitted with the approval drawings to verify compliance with the latest version of IEEE-519 voltage and current distortion limits as shown in table 10.2 and 10.3 at the point of common coupling (PCC). The PCC shall be defined as the consumer-utility interface or primary side of the main distribution transformer.
- .7 Operating and Maintenance manuals: Include instructions for safe operating procedures and maintenance requirements. Include complete assembly and wiring drawings.

1.4 QUALITY ASSURANCE

- .1 Manufacturer: Company specializing in manufacture of variable frequency drives for HVAC use, and their accessories, with minimum ten (10) years documented product development, testing, and manufacturing experience.
- .2 To ensure quality and minimize infantile failures at the jobsite, the complete VFD shall be tested by the manufacturer. The VFD shall operate a dynamometer at full load and speed and shall be cycled during the test.
- .3 All optional features shall be functionally tested at the factory for proper operation.

1.5 REGULATORY REQUIREMENTS

- .1 Conform to Ontario Electrical Safety Code.
- .2 Provide certificate of compliance from authority having jurisdiction indicating approval of variable frequency drives.
- .3 Products Requiring Electrical Connection: Listed and classified by CSA, ULC, cUL or Special Inspection as suitable for the purpose specified and indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

- .1 Transport, handle, store, and protect products.
- .2 Protect variable frequency drives stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering.

1.7 WARRANTY

- .1 Refer to Division 1 and Section 20 01 01.
- .2 Provide extended coverage five year warranty for variable frequency drives.

2 PRODUCTS

2.1 MANUFACTURERS

- .1 Provide Danfoss VLT FC102 Variable Frequency Drives as per the specifications below and the schedules shown.
- .2 Acceptable alternates;
 - .1 ABB, ACH550
 - .2 Allan Bradley.
 - .3 Eaton Cutler Hammon
 - .4 Toshiba
 - .5 Emmerson
 - .6 Hitachi

2.2 VARIABLE FREQUENCY DRIVES

- .1 Furnish complete variable frequency VFDs as specified herein for the fans and pumps designated on the drawing schedules to be variable speed. All standard and optional features shall be included within the VFD enclosure, unless otherwise specified. VFD shall be housed in a metal NEMA 1 enclosure, The VFD's UL listing shall allow mounting in plenum or other air handling compartments.
- .2 The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump and fan control and to eliminate the need for motor de-rating.
- .3 With the motor's rated voltage applied to the VFD input, the VFD shall allow the motor to produce full rated power at rated amps, RMS fundamental volts, and speed without using the motor's service factor. VFDs utilizing sine weighted/coded modulation (with or without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.
- .4 The VFD shall include an input full-wave bridge rectifier and maintain a fundamental power factor near unity regardless of speed or load.
- .5 The VFD and options shall be tested to ANSI/UL Standard 508. The complete VFD, including all specified options, shall be assembled by the manufacturer, which shall be UL-508 certified for the building and assembly of option panels. Assembly of the option panels by a third-party panel shop is not acceptable. The appropriate CSA or C-UL stickers shall be applied to both the VFD and option panel, in the case where these are not contained in one panel. Both VFD and option panel shall be manufactured in ISO 9001 certified facilities.
- .6 The VFD shall have DC link reactors on both the positive and negative rails of the DC bus to minimize power line harmonics. VFDs without DC link reactors shall provide a minimum 3% impedance line reactor.
- .7 The VFD's full load amp rating shall meet or exceed NEC Table 430-150. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 160% of rated current for up to 0.5 second while starting.
- .8 The VFD shall be able to provide full torque at any selected frequency from 28 Hz to base speed to allow driving direct drive fans without de-rating.
- .9 An automatic energy optimization selection feature shall be provided standard in the VFD. This feature shall automatically and continually monitor the motor's speed and load and adjust the applied voltage to maximize energy savings and provide up to an additional 3% to 10% energy savings.
- .10 Input and output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD. Switching rate may be up to 1 time per minute on the input and unlimited on the output.
- .11 An automatic motor adaptation test algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor

- from the load to run the test.
- .12 Galvanic and/or optical isolation shall be provided between the VFD's power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFDs not including either galvanic or optical isolation on both analog I/O and discrete I/O shall include additional isolation modules.
 - .13 VFD power components to be designed for 575VAC. Components designed for 480VAC are not acceptable.
 - .14 VFD shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD efficiencies while reducing motor noise.
 - .15 VFD's operating motors not designed to meet Nema MG1 Part 31 should include Output Load reactors.
 - .16 The VFD shall be provided with integral main disconnect switch rated to suit the VFD rating.

2.3 PROTECTIVE FEATURES

- .1 A minimum of Class 20 I2t electronic motor overload protection for single motor applications and thermal-mechanical overloads for multiple motor applications shall be provided.
- .2 Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over-voltage, under-voltage, VFD over-temperature and motor over-temperature. The VFD shall display all faults in plain English. Codes are not acceptable.
- .3 Protect VFD from sustained power or phase loss. The VFD shall provide full rated output with an input voltage as low as 90% of the nominal.
- .4 The VFD shall incorporate a motor preheat circuit to keep the motor warm and prevent condensation build up in the stator.
- .5 To prevent breakdown of the motor winding insulation, the VFD shall be designed to comply with IEC Part 34-17. Motors shall have inverter rated insulation (1600V).
- .6 VFD shall include a "signal loss detection" circuit to sense the loss of an analog input signal such as 4 to 20 mA or 2 to 10 V DC, and shall be programmable to react as desired in such an instance.
- .7 VFD shall function normally when the keypad is removed while the VFD is running and continue to follow remote commands. No warnings or alarms shall be issued as a result of removing the keypad.
- .8 VFD shall catch a rotating motor operating forward or reverse up to full speed.
- .9 VFD shall be rated for 100,000 amp interrupting capacity (AIC).
- .10 VFD shall include current sensors on all three output phases to detect and report phase loss to the motor. The VFD will identify which of the output phases is low or lost.
- .11 VFD shall continue to operate without faulting until input voltage reaches 300 V AC on 208/230 volt VFDs, 539 V AC on 460 volt VFDs, and 701V AC on 575 volt VFDs.

2.4 INTERFACE FEATURES

- .1 Hand/Start, Off/Stop and Auto/Start selector switches shall be provided to start and stop the VFD and determine the speed reference.
- .2 The VFD shall be able to be programmed to provide a 24 V DC output signal to indicate that the VFD is in Auto/Remote mode.
- .3 The VFD shall provide digital manual speed control. Potentiometers are not acceptable.
- .4 Lockable, alphanumeric backlit display keypad can be remotely mounted up to 10 feet (3 m) away using standard 9-pin cable.
- .5 The keypads for all sizes of VFDs shall be identical and interchangeable.
- .6 To set up multiple VFDs, it shall be possible to upload all setup parameters to the VFD's keypad, place that keypad on all other VFDs in turn and download the setup parameters to each VFD. To facilitate setting up VFDs of various sizes, it shall be possible to download from the keypad only size independent parameters.
- .7 Display shall be programmable to display in 9 languages including English, Spanish and French.
- .8 The display shall have four lines, with 20 characters on three lines and eight large characters on one line.
- .9 A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These

- indications shall be visible both on the keypad and on the VFD when the keypad is removed.
- .10 A quick setup menu with factory preset typical HVAC parameters shall be provided on the VFD eliminating the need for macros.
- .11 The VFD shall include a standard RS-485 communications port and capabilities to be connected at a future date to a Johnson Controls N2, Siemens FLN, or Lonworks. The connection shall be software selectable by the user.
- .12 As a minimum, the following points shall be controlled and/or accessible:
- .1 VFD Start/Stop, Speed reference, Fault diagnostics, and Meter points as follows;
 - .2 Motor power in HP, Motor power in kW, Motor kW-hr, Motor current, Motor voltage, Hours run, Feedback signal #1, Feedback signal #2, DC link voltage, Thermal load on motor, and Thermal load on VFD, Heatsink temperature.
- .13 Four additional Form C 230 volt programmable relays shall be available for factory or field installation within the VFD.
- .14 Two set-point control interface (PID control) shall be standard in the unit. VFD shall be able to look at two feedback signals, compare with two set-points and make various process control decisions.
- .15 Floating point control interface shall be provided to increase/decrease speed in response to contact closures.
- .16 Four simultaneous displays shall be available. They shall include frequency or speed, run time, output amps and output power. VFDs unable to show these four displays simultaneously shall provide panel meters.
- .17 Sleep mode shall be provided to automatically stop the VFD when its speed drops below set "sleep" level for a specified time. The VFD shall automatically restart when the speed command exceeds the set "wake" level.
- .18 The sleep mode shall be functional in both follower mode and PID mode.
- .19 Run permissive circuit shall be provided to accept a "system ready" signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of sending an output signal as a start command to actuate external equipment before allowing the VFD to start.
- .20 The following displays shall be accessible from the control panel in actual units: Reference Signal Value in actual units, Output Frequency in Hz or percent, Output Amps, Motor HP, Motor kW, kWhr, Output Voltage, DC Bus Voltage, VFD Temperature in degrees, and Motor Speed in engineering units per application (in GPM, CFM, etc.). VFD will read out the selected engineering unit either in a linear, square or cubed relationship to output frequency as appropriate to the unit chosen.
- .21 The display shall be programmed to read in inches of water column (in-wg) for an air handler application, pressure per square inch (psi) for a pump application, and temperature (°F) for a cooling tower application.
- .22 VFD shall be able to be programmed to sense the loss of load and signal a no load/broken belt warning or fault.
- .23 If the temperature of the VFD's heat sink rises to 176 °F (80 °C), the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. If the temperature of the heat sink continues to rise the VFD shall automatically reduce its output frequency to the motor. As the VFD's heat sink temperature returns to normal, the VFD shall automatically increase the output frequency to the motor and return the carrier frequency to its normal switching speed.
- .24 The VFD shall have temperature controlled cooling fans for quiet operation and minimized losses.
- .25 The VFD shall store in memory the last 10 faults and related operational data.
- .26 Eight programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.
- .27 Two programmable relay outputs, one Form C 240 V AC, one Form A 30 V AC, shall be provided for remote indication of VFD status.
- .28 Three programmable analog inputs shall be provided and shall accept a direct-or-reverse acting signal. Analog reference inputs accepted shall include two voltage (0 to 10 V DC, 2 to 10 V DC) and one current (0 to 20 mA, 4 to 20 mA) input.
- .29 Two programmable 0 to 20 mA analog outputs shall be provided for indication of VFD status. These outputs shall be programmable for output speed, frequency, current and power. They shall also be programmable to provide a selected 24 V DC status indication.
- .30 Under fire mode conditions, the VFD shall be able to be programmed to automatically default to a preset speed.

2.5 ADJUSTMENTS

- .1 VFD shall have an adjustable carrier frequency in steps of not less than 0.1 kHz to allow tuning the VFD to the motor.
- .2 Sixteen preset speeds shall be provided.
- .3 Four acceleration and four deceleration ramps shall be provided. Accel and decel time shall be adjustable over the range from 0 to 3,600 seconds to base speed. The shape of these curves shall be automatically contoured to ensure no-trip acceleration and deceleration.
- .4 Four current limit settings shall be provided.
- .5 If the VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: undervoltage, overvoltage, current limit and inverter overload.
- .6 The number of restart attempts shall be selectable from 0 through 20 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds.
- .7 An automatic "on delay" may be selected from 0 to 120 seconds.

2.6 BY-PASS

- .1 Provide a manual 3-contactor bypass, were indicated in schedules, consisting of a door interlocked main fused disconnect padlockable in the off position, a built-in motor starter and a four position DRIVE/OFF/BYPASS/TEST switch controlling three contactors. In the DRIVE position, the motor is operated at an adjustable speed from the VFD. In the OFF position, the motor and VFD are disconnected. In the BYPASS position, the motor is operated at full speed from the AC power line and power is disconnected from the VFD so that service can be performed. In the TEST position, the motor is operated at full speed from the AC line power while power is applied to the input of the VFD. This allows the VFD to be given an operational test while continuing to run the motor at full speed in bypass. In case of an external safety fault, a customer supplied normally closed dry contact shall be able to stop the motor whether in DRIVE or BYPASS mode.
- .2 Service personnel shall be able to defeat the main power disconnect and open the bypass enclosure without disconnecting power. This shall be accomplished through the use of a specially designed tool and mechanism while meeting all local and national code requirements for safety.

2.7 SERVICE CONDITIONS

- .1 Ambient temperature, 14° to 104°F (-10° to 40°C).
- .2 0 to 95% relative humidity, non-condensing.
- .3 Elevation to 3,300 feet (1006 m) without de-rating.
- .4 AC line voltage variation, -10 to +10% of nominal with full output.
- .5 No side clearance shall be required for cooling of any units. All power and control wiring shall be done from the bottom.

3 EXECUTION

3.1 START-UP SERVICE

- .1 The manufacturer shall provide start-up commissioning of the VFD and its optional circuits by a factory certified service technician who is experienced in start-up and repair services. Sales personnel and other agents who are not factory certified shall not be acceptable as commissioning agents. Start-up services shall include checking for verification of proper operation and installation for the VFD, its options and its interface wiring to the building automation system.
- .2 Adjust and record minimum and maximum speeds to accommodate required design flows and flow variations.
- .3 Record internal overload settings on start-up form.

3.2 WARRANTY

- .1 The VFD shall be warranted by the manufacturer for a period of 5 years from date of Substantial Performance.
- .2 The warranty shall include parts, labour, travel costs and living expenses incurred by the manufacturer

to provide factory authorized on-site service.

3.3 EXAMINATION

- .1 Contractor to verify that job site conditions for installation meet factory recommended and code-required conditions for VFD installation prior to start-up, including clearance spacing, temperature, contamination, dust, and moisture of the environment. Separate conduit installation of the motor wiring, power wiring, and control wiring, and installation per the manufacturer's recommendations shall be verified.
- .2 The VFD is to be covered and protected from installation dust and contamination until the environment is cleaned and ready for operation. The VFD shall not be operated while the unit is covered.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 01 01 applies to and governs all work of Division 21, 22 and 23.

1.2 SECTION INCLUDES

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

1.3 REFERENCES

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

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

1.4 SUBMITTALS

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

1.5 QUALIFICATIONS

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

1.6 REGULATORY REQUIREMENTS

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

1.7 DELIVERY, STORAGE, AND HANDLING

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

2 PRODUCTS

2.1 VALVES - GENERAL

- .1 Conform to requirements of ANSI, ASTM, ASME, and applicable MSS standards.
- .2 Provide valves of the same manufacturer where possible.
- .3 Manufacturer's name and pressure rating clearly marked on body to MSS-SP-25.
- .4 Valid CRN (Canadian Registration Number) required for each valve.
- .5 Materials:
 - .1 Bronze: ASTM B62 or B61 as applicable
 - .2 Brass: ASTM B283 C3770
 - .3 Cast Iron: ASTM A126 Class B
- .6 End Connections:
 - .1 Threaded ends: ANSI B1.20.1
 - .2 Flanged ends: ANSI B16.1 (Class 125), ANSI B16.5
 - .3 Face-to-face dimensions: ANSI B16.10
- .7 Design and Testing:
 - .1 Bronze Gate & Check valves: MSS-SP-80
 - .2 Ball Valves: MSS-SP-110
 - .3 Cast Iron Gate Valves: MSS-SP-70
 - .4 Cast Iron Globe Valves: MSS-SP-85

- .5 Cast Iron Check: MSS-SP-71
- .6 Butterfly Valves: MSS-SP-67
- .8 First named product as indicated in paragraphs below; other acceptable manufacturers, subject to equivalent products include:
 - .1 Kitz.
 - .2 Crane
 - .3 Conbraco.
 - .4 Nibco
 - .5 Jenkins

2.2 HYDRONIC SYSTEMS TO 150 PSIG, ABOVE GROUND

- .1 Nominal Operating Pressure 125 psig
- .2 Design Pressure 150 psig
- .3 Test Pressure 225 psig
- .4 Design Temperature 350°F
- .5 Corrosion Allowance 0.0625 in.
- .6 Steel Pipe ASTM A53 Gr.B ERW or ASTM A106 Gr.B SMLS, sch 40,
- .7 Joints, 2" and smaller screwed
- .8 Screwed Fittings 150 Lb. malleable iron
- .9 Unions Cl.150, ASTM A-47 malleable iron, ASTM A-153 galvanized, ANSI B2.1 threads.
- .10 Joints, 2-1/2" and larger welded, with flanges at connections to equipment
- .11 Butt weld fittings ASTM A234 Gr. WFB
- .12 Flanges ASTM A105, Class 150, raised face, weld neck or slip on
- .13 Bolts ASTM A307 C.S. bolts, sq. head; ASTM A563 nuts, hex head
- .14 Gaskets 1/16" (1.6 mm) thick preformed non-asbestos graphite fibre.
- .15 Copper Tubing, 2" and Smaller ASTM B88, Type L, hard drawn.
- .16 Joints: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 220°C to 280°C.
- .17 Fittings: ASME B16.18, cast brass, or ASME B16.22, solder wrought copper
- .18 Dielectric Unions Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.
- .19 Valves, 2" and smaller ASTM A105
 - Gate Valves (Isolating) 300 psig non-shock WOG, ASTM B62 bronze body, solid wedge disc, rising stem, bronze trim, threaded ends, Kitz #25
 - Globe Valves (Throttling) 300 psig non-shock WOG, ASTM B62 bronze body, composition (Teflon) disc, rising stem, bronze trim, threaded ends, Kitz #09
 - Check Valves (Backflow) 300 psig non-shock WOG, ASTM B62 bronze body, Y-pattern horizontal, swing type disc, threaded ends, Kitz #29
 - Ball Valves (Drain) 600 psig non-shock WOG, forged brass, 2-piece, chrome ball and stem, full port, blow-out proof PTFE seats & stem, lever handle, threaded ends, Kitz #68AC.
- .20 Valves, 2-1/2" and larger ASTM A216 WCB
 - Gate Valves (Isolating) 200 psig non-shock WOG, ASTM A126 Class B cast iron body, bolted bonnet, bronze mounted, solid wedge disc, OS&Y, non-asbestos packing, flanged ends, Kitz #72.
 - Globe Valves (Throttling) 200 psig non-shock WOG, ASTM A126 Class B cast iron body, bolted bonnet, bronze mounted, bevelled wedge disc, OS&Y, non-asbestos packing, flanged ends, Kitz #76.
 - Check (Backflow) 200 psig non-shock WOG, ASTM 126 Class B cast iron body, bolted cover, bronze mounted, swing type disc, flanged ends, Kitz #78
- .21 Provide stem extensions for insulated piping.
- .22 Provide gear operator and chain on valves installed above 10-ft AFF.
- .23 Strainers, 2" and smaller Class 250, 400 psig WOG, cast iron body, Y-pattern, screwed cap and ends, A167 304 stainless steel screen with 1/32" perforations.

- .24 Strainers, 2-1/2" and larger Mueller Steam 11M.
Class 250 psig non-shock WOG, cast iron, Y-pattern, bolted flange cover, blow-out plug, A167 304 stainless steel screen with 1/32" perforations, flanged ends, Mueller Steam 752 .

2.3 EQUIPMENT DRAINS AND OVERFLOWS

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

2.4 CIRCUIT BALANCING VALVES

- .1 Circuit Balancing Valves; 2" (50 mm) and smaller
.1 Screwed connection, globe style design, nonferrous, pressure die-cast, nonporous Ametal Copper Alloy. Each valve shall be such that when installed in any direction, it will not affect flow measurement.
.2 Valves shall provide the following functions:
.1 Precise flow measurement.
.2 Precision flow balancing.
.3 Positive shut off with no drip seat and teflon disc.
.4 Drain connection with protective cap.
.3 Valves shall have four 360° adjustment turns of handwheel for maximum vernier-type setting with "Hidden Memory" feature to program the valve with precision tamper-proof balancing setting.
.4 Valves shall be shipped in a 4.5 R factor polyurethane container that shall be used as insulation after valve in installed.
.5 Provide valves suitable for maximum working pressure of 250 psi (1720 kPa) and maximum operating temperature of 250°F (121°C).
.6 Acceptable Products: S.A. Armstrong CRV I indicated or Tour & Anderson STA-D or Newman Hattersley.
.2 Circuit Balancing Valves 2 1/2" (65 mm) and larger
.1 Flanged, line size connection, globe style design, nonferrous, pressure die-cast, nonporous Ametal Copper Alloy.
.2 Valves, shall provide the following functions:
.1 Precise flow measurement.
.2 Precision flow balancing.
.3 Positive shut off with no drip seat and teflon disc.
.3 Valves shall have twelve 360° adjustment turns of handwheel for maximum vernier-type setting with "Hidden Memory" feature to program the valve with precision tamper-proof balancing setting.
.4 Valves shall be suitable for maximum working pressure of 250 psi (1720 kPa) and maximum operating temperature of 250°F (120°C).
.5 Acceptable Products: S.A. Armstrong CBV II indicated or Tour & Anderson STA-F or Newman Hattersley.

3 EXECUTION

3.1 PREPARATION

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

3.2 APPLICATIONS

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

3.3 INSTALLATION

- .1 Install to manufacturer's instructions.
- .2 Install heating water, piping to CSA B51.
- .3 Route piping in orderly manner, parallel to building structure, and maintain gradient.
- .4 Install piping to conserve building space, and not interfere with use of space.
- .5 Group piping whenever practical at common elevations.
- .6 Sleeve pipe passing through partitions, walls and floors.
- .7 Slope piping and arrange to drain at low points.
- .8 Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- .9 Inserts:
 - .1 Provide inserts for placement in concrete formwork.
 - .2 Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - .3 Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4" (100 mm).
 - .4 Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
 - .5 Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- .10 Pipe Hangers and Supports:
 - .1 Install to CSA B51.
 - .2 Support horizontal piping as scheduled.
 - .3 Install hangers to provide minimum 1/2" (13 mm) space between finished covering and adjacent work.
 - .4 Place hangers within 12" (300 mm) of each horizontal elbow.
 - .5 Use hangers with 1-1/2" (38 mm) minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
 - .6 Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
 - .7 Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
 - .8 Provide copper plated hangers and supports for copper piping.
 - .9 Prime coat exposed steel hangers and supports. Hangers and supports located in crawl

- spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
- .11 Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
 - .12 Provide access where valves and fittings are not exposed.
 - .13 Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.
 - .14 Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer (VOC content not to exceed 250 g/L) to welds.
 - .15 Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting.
 - .16 Install valves with stems upright or horizontal, not inverted.
 - .17 Air vents shall be selected to suit the system operating pressures and shall be automatic and complete with isolating valves.
 - .18 All strainers 1-1/2" (38mm) & larger shall be fitted with chain valves.
 - .19 Unless specified otherwise, drain piping shall be sloped down in the direction of flow not less than 1" in 40 feet.
 - .20 Eccentric reducers shall be provided to keep the bottom of sloped piping aligned in order to minimize risk of water hammer and to facilitate drainage.
 - .21 Valves shall be installed with stems upright or angled 45 deg. above horizontal unless instructed otherwise.
 - .22 Pipe all discharge from temperature & pressure safety relief valves to a point of safe discharge directly into a floor drain, hub drain or safe outdoor location.

3.4 EQUIPMENT CONNECTIONS

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

3.5 VALVES, COCKS AND FAUCETS

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

3.6 HYDRONIC SPECIALTIES

- .1 Air Vents
 - .1 Provide 1" (25 mm) diameter air vent chamber at each riser feeding terminal units. Install chambers as high as possible within unit, and provide manual air vent connected to air chamber by flexible tubing.
 - .2 Provide a float type automatic air vent at any high points of hot water supply and return piping not vented through a convactor etc. and at high point of piping for each hot water coil. The discharge of air vent shall terminate over a floor drain in mechanical rooms or over a sink in service rooms. A shut-off valve shall be provided on each automatic air vent and an access door and frame shall be provided for air vents located above ceilings.
- .2 Automatic Feed Valves: provide automatic feed valve on the cold water make-up line to each new hot water heating system.

- .3 Air Cushion Tanks
 - .1 Provide air cushion tanks of size noted where indicated.
 - .2 Provide housekeeping pad for floor mounting of tank.
 - .3 Terminate drainout line at nearest funnel floor drain, or service sink.
 - .4 Adjust charge to system static pressure at point of connection plus 5 psi (35 kPa).
- .4 Air Eliminators: provide an air eliminator at each new air cushion (expansion) tank.
- .5 Circuit Balancing Valve (CBV): provide a CBV in each branch serving a heating and/or cooling terminal unit and where indicated on drawings. Installation shall be in accordance with manufacturer's installation instructions. Ensure that manufacturer's recommended clearances are maintained to minimize turbulence and to promote accuracy.
- .6 Supply and install threaded couplings or half coupling for flow switches that are supplied under Section 25
- .7 Install flow switches as supplied under Section 25

3.7 CONTROLS DEVICES

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

3.8 TESTING AND INSPECTION

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

3.9 ADJUSTING AND BALANCING

- .1 Instruments used for this work shall be accurately calibrated and maintained in good working order, and shall include:
 - .1 one set of pressure gauges and fittings.
 - .2 dry bulb thermometer.
 - .3 wet bulb thermometer.
 - .4 thermocouple unit and thermocouple.
 - .5 set of balancing cock adjustment wrenches.
 - .6 portable field flow meter.
- .2 Prepare the liquid heat transfer systems as follows:
 - .1 Install any additional devices required for effective balancing as advised by the Systems Verification Agency.
 - .2 Open all valves, and return line balancing cocks.
 - .3 Remove and clean all strainers.
 - .4 Check pump rotation.
 - .5 Check expansion tanks to make sure they are not air bound and that the system is full of water.
 - .6 Check all air vents at high points of water systems to make sure they are installed properly and are operating freely. Make certain all air is removed from circulating system.
 - .7 To balance hot water coils, set systems to call for full heating.
 - .8 Check operation of automatic bypass valve.
- .3 Balance the liquid heat transfer systems as follows:
 - .1 Complete air balance must have been accomplished before water balance is begun.
 - .2 Set hot water pumps to proper gpm delivery.
 - .3 Check leaving water temperatures and return water temperatures. Reset to correct design temperatures.
 - .4 Upon completion of flow readings and coil adjustments, mark all settings and record all data.
 - .5 Install pressure gauges where indicated on the drawings and specification, then read pressure

drop across heating element at set flow rate on call for full cooling and full heating. Set pressure drop across bypass valve to match coil full flow pressure drop. This prevents unbalanced flow conditions when coils are on full bypass.

- .6 Check and record the following items at each cooling and heating element:
 - .1 Inlet water and air temperature.
 - .2 Leaving water and air temperature.
 - .3 Pressure drop of each coil.
 - .4 Pump operating suction and discharge pressures and final t.d.h.
 - .5 Pressure drop across bypass valve.
 - .6 All mechanical specifications of pumps.
 - .7 Rated and actual running amperage of pump motor.
- .4 After completion of adjusting and balancing and submittal of records notify the Systems Verification Agency and the Consultant and assist in verifications. If systems fail verification, readjust and balance systems to the satisfaction of the Consultant.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 01 01 applies to and governs all work of Division 21, 22 and 23.

1.2 SECTION INCLUDES

- .1 Expansion tanks.
- .2 Air vents.
- .3 Air separators.
- .4 Strainers.
- .5 Pump suction fittings.
- .6 Combination fittings.
- .7 Relief valves.

1.3 REFERENCES

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

1.4 SUBMITTALS

- .1 Section 20 01 01: Procedures for submittals.
- .2 Product Data: Provide product data for manufactured products and assemblies required for this project. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description, model and dimensions.
- .3 Submit inspection certificates for pressure vessels from TSSA.
- .4 Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
- .5 Record actual locations of flow controls.
- .6 Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.5 QUALIFICATIONS

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

1.6 DELIVERY, STORAGE, AND HANDLING

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

2 PRODUCTS

2.1 DIAPHRAGM-TYPE EXPANSION TANKS

- .1 Manufacturers:
 - .1 Amtrol
 - .2 Other acceptable manufacturers offering equivalent products.
 - .1 Expanflex.
 - .2 Bell & Gosset.
 - .3 SA Armstrong
 - .4 Taco
- .2 Construction: Welded steel, tested and stamped to ASME SEC 8-D; supplied with National Board Form U-1, rated for working pressure of 125 psi (860 kPa), with flexible butyl diaphragm sealed into

- tank , and steel support stand.
- .3 Accessories: Pressure gauge and air-charging fitting, tank drain; precharge to 11 psi (80 kPa).
- .4 Automatic Cold Water Fill Assembly: Pressure reducing valve, reduced pressure double check back flow preventer, test cocks, strainer, vacuum breaker, and valved by-pass.
 - .1 Size: As scheduled.

2.2 AIR VENTS

- .1 Manual Type: Short vertical sections of 2" (50 mm) diameter pipe to form air chamber, with 3 mm brass needle valve at top of chamber.
- .2 Float Type:
 - .1 Manufacturers:
 - .1 Armstrong.
 - .2 Amtrol.
 - .3 Taco.
 - .2 Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.

2.3 AIR SEPARATORS

- .1 Air Separators:
 - .1 Manufacturers:
 - .1 Amtrol.
 - .2 Armstrong.
 - .3 Bell & Gossett.
 - .4 Taco
 - .5 Expanflex
 - .2 Steel, tested and stamped to ASME SEC 8-D; for 125 psi (860 kPa) operating pressure, tangential inlet and outlet connections, and internal stainless steel air collector tube.

2.4 STRAINERS

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

2.5 PUMP SUCTION FITTINGS

- .1 Manufacturers:
 - .1 Armstrong.
 - .2 Other acceptable manufacturers offering equivalent products.
 - .1 Bell & Gossett.
 - .2 Taco
 - .3 Patterson
- .2 Fitting: Angle pattern, cast-iron body, threaded for 2" (50 mm) and smaller, flanged for 2-1/2" (65 mm) and larger, rated for 175 psi (1200 kPa) working pressure, with inlet vanes, cylinder strainer with 3/16"

(5 mm) diameter openings, disposable fine mesh strainer to fit over cylinder strainer, and permanent magnet located in flow stream and removable for cleaning.

- .3 Accessories: Adjustable foot support, blowdown tapping in bottom, gauge tapping in side.

2.6 COMBINATION PUMP DISCHARGE VALVES

- .1 Manufacturers:
 - .1 Armstrong.
 - .2 Other acceptable manufacturers offering equivalent products.
 - .1 Bell & Gossett.
 - .2 Taco
 - .3 Patterson
- .2 Valves: Straight or angle pattern, flanged cast-iron valve body with bolt-on bonnet for 175 psi (1200 kPa) operating pressure, non-slam check valve with spring-loaded bronze disc and seat, stainless steel stem, and calibrated adjustment permitting flow regulation.

2.7 RELIEF VALVES

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

3 EXECUTION

3.1 INSTALLATION

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

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 01 01 applies to and governs all work of Division 21, 22 and 23.

1.2 SECTION INCLUDES

- .1 Circulators
- .2 Vertical in-line pumps.

1.3 REFERENCES

- .1 UL 778 Motor Operated Water Pumps
- .2 ASHRAE Standard 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings.
- .3 CSA B214 Installation Code for Hydronic Heating Systems

1.4 PERFORMANCE REQUIREMENTS

- .1 Ensure pumps operate at specified system fluid temperatures without vapour binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

1.5 SUBMITTALS

- .1 Product Data: Provide certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable. Include electrical characteristics and connection requirements.
- .2 Manufacturer's Installation Instructions: Indicate hanging and support requirements and recommendations.
- .3 Operation and Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.6 QUALIFICATIONS

- .1 Manufacturer: Company specializing in manufacture, assembly, and field performance of pumps with minimum ten years experience.

1.7 REGULATORY REQUIREMENTS

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

1.8 EXTRA MATERIALS

- .1 Provide one set of mechanical seals for each pumps.

2 PRODUCTS

2.1 MANUFACTURERS

- .1 S. A. Armstrong
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Bell & Gosset (XYLEM)
 - .2 Taco
 - .3 Patterson
 - .4 Grundfos

2.2 IN-LINE CIRCULATORS

- .1 Type: Horizontal shaft, single stage, direct connected, with resiliently mounted motor for in-line mounting, oil lubricated, for 125psi (860 kPa) maximum working pressure.
- .2 Casing: Cast iron, with flanged pump connections.
- .3 Impeller: Cadmium plated steel, keyed to shaft.
- .4 Bearings: Two, oil lubricated bronze sleeves.
- .5 Shaft: Alloy or stainless steel with copper or bronze sleeve, integral thrust collar.
- .6 Seal: Carbon rotating against a stationary ceramic seat, 225°F (107°C) maximum continuous operating temperature.
- .7 Seal: Carbon rotating against a stationary ceramic seat, viton fitted 275°F (135°C) maximum continuous operating temperature.
- .8 Drive: Flexible coupling.
- .9 Performance: as scheduled
- .10 Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to code.

2.3 VERTICAL IN-LINE PUMPS

- .1 Type: Vertical, single stage, close coupled, radially or horizontally split casing, for in-line mounting, for 175 psi (1200 kPa) working pressure.
- .2 Casing: Cast iron, with suction and discharge gauge port, casing wear ring, seal flush connection, drain plug, flanged suction and discharge.
- .3 Impeller: Bronze, fully enclosed, keyed directly to motor shaft or extension.
- .4 Shaft: Carbon steel with stainless steel impeller cap screw or nut and bronze sleeve.
- .5 Seal: Carbon rotating against a stationary ceramic seat, viton fitted 225°F (107°C) maximum continuous operating temperature.
- .6 Performance: as scheduled
- .7 Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to code.

3 EXECUTION

3.1 PREPARATION

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

3.2 INSTALLATION

- .1 Install to manufacturer's instructions and as indicated by flow arrows.
- .2 Support piping adjacent to pump such that no weight is carried on pump casings. For close coupled or base mounted pumps, provide supports under elbows on pump suction and discharge line sizes 4" (102 mm) and over.
- .3 Provide access space around pumps for service. Provide no less than minimum recommended by manufacturer.
- .4 Decrease from line size with long radius reducing elbows or reducers.
- .5 Provide line sized shut-off valve and strainer on pump suction, and line sized soft seat check valve and balancing valve on pump discharge.
- .6 Provide air cock and drain connection on horizontal pump casings.
- .7 Provide drains for bases and seals, piped to and discharging into floor drains.
- .8 Check rotation, align, and certify alignment of base mounted pumps prior to start-up.
- .9 Lubricate pumps before start-up.

3.3 START-UP

- .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.
- .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 at all times.
- .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.

3.4 PERFORMANCE VERIFICATION

- .1 General
 - .1 In accordance with manufacturer's recommendations.
- .2 Exclusions:
 - .1 This paragraph does not apply to small in-line circulators.
- .3 Assumptions: These PV procedures assume that:
 - .1 Manufacturer's performance curves are accurate.
 - .2 Valves on pump suction and discharge provide tight shut-off.
- .4 Net Positive Suction Head (NPSH):
- .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.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 01 01 applies to and governs all work of Division 21, 22 and 23.

1.2 SECTION INCLUDES

- .1 Cleaning of pipe and fittings
- .2 Cleaning of equipment
- .3 Supply, installation testing and adjusting of chemical feed equipment
- .4 Chemical treatments of piping systems and boilers
- .5 Supply of chemicals

1.3 SUBMITTALS

- .1 Shop Drawings: Indicate system schematic, equipment locations, and controls schematics, electrical characteristics and connection requirements.
- .2 Product Data: Provide chemical treatment materials, chemicals, and equipment including electrical characteristics and connection requirements.
- .3 Manufacturer's Installation Instructions: Indicate placement of equipment in systems, piping configuration, and connection requirements.
- .4 Manufacturer's Field Reports: Indicate start-up of treatment systems when completed and operating properly. Indicate analysis of system water after cleaning and after treatment.
- .5 Operation and Maintenance Data: Include data on chemical pot feeders, filters and other equipment including spare parts lists, procedures, and treatment programs. Include step by step instructions on test procedures including target concentrations.

1.4 QUALIFICATIONS

- .1 Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years documented experience. Company to have local representatives with water analysis laboratories and full time service personnel.
- .2 Installer: Company specializing in performing the work of this section with minimum three years documented experience and approved by manufacturer.

1.5 REGULATORY REQUIREMENTS

- .1 Conform to applicable code for addition of non-potable chemicals to building mechanical systems, and for to public sewage systems.
- .2 Products Requiring Electrical Connection: Listed and classified by CSA as suitable for the purpose specified and indicated.

1.6 MAINTENANCE MATERIALS

- .1 Provide sufficient chemicals for treatment and testing during warranty period.

2 PRODUCTS

2.1 MANUFACTURERS

- .1 Keytech

2.2 MATERIALS

- .1 System Cleaner:
 - .1 Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products; sodium tripoly phosphate and sodium molybdate.

- .2 Biocide; chlorine release agents such as sodium hypochlorite or calcium hypochlorite, or microbiocides such as quarternary ammonia compounds, tributyl tin oxide, methylene bis (thiocyanate), or isothiazolones.
- .2 Closed System Treatment (Water):
 - .3 Sequestering agent to reduce deposits and adjust pH; polyphosphate.
 - .4 Corrosion inhibitors; liquid boron-nitrite, sodium nitrite and borax, sodium totyltriazone, low molecular weight polymers, phosphonates, sodium molybdate, or sulphites.
 - .5 Conductivity enhancers; phosphates or phosphonates.
- .3 Chemicals:
 - .6 Provide all chemicals required for cleaning and start-up of systems.
 - .7 In addition, provide 3 months supply of chemicals for each system in full operation.

2.3 BY-PASS (POT) FEEDER

- .1 5 gal. (19 litre) welded steel, quick opening cap, pressure rating of 175 psi (1200 kPa), temperature rating: 195°F (90° C).
- .2 Micron filter for each pot feeder:
 - .1 Capacity 2% of pump recirculating rate at operating pressure.
 - .2 Six (6) sets of filter cartridges for each type, size of micron filter

2.4 CONDUCTIVITY CONTROLLER

- .1 Fully transistorized, suitable for wall or flush panel mounting, linear over full measuring range of 0-5000 micromhs.
- .2 Insensitive to phase angle shifts, capable of operating on 95-130 Volts without affecting accuracy, power, bleedoff status lights.

2.5 CONDUCTIVITY PROBES

- .1 Dual carbon elements in PVC holder, quick disconnect, self-locking connection.

2.6 CLOSED SYSTEMS WATER TREATMENT INCLUDING HOT AND WATER LOOPS

- .1 Provide complete water treatment equipment and chemicals for corrosion protection, and sidestream filtration, for each closed system.
- .2 Each Closed System to include the following water treatment equipment:
 - .1 One (1) Bypass Feeder, 1.65 gallon (7.5L) capacity.
 - .2 One (1) Bypass Filter Unit with the capacity to handle 2.5 - 5% of the recirculating pump flow rate.
 - .3 One (1) case of 30 pieces, filter cartridges, 20 micron rated.
 - .4 One (1) corrosion coupon station, 3/4" (19mm) black iron assembled, 4 coupon port connections, 8 gpm (0.5 l/s) flow regulator.
 - .5 One (1) Copper corrosion coupon, holder and plug.
 - .6 One (1) Mild Steel corrosion coupon, holder and plug.

3 EXECUTION

3.1 PREPARATION

- .1 Systems to be operational, filled, started, and vented prior to cleaning. Use water meter to record capacity in each system.
- .2 Place terminal control valves in open position during cleaning.
- .3 Verify that electric power is available and of the correct characteristics.

3.2 CLEANING SEQUENCE

- .1 Concentration:
 - .1 As recommended by manufacturer.

- .2 1 kg per 1000 L of water contained in the system.
- .2 Hot Water Heating Systems:
 - .1 Apply heat while circulating, slowly raising temperature to 160°F (1°C) and maintain for 12 hours minimum.
 - .2 Remove heat and circulate to 100°F (37.8°C) or less; drain systems as quickly as possible and refill with clean water.
 - .3 Circulate for 6 hours at design temperatures, then drain.
 - .4 Refill with clean water and repeat until system cleaner is removed.
- .3 Use neutralizer agents on recommendation of system cleaner supplier and approval of Consultant.
- .4 Remove, clean, and replace strainer screens.
- .5 Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

3.3 INSTALLATION

- .1 Install to manufacturer's instructions.

3.4 CLOSED SYSTEM TREATMENT

- .1 Provide one bypass feeder on each system. Install isolating and drain valves and necessary piping. Install around balancing valve downstream of circulating pumps unless indicated otherwise.
- .2 Introduce closed system treatment through bypass feeder when required or indicated by test.
- .3 Provide 3/4" (19 mm) water coupon rack around circulating pumps with space for 4 test specimens.

3.5 CLOSED SYSTEMS

- .1 Equipment Installation
 - .1 Install the feeder and filter in a by-pass arrangement across the headers of the primary pump set. Isolation, venting and drain valves to be installed as per installation drawing and on-site instruction by water treatment representative. Installation and electrical connections as required is the responsibility of the Mechanical Trade.
- .2 System Flushing
 - .1 Thoroughly flush the closed system(s) with raw water to remove loose mill scale and debris. Remove and clean all strainers and flush low points before chemical cleaner is added to the system.
- .3 Add new system cleaner CSW 600 6.8 - 9 kg per 3800 litres system water for the removal of oil, mill scale and iron oxides. Recirculate for a minimum of 24 hours and flush. Repeat fill and flush procedure as often as required, adding inhibitor with each fill, to achieve prescribed maintenance levels.
- .4 Acceptability of water condition to be determined through testing and visual examination of representative water samples, by the water treatment supplier. Copies of test reports to be submitted by the water treatment supplier to the Mechanical Trade for verification to the Engineer.
 - .1 Add corrosion inhibitor CSW 311 at 23 kg per 3800 litres to the final water fill to achieve prescribed maintenance levels.
 - .2 Insert cartridges in filter.

3.6 MAINTENANCE

- .1 Maintain inhibitor levels and other water quality control ranges as they apply, from the time the system is brought on-line after flushing and cleaning, up to Substantial Completion of contract. The chemical supply allotment provided by the water treatment supplier is effective from the time the system is brought on line.
- .2 The water treatment supplier shall provide all necessary supervision during installation and shall test the system over the course of the construction period to ensure that proper treatment is being maintained, up to Substantial Completion. Reports generated by the water treatment supplier and left on-site are to be compiled for the Engineer's review.
- .3 The water treatment supplier shall provide a chemical supply service program for a period of one year from Substantial Completion. This program shall include training of operating personnel, laboratory

- .4 testing as required, technical assistance and routine water analysis and recommendaions.
Frequency of service calls by the water treatment supplier to be sufficient to meet system stability requiriements.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 01 01 applies to and governs all work of Division 21, 22 and 23.

1.2 SECTION INCLUDES

- .1 Double Wall Positive Pressure Vent System.

1.3 REFERENCES

- .1 ASTM A167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
- .2 ASTM A653/A653M - Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- .3 ASTM A1011/A1011M - Standard Specification for Steel, Sheet, and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
- .4 NFPA 54 (ANSI Z223.1) - The National Fuel Gas Code.
- .5 NFPA 211 - Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances.
- .6 UL 103 - Standard for Factory Built Chimneys for Residential Type and Building Heating Appliances.
- .7 UL 1738 – Standard for Venting Systems for Gas-Burning Appliances, Category II, III and IV
- .8 ULC-S636 - Canadian Standard for Type BH Gas Vent System

1.4 DEFINITIONS

- .1 Breeching: Vent Connector.
- .2 Chimney: Primarily vertical shaft enclosing at least one vent for conducting flue gases outdoors.
- .3 Smoke Pipe: Round, single wall vent connector.
- .4 Vent: That portion of a venting system designed to convey flue gases directly outdoors from a vent connector or from an appliance when a vent connector is not used.
- .5 Vent Connector: That part of a venting system that conducts the flue gases from the flue collar of an appliance to a chimney or vent, and may include a draft control device.

1.5 DESIGN REQUIREMENTS

- .1 Factory built vents and chimneys used for positive pressure venting NFPA 211, ULC listed and labeled.

1.6 SUBMITTALS FOR REVIEW

- .1 Section 20 01 01: Procedures for submittals.
- .2 Shop Drawings: Provide shop drawings for the entire breeching system being supplied. Indicate general construction, dimensions, weights, support and layout of breechings and vents.
 - .1 Product Data: Provide catalogue cuts, including dimensional details of components including but not limited to flue caps, roof support, and connection requirements.
 - .2 Sizing Calculations
 - .3 Submit manufacturer's installation instructions and drawings: Indicate assembly, support details, and connection requirements.
 - .4 Copy of product warranties.

1.7 QUALITY ASSURANCE

- .1 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum five (5) years documented experience.
- .2 Installer Qualifications: Company specializing in performing the work of this section with minimum five (5) years documented experience.

1.8 REGULATORY REQUIREMENTS

- .1 Conform to applicable code for installation of natural gas burning appliances and equipment.

1.9 WARRANTY

- .1 The Manufacturer shall warrant the Positive Pressure Vent System against defects in material and workmanship for a period of 15 years from the date of original installation. Any portion of the vent repaired or replaced under the warranty shall be warranted for the remainder of the original warranty period.

2 PRODUCTS

2.1 MANUFACTURERS

- .1 Security Chimney International
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Selkirk
 - .2 Schebler Co.
 - .3 Van Packer

2.2 DOUBLE WALL METAL VENTS

- .1 All stainless steel, positive pressure, condensing applications, double wall
- .2 The factory built double-wall built vent system designed for use in conjunction with Category I, II, III or IV condensing or non-condensing gas fired appliances, ULC tested and rated for 288 (550°F). and as specified by the boiler manufacturer.
- .3 Listed for a maximum positive pressure rating of 6" w.c and shall have passed at 35" w.c.
- .4 The vent system shall be continuous from the appliance's flue outlet to the vent termination outside the building. All system components shall be listed to UL or ULC standard and supplied from the same manufacturer. The vent shall be constructed with an inner and outer tube, where the annular air space between the tubes is 25 mm (1 Inch). The inner tube shall be constructed from AL2904C stainless steel with a minimum wall thickness of .020". The outer tube (jacket) shall be constructed from stainless steel, with a minimum wall thickness of .020".
- .5 All systems components such as vent supports, roof or wall penetrations, termination kits, appliance connectors and drain fittings, cleanouts, expansion joints, required to install the vent system shall be listed to UL / ULC standard and provided by the vent manufacturer. The entire system from each boiler to the termination, including accessories, shall be from one manufacturer.
- .6 Vent layout shall be designed an installed in compliance with manufacturer's installation instructions and all applicable local codes.

3 EXECUTION

3.1 INSTALLATION

- .1 Install to manufacturer's instructions. Route vent system to maintain minimum clearance to combustible as specified by the manufacturer.
- .2 Vent installation shall conform to the manufacturer's installation instructions, its listing to UL/ULC standard.
- .3 The vent system and breeching shall be inspected and cleaned before the final connection to the appliances.
- .4 Install to NFPA 54 (ANSI Z223.1), CAN/CSA B149.
- .5 Support breechings from building structure. Support vertical breechings, chimneys, and stacks to adjacent structural surfaces, or at floor penetrations as per manufacturer's installation instructions.
- .6 Pitch breechings with positive slope up from fuel-fired equipment to vent stack.
- .7 For double wall gas vents, maintain UL listed minimum clearances from combustibles. Assemble pipe and accessories as required for complete installation.
- .8 Provide breeching as recommended by manufacturer to satisfaction of local authority having

- jurisdiction.
- .9 Roof penetrations shall be suitable for a combustible roof and shall be according to the manufacturer's detail drawings and installation instructions.
 - .10 Provide and install termination vent cap as per manufacturer instruction.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 01 01 that applies to and governs all work of Division 21, 22, 23 and 25.

1.2 SECTION INCLUDES

- .1 Boilers.
- .2 Flue Gas Venting.

1.3 REFERENCES

- .1 CSA B51 Boiler, Pressure Vessel and Pressure Piping Code as adopted
- .2 CSA B149.1 Natural Gas and Propane Installation Code as adopted.
- .3 AGA - Directory of Certified Appliances and Accessories.
- .4 AGA Z21.13 - Gas-Fired Low-Pressure Steam and Hot Water Boilers.
- .5 ASME SEC 4 - Boiler and Pressure Vessel Codes - Rules for Construction of Heating Boilers.
- .6 ASME SEC 8D - Boilers and Pressure Vessel Codes - Rules for Construction of Pressure Vessels.
- .7 HI (Hydronics Institute) - Testing and Rating Standard for Cast Iron and Steel Heating Boilers.
- .8 NFPA 54 (AGA Z223.1) - National Fuel Gas Code.

1.4 SUBMITTALS

- .1 Refer to Division 20 01 01 procedures for submittals.
- .2 Product Data: Provide data indicating general layout, dimensions, and size and location of water, gas, and vent connections, and electrical characteristics and connection requirements.
- .3 Submit manufacturer's installation instructions.
- .4 Manufacturer's Field Reports: Indicate condition of equipment after start-up including control settings and performance chart of control system.
- .5 Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, cleaning procedures, replacement parts list, and maintenance and repair data.

1.5 REGULATORY REQUIREMENTS

- .1 CSA B51 Boiler, Pressure Vessel and Pressure Piping Code as adopted
- .2 CSA B149.1 Natural Gas and Propane Installation Code as adopted.
- .3 Conform to ASME SEC 4 and SEC 8D for boiler construction.
- .4 Units: CSA/CGA certified.
- .5 Products Requiring Electrical Connection: Listed and classified by CSA as suitable for the purpose specified and indicated.

1.6 DELIVERY, STORAGE, AND PROTECTION

- .1 Transport, handle, store, and protect products.
- .2 Protect units before, during, and after installation from damage to casing by leaving factory shipping packaging in place until immediately prior to final acceptance.

1.7 QUALITY ASSURANCE

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

1.8 WARRANTY

- .1 The stainless steel heat exchanger shall carry a non-prorated 10-year warranty against failure due to condensate corrosion, thermal stress, mechanical defects or workmanship.
- .2 All other components and controls supplied with the boiler shall carry a 2 year warranty against failure

- due to defective materials or workmanship.
- .3 Boiler must be registered with the manufacturer at time of start up with warranty card and start up report.

2 PRODUCTS

2.1 MANUFACTURERS

- .1 Basis of Design: Lochinvar

2.2 BOILERS (SUPPLIED BY OWNER)

- .1 The boiler shall have a modulating input rating and output rating as scheduled and shall operate on natural gas. The boiler shall be capable of full modulation firing down to 20% of rated input with a turndown ratio of 5:1.
- .2 The boiler shall bear the ASME "H" stamp for 160 psi working pressure and shall be National Board listed. There shall be no banding material, bolts, gaskets or "O" rings in the header configuration. The boiler shall have a 316L stainless steel heat exchanger. The combustion chamber shall be designed to drain condensation to the bottom of the heat exchanger assembly including a condensate trap. The complete heat exchanger assembly shall carry a ten (10) year limited warranty.
- .3 The boiler shall be certified and listed by C.S.A. International under the latest edition of the harmonized ANSI Z21.13 test standard for the U.S. and Canada. The boiler shall comply with the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard. The boiler shall operate at a minimum of 94% thermal efficiency at full fire. All models shall operate up to 98% thermal efficiency with return water temperatures at 100°F or below. The boiler shall be certified for indoor installation.
- .4 The boiler shall be constructed with a heavy gauge steel jacket assembly, primed and pre-painted on both sides. The combustion chamber shall be sealed and completely enclosed, independent of the outer jacket assembly, so that integrity of the outer jacket does not affect a proper seal. A burner/flame observation port shall be provided. The burner shall be a premix design and constructed of high temperature stainless steel with a woven metal fiber outer covering to provide modulating firing rates. The boiler shall be supplied with a gas valve designed with negative pressure regulation and be equipped with a variable speed blower system, to precisely control the fuel/air mixture to provide modulating boiler firing rates for maximum efficiency. The boiler shall operate in a safe condition at a derated output with gas supply pressures as low as 4 inches of water column.
- .5 The boiler shall be equipped with two terminal strips for electrical connection.
- .1 A low voltage connection board with 30 data points for safety and operating controls, i.e., Alarm Contacts, Runtime Contacts, two (2) Flow Switches, Tank Thermostat, Enable/Disable (Wall Thermostat/Zone Control), System Supply Sensor, Outdoor Sensor, Tank Sensor, Building Management System signal and Cascade control circuit.
- .2 A high voltage terminal strip shall be provided for 120 volt / 60 hertz / single phase. The high voltage terminal strip plus integral relays are provided for independent pump control of the Boiler pump. The System pump and boiler pump dry contacts shall be sized for up to 1.5 HP/208V, or 30 amp pumps.
- .6 The boiler shall have an independent laboratory rating for Oxides of Nitrogen (NOx) of 30 ppm or less corrected to 3% O₂. The manufacturer shall verify proper operation of the burner, all controls and the heat exchanger by connection to water and venting for a factory fire test prior to shipping.
- .7 The boiler shall operate at altitudes up to 4,500 feet above sea level without additional parts or adjustments.

2.3 BOILER COMPONENTS (SUPPLIED AND INSTALLED BY THIS DIVISION)

- .1 The boiler shall be installed and vented with a direct vent system with vertical rooftop termination of both the exhaust vent and combustion air. The flue shall be Category IV approved Stainless Steel AL29-4C alloy sealed vent material terminating at the roof top with the manufacturers specified vent termination. The boiler's total combined air intake length shall not exceed 100 equivalent feet. The boiler's total combined exhaust venting length shall not exceed 100 equivalent feet. Refer to section 23 51 00 – Breeching, Chimneys and Stacks for further information on venting requirements.

- .2 The boiler shall be equipped with a temperature/pressure gauge; high limit temperature control with manual reset; ASME certified pressure relief valve set for 30 psi; outlet water temperature sensor; return water temperature sensor; flue temperature sensor; high and low gas pressure switches, low water cut off with manual reset and a condensate trap for the heat exchanger condensate drain. Purchase components from boiler manufacturer and install as required.

2.4 BOILER CONTROLS - Lochinvar

- .1 The boiler shall utilize a 24 VAC control circuit and components. The control system shall have a electronic display for boiler set-up, boiler status, and boiler diagnostics. All components shall be easily accessed and serviceable from the front of the jacket.
- .2 The BOILER shall feature a Multi-Coloured Graphic LCD display and for password security, three loop temperature setpoints with individual outdoor air reset curves; pump delay with adjustable freeze protection, pump exercise. The BOILER shall have the capability to accept a 0-10 VDC input connection for BMS control of modulation or setpoint, enable/disable of the boiler, variable system pump signal and a 0-10 VDC output of boiler modulation rate. The Boiler shall have a built-in "Cascade" with sequencing options for "lead lag" of "efficiency optimized" modulation logic. Supply voltage shall be 120 volt/60 hertz/single phase.

3 EXECUTION

3.1 INSTALLATION

- .1 Install to manufacturer's instructions.
- .2 Install to Ontario Gas Utilization Code.
- .3 Install boiler on concrete housekeeping base, sized minimum 100 mm larger than boiler base.
- .4 Provide connection of natural gas service to each boiler. Each boiler shall require a minimum gas pressure of 4" W.C. to 14" W.C.
- .5 Provide piping connections and accessories. Each boiler shall have individually isolating shutoff valves for service and maintenance.
- .6 Pipe relief valves to nearest floor drain.
- .7 Install circulator and diaphragm expansion tank on boiler.
- .8 Provide for connection to electrical service.
- .9 Flush and clean the boilers prior to start-up.

3.2 MANUFACTURER'S FIELD SERVICES

- .1 A manufacturer's factory authorized service technician must be used to start-up and service the boilers.
- .2 Instruct operating personnel in the operation and maintenance of units.

3.3 TSSA INSPECTION

- .1 The contractor is to arrange and pay for inspection by the local TSSA inspector prior to boiler start-up. Make modification required by the authorities having jurisdiction (AHJ). Include a copy of TSSA certificate of inspection with close-out documentation as per General Requirements of 20 01 01.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 01 01 applies to and governs all work of Division 21, 22 and 23.

1.2 SECTION INCLUDES

- .1 Cabinet unit heaters.
- .2 Wall Fin

1.3 SUBMITTALS FOR REVIEW

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

1.4 QUALITY ASSURANCE

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

1.5 REGULATORY REQUIREMENTS

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

2 PRODUCTS

2.1 CABINET UNIT HEATERS

- .1 Manufacturers:
 - .1 Engineered Air Model CUH.
 - .2 Sterling
 - .3 Sigma
 - .4 Trane
- .2 Coils: 1/2" (13mm) evenly spaced rippled aluminum fins mechanically bonded to copper tubes, designed for 1380 kPa and 104°C (220°F).
- .3 Cabinet: 16 ga. (1.5 mm) steel with exposed corners and edges rounded, easily removed panels, glass fibre insulation and integral air outlet.
- .4 Finish: Factory applied baked enamel coat on all surfaces of enclosure or cabinet. Colour as selected by the Architect.
- .5 Fans: Centrifugal forward-curved double-width double-inlet (DWDI) wheels, statically and dynamically balanced, direct driven.
- .6 Motor: 3-speed permanent split capacitor with internal automatic re-set overload protection and sleeve

- bearings, resiliently mounted.
- .7 Control: 3-speed plus off fan switch, factory wired, located in cabinet.
- .8 Filter: easily removed 1" (25 mm) thick glass fibre throw-away permanent washable type, located to filter air before coil.
- .9 Mixing Dampers: Where indicated, mixing sections with dampers. Refer to Section 25 for operating sequence.
- .10 Capacity: As Scheduled, based on 18°C (65°F) entering air temperature, 83°C (180°F) average water temperature.

2.2 WALL FIN WF-1

- .1 Manufacturers:
 - .1 Engineered Air WF-2A
 - .2 Sterling
 - .3 Sigma Trane
- .2 Wall fin shall be flat top free standing wall cabinet convector, Fabricated from 1.7mm (14 gauge) reinforced sheet steel with removable front panel, top outlet grille and all necessary mounting hardware. Prime coat painted suitable for single finish coat. Heating Elements shall be aluminum fins mechanically bonded to seamless copper tubing.
- .3 Capacities: As scheduled

3 EXECUTION

3.1 INSTALLATION

- .1 Install to manufacturer's instructions.
- .2 Install equipment exposed to finished areas after walls and ceiling are finished and painted. Avoid damage
- .3 Protection: Provide finished cabinet units with protective covers during balance of construction.
- .4 Cabinet Unit Heaters: Install as indicated. Coordinate to assure correct recess size for recessed units.
- .5 Hydronic Units: Provide with shut-off valve on supply and lockshield balancing valve on return piping. If not easily accessible, extend vent to exterior surface of cabinet for easy servicing for cabinet unit heaters, wall fin enclosures provide float operated automatic air vents with stop valve.

3.2 CLEANING

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

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 20 01 01.

1.2 COMMON WORK RESULTS

- .1 Section 25 05 00 applies to and governs all work of Division 25.

1.3 REFERENCE STANDARDS

- .1 Provide all work in accordance with requirements of Regulatory Agencies and conform to:
 - .1 Local and district by-laws, regulations and published engineering standards.
 - .2 the Ontario Building Code (OBC) as amended,
 - .3 the Ontario Fire Code (OFC) as amended,
 - .4 the Ontario Electrical Safety Code (OESC).
 - .5 Regulations for Construction Projects under The Occupational Health and Safety Act.
- .2 Conform to following National Research Council Canada publications:
 - .1 National Building Code of Canada (NBC) and Supplements to National Building Code of Canada
 - .2 National Fire Code of Canada (NFC).
- .3 Conform to following National Fire Protection Association publications:
 - .1 NFPA 70 National Electrical Code (NEC)

1.4 FIELD QUALITY CONTROL

- .1 All work, materials, and equipment shall comply with the rules and regulations of applicable local, provincial and federal codes and standards.
- .2 Contractor shall continually monitor the field installation for code compliance and quality of workmanship.

1.5 QUALIFICATIONS

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

1.6 SUBMITTALS

- .1 Submit shop drawings in accordance with Section 20 01 01, for the following items:
 - .1 Firestopping compounds and applications schedule
 - .2 Access doors

1.7 DELIVERY, STORAGE, AND HANDLING

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

1.8 WASTE MANAGEMENT & DISPOSAL

- .1 Separate and recycle waste materials in accordance with Division 1 Waste Management and Disposal, and with the Contractor's Waste Reduction Workplan.

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

1.9 WARRANTY

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

2 PRODUCTS

2.1 ELECTRICAL COMPONENTS AND WIRING

- .1 Conform to requirements of Division 26 for all wiring, conduits and raceways, boxes, and cable trays included in Division 25.
- .2 All pre-wired equipment provided by Sections under Division 25 shall conform to requirements of Division 26. Ensure that all pre-wired electrical equipment is CSA approved. Arrange and pay for special approval where this is not possible.
- .3 Communication and control wiring and power supplies specified as conforming to NEC Class 1, Class 2 and Class 3 wiring practices must also conform to OESC Section 16 requirements.

2.2 COMMUNICATION AND CONTROL WIRING

- .1 General:
 - .1 Provide copper wiring, plenum cable, and raceways as specified in the applicable Sections of Division 26 unless otherwise noted herein.
 - .2 All insulated wire to be copper conductors, ULC labeled for 90°C minimum service.
- .2 Wire Sizing and Insulation
 - .1 Wiring shall comply with minimum wire size and insulation based on services listed below:

Service	Minimum Gage/Type	Insulation Class
AC 24V Power	12 Ga Solid	600 Volt
DC 24V Power	10 Ga Solid	600 Volt
Class 1	14 Ga Stranded	600 Volt
Class 2	18 Ga Stranded	300 Volt
Class 3	18 Ga Stranded	300 Volt

- .2 Provide plenum-rated cable when open cable is permitted in supply or return air plenum.
- .3 Power Wiring:
 - .1 115V power circuit wiring above 100 feet distance shall use minimum 10 gauge.
 - .2 24V control power wiring above 200 feet distance shall use minimum 12 gauge.
- .4 Control Wiring:
 - .1 Digital Input/Output wiring shall use Class 2 twisted pair, insulated.
 - .2 Analog inputs shall use Class 2 twisted shielded pair, insulated and jacketed and require a grounded shield.
 - .3 Actuators with tri-state control shall use Class 3 conductor with same characteristics
- .5 Communication Wiring
 - .1 Ethernet Cable shall be minimum CAT5e and as required for system components.
 - .2 Secondary level network shall be 24 gage, TSP, low capacitance cable
- .6 Approved Cable Manufacturers: Wiring from the following manufacturers which meet the above criteria shall be acceptable:
 - .1 Anixter
 - .2 Belden
 - .3 Cerco

2.3 POWER SUPPLIES AND LINE FILTERING

- .1 Control transformers shall be ULC listed. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.
- .2 DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand a 150% current overload for at least three seconds without trip-out or failure.
 - .1 Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
 - .2 Line voltage units shall be ULC recognized and CSA approved.
- .3 Power line filtering: Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component. Surge protection shall have the following at a minimum:
 - .1 Dielectric strength of 1000 volts minimum
 - .2 Response time of 10 nanoseconds or less
 - .3 Transverse mode noise attenuation of 65 dB or greater
 - .4 Common mode noise attenuation of 150 dB or better at 40 Hz to 100 Hz.

2.4 FIRESTOPPING COMPOUNDS

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

2.5 ACCESS DOORS

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

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

2.6 NAMEPLATES

- .1 Provide laminated plastic plates with black face and white centre of minimum size 3-1/2" x 1-1/2" x 3/32" (90 x 40 x 2 mm) nominal thickness, engraved with 1/4" (6 mm) high lettering. Use 1" (25 mm) lettering for major equipment.
- .2 Fasten nameplates securely in conspicuous place. Where nameplates cannot be mounted on cool surface, provide standoffs.
- .3 Identify equipment type and number and service of areas or zone of building served.
- .4 For each item of equipment supplied and/or installed under this Division which may be started automatically or remotely, provide a red lamacoid plate, 2-1/2" x 9" (60 x 230 mm), reading:
"WARNING. THIS EQUIPMENT IS AUTOMATICALLY
CONTROLLED AND MAY START AT ANY TIME."

2.7 TAGS

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

3 EXECUTION

3.1 INSPECTION

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

3.2 PREPARATION

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

3.3 ELECTRICAL COMPONENTS AND WIRING

- .1 Coordinate all wiring requirements with other Divisions. Line voltage wiring from power distribution panels to starters and from starters to motors will be provided under Division 26. All other field wiring for equipment shall be included under Division 25.

3.4 PROTECTION

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

3.5 CUTTING AND PATCHING

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

3.6 SEALANTS & CAULKING

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

- .2 Temporarily plug all openings during construction.

3.7 FIRESTOPPING

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

3.8 SUPPORT AND ATTACHEMENT

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

3.9 PAINTING

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

3.10 EQUIPMENT BASES AND CURBS

- .1 Supply and erect structural work required for installation of equipment, cabinets, enclosures and panels.
- .2 Build 4" (100 mm) high concrete curbs around all openings through mechanical room floors. Ensure joint between curb and floor is watertight and maintains integrity of floor membrane where applicable.
- .3 Build concrete bases 6" (150 mm) high, providing all necessary inserts, anchor bolts and other fasteners required, for floor mounted tanks, compressors, etc. Make concrete bases 6" (150 mm) larger all around than the base of the supported equipment and trowel finish to a neat smooth finish. Anchor equipment to pads using 8" (200 mm) cast-in-place anchor bolts. Ensure concrete supplied under this Division is 2500 psi (17 MPa) compressive strength after 28 days.

3.11 MOCK-UP

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

3.12 FLOW DIAGRAMS AND DIRECTORIES

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

3.13 INSTALLATION OF ACCESS DOORS

- .1 Supply access doors for access to equipment requiring service, lubrication or adjustment and all concealed valves, cleanouts, trap primers, control and volume dampers, and other such equipment.
- .2 Turn over access doors to the appropriate trade for installation under other Sections.

- .3 Refer to architectural drawings for ratings of fire separations and assemblies. install fire rated access doors in fire rated partitions, walls, and ceilings.
- .4 Access doors in ceilings shall be minimum 24" x 24" (600mm x 600mm), unless otherwise approved by the Consultant.
- .5 Provide concealed access doors in GWB ceilings and coordinate in-fill with general trades.
- .6 Provide Air Seal Flush Mount access doors in all Clean Rooms, Laboratories and Health Care Facility Class 1 rooms [e.g. operating rooms, procedure rooms, ICU, CCU, PACU, and all sterile environments].

3.14 INSTALLATION PRACTICES

- .1 BMS Wiring
 - .1 All conduit, wiring, accessories and wiring connections required for the installation of the Building Management System, as herein specified, shall be provided by the BMS Contractor unless specifically shown on the Electrical Drawings under Division 26 Electrical. All wiring shall comply with the requirements of applicable portions of Division 26 and all local and national electric codes, unless specified otherwise in this section.
 - .2 All BMS wiring materials and installation methods shall comply with BMS manufacturer recommendations.
 - .3 Class 2 Wiring
 - .1 All Class 2 (24VAC or less) wiring shall be installed in conduit unless otherwise specified.
 - .2 Class 2 wiring in concealed accessible locations shall be FT-6 plenum rated.
 - .3 Class 2 wiring not installed in conduit shall be supported every 5' from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements.
 - .4 Class 2 signal wiring and 24VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.
 - .5 Provide for complete grounding of all applicable signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops.
- .2 BMS Line Voltage Power Source
 - .1 120-volt AC circuits used for the Building Management System shall be taken from panel boards and circuit breakers provided under Division 26.
 - .2 Circuits used for the BMS shall be dedicated to the BMS and shall not be used for any other purposes.
 - .3 DDC terminal unit controllers may use AC power from motor power circuits.
- .3 BMS Raceway
 - .1 All wiring shall be installed in conduit or raceway except as noted elsewhere in this specification. Minimum control wiring conduit size 1/2".
 - .2 Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used as approved by the Architect.
 - .3 All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.
 - .4 Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.
- .4 Penetrations
 - .1 Provide fire stopping for all penetrations used by dedicated BMS conduits and raceways.
 - .2 All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.
 - .3 All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.
 - .4 Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.
- .5 BMS Identification Standards

- .1 Node Identification. All nodes shall be identified by a permanent label fastened to the enclosure. Labels shall be suitable for the node location.
- .2 Cable types specified in Item A shall be color coded for easy identification and troubleshooting.
- .6 BMS Panel Installation
 - .1 The BMS panels and cabinets shall be located as indicated at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer's recommendations.
 - .2 The BMS contractor shall be responsible for coordinating panel locations with other trades and electrical and mechanical contractors.
- .7 Input Devices
 - .1 All Input devices shall be installed per the manufacturer recommendation
 - .2 Locate components of the BMS in accessible local control panels wherever possible.
- .8 HVAC Input Devices - Genera1
 - .1 All Input devices shall be installed per the manufacturer recommendation
 - .2 Locate components of the BMS in accessible local control panels wherever possible.
 - .3 The mechanical contractor shall install all in-line devices such as temperature wells, pressure taps, airflow stations, etc.
 - .4 Input Flow Measuring Devices shall be installed in strict compliance with ASME guidelines affecting non-standard approach conditions.
 - .5 Outside Air Sensors
 - .1 Sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air conditions accurately.
 - .2 Sensors shall be installed with a rain proof, perforated cover.
 - .6 Water Differential Pressure Sensors
 - .1 Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device.
 - .2 Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.
 - .3 The transmitters shall be installed in an accessible location wherever possible.
 - .7 Medium to High Differential Water Pressure Applications (Over 21" w.c.):
 - .1 Air bleed units, bypass valves and compression fittings shall be provided.
 - .8 Building Differential Air Pressure Applications (-1" to +1" w.c.):
 - .1 Transmitters exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.
 - .2 The interior tip shall be inconspicuous and located as shown on the drawings.
 - .9 Air Flow Measuring Stations:
 - .1 Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct.
 - .2 Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.
 - .10 Duct Temperature Sensors:
 - .1 Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
 - .2 The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.
 - .3 For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.
 - .4 The sensor shall be mounted to suitable supports using factory approved element holders.
 - .11 Space Sensors:
 - .1 Shall be mounted per ADA requirements.
 - .2 Provide lockable tamper-proof covers in public areas and/or where indicated on the plans.
 - .12 Low Temperature Limit Switches:
 - .1 Install on the discharge side of the first water or steam coil in the air stream.

- .2 Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by 1 foot of sensor.
- .3 For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream.
- .13 Air Differential Pressure Status Switches:
 - .1 Install with static pressure tips, tubing, fittings, and air filter.
- .14 Water Differential Pressure Status Switches:
 - .1 Install with shut off valves for isolation.
- .9 HVAC Output Devices
 - .1 All output devices shall be installed per the manufacturers' recommendation. The mechanical contractor shall install all in-line devices such as control valves, dampers, airflow stations, pressure wells, etc.
 - .2 Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke. When any pneumatic actuator is sequenced with another device, pilot positioners shall be installed to allow for proper sequencing.
 - .3 Control Dampers: Shall be opposed blade for modulating control of airflow. Parallel blade dampers shall be installed for two position applications.
 - .4 Control Valves: Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI. The maximum pressure drop for steam applications shall be 7 PSI.
 - .5 Electronic Signal Isolation Transducers: Whenever an analog output signal from the Building Management System is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input a signal from a remote system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between systems. Signals shall provide optical isolation between systems

3.15 WIRING

- .1 All control and interlock wiring shall comply with provincial electrical codes, standards and Division 26.
- .2 All NEC Class 1 wiring shall be ULC Listed in approved conduit according to OESC and Division 26 requirements.
- .3 All low-voltage wiring shall meet NEC Class 2 requirements. Low-voltage power circuits shall be sub-fused when required to meet NEC Class 2 current limitations.
- .4 Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in conduit may be used provided that cables are ULC Listed for the intended application. For example, cables used in ceiling plenums shall be ULC Listed specifically for that purpose.
- .5 All wiring in mechanical, electrical, or service rooms-or where subject to mechanical damage- shall be installed in conduit.
- .6 Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).
- .7 Do not install wiring in conduit containing tubing.
- .8 Where plenum rated cable is run exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 3 m (10 ft) intervals.
- .9 Where plenum rated cable is used without conduit, it shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical conduits, piping, or ceiling suspension systems.
- .10 All wire-to-device connections shall be made at a terminal block or wire nut. All wire-to-wire connections shall be at a terminal strip or wire nut.
- .11 All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
- .12 Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, this Division shall provide step-down transformers or interposing relays.
- .13 All plenum rated wiring shall be installed as continuous lengths, with no splices permitted between

- termination points
- .14 All wiring in conduit shall be installed as continuous lengths, with no splices permitted between termination points or junction boxes.
 - .15 Maintain fire rating at all penetrations. Install plenum wiring in sleeves where it passes through walls and floors.
 - .16 Size and type of conduit and size and type of wire shall be the responsibility of the contractor, in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.
 - .17 Include one pull string in each conduit 3/4 in. or larger.
 - .18 Control and status relays are to be located in designated enclosures only. These enclosures can include packaged equipment control panel enclosures unless they also contain Class 1 starters.
 - .19 Conceal all conduit, except within mechanical, electrical, or service rooms. Install conduit to maintain a minimum clearance of 15 cm (6 in.) from high-temperature equipment (e.g., steam pipes, gas vents or flues).
 - .20 Secure conduit with conduit clamps fastened to the structure and spaced according to code requirements. Conduit and pull boxes may not be hung on flexible duct strap or tie rods. Conduits may not be run on or attached to ductwork.
 - .21 Adhere to this specification's Division 26 requirements where conduit crosses building expansion joints.
 - .22 This Division shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
 - .23 Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 1 m (3 ft) in length and shall be supported at each end. Flexible metal conduit less than 1/2 in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.
 - .24 Conduit must be adequately supported, properly reamed at both ends, and left clean and free of obstructions. Conduit sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

3.16 COMMUNICATION WIRING

- .1 This Division shall adhere to the items listed in the "Wiring" article 3.14.
- .2 All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.
- .3 Do not install communication wiring in raceway and enclosures containing NEC Class 1 or other Class 2 wiring.
- .4 Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.
- .5 Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.
- .6 When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lightning arrestor shall be installed according to the manufacturer's instructions.
- .7 All runs of communication wiring shall be unspliced length when that length is commercially available.
- .8 All communication wiring shall be labeled to indicate origination and destination data.
- .9 Grounding of coaxial cable shall be in accordance with OESC and NEC regulations on "Communications Circuits, Cable, and Protector Grounding."

3.17 INPUT/OUTPUT INTERFACE

- .1 Hardwired inputs and outputs may tie into the system through building or application specific controllers.
- .2 All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no damage to the controller.
- .3 Binary inputs shall allow the monitoring of On/Off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices

- and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.
- .4 Pulse accumulation input objects. This type of object shall conform to all the requirements of binary input objects and also accept up to 10 pulses per second for pulse accumulation.
 - .5 Analog inputs shall allow the monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with-and field configurable to commonly available sensing devices.
 - .6 Binary outputs shall provide for On/Off operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers shall have three-position (On/Off/Auto) override switches and status lights. Outputs shall be selectable for either normally open or normally closed operation.
 - .7 Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC, 4 to 20 mA or 0-20 PSI signal as required to provide proper control of the output device. Analog outputs on building or custom application controllers shall have status lights and a two-position (AUTO/MANUAL) switch and manually adjustable potentiometer for manual override. Analog outputs shall not exhibit a drift of greater than 0.4% of range per year.
 - .8 Tri-State Outputs. Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point floating devices shall be limited to zone control and terminal unit control applications (VAV terminal units, duct-mounted heating coils, zone dampers, radiation, etc.). Control algorithms shall run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.
 - .9 System Object Capacity: The system size shall be expandable to at least twice the number of input/output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

3.18 INSTALLATION OF SENSORS

- .1 General:
 - .1 Install sensors in accordance with the manufacturer's recommendations.
 - .2 Mount sensors rigidly and adequately for the environment within which the sensor operates.
 - .3 Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.
 - .4 All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.
 - .5 Sensors used in mixing plenums and hot and cold decks shall be of the averaging type.
 - .6 Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across the full face of the coil.
 - .7 All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.
 - .8 Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.
- .2 Room Instrument Mounting
 - .1 Room instruments, including but not limited to wall mounted thermostats and sensors located in occupied spaces shall be mounted 48" (1200mm) inches above the finished floor unless otherwise shown.
- .3 Instrumentation Installed in Piping Systems
 - .1 Thermometers and temperature sensing elements installed in liquid systems shall be installed in thermowells.
 - .2 Gauges in piping systems subject to pulsation shall have snubbers.
 - .3 Gauges for steam service shall have pigtail fittings with isolation valve.
 - .4 Contractor shall connect the DDC System to the auxiliary contacts provided on the Smoke Detector as required for system safeties and to provide alarms to the DDC system.
- .4 Averaging Temperature Sensing Elements
 - .1 Sensing elements shall be installed in a serpentine pattern.
 - .2 Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each

- bend shall be supported with a capillary clip.
- .5 Relative Humidity Sensors
 - .1 Relative humidity sensors in supply air ducts shall be installed at least 3m (10 feet) downstream of humidity injection elements.

3.19 ACTUATORS

- .1 Mount and link control damper actuators according to manufacturer's instructions.
 - .1 To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
 - .2 Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
 - .3 Provide all mounting hardware and linkages for actuator installation.
- .2 Electric/Electronic
 - .1 Dampers: Actuators shall be direct-mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° available for tightening the damper seals. Actuators shall be mounted following manufacturer's recommendations.
 - .2 Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.
- .3 Identification of Tubing and Wiring
 - .1 All wiring and cabling including that within factory-fabricated panels shall be labeled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.
 - .2 Permanently label or code each point of field terminal strips to show the instrument or item served.
 - .3 All pneumatic tubing shall be labeled at each end within 5 cm (2 in.) of termination with a descriptive identifier.

3.20 IDENTIFICATION OF HARDWARE AND WIRING

- .1 All wiring and cabling, including that within factory-fabricated panels shall be labeled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.
- .2 Permanently label or code each point of field terminal strips to show the instrument or item served.
- .3 Identify control panels and major control components on outside with minimum 1 cm (½ in.) letters on laminated plastic nameplates.
- .4 Identify all other control components with permanent labels. All plug-in components shall be labeled such that removal of the component does not remove the label.
- .5 Identify room sensors relating to terminal box or valves with nameplates.
- .6 Manufacturers' nameplates and ULC or CSA labels are to be visible and legible after equipment is installed.
- .7 Identifiers shall match record documents.
- .8 Degrease and clean surfaces to receive adhesive for identification materials.
- .9 Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer (VOC content not to exceed 680 g/L).
- .10 Install tags with corrosion resistant chain.
- .11 Clearly identify abandoned services left in place as "ABANDONED".
- .12 For each item of equipment which may be started automatically or remotely, add a red lamacoid plate, 2-3/8" x 9" (60 x 230 mm), reading: **"WARNING. THIS EQUIPMENT IS AUTOMATICALLY CONTROLLED. IT MAY START AT ANY TIME."**
- .13 Provide colour coded self-adhesive dots to locate control devices and panels located above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

3.21 EQUIPMENT TESTING AND INSPECTION

- .1 Test operation of equipment installed under this Division according to instructions in appropriate

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

3.22 ADJUST AND CLEAN

- .1 Clean up all debris resulting from their activities daily. Remove all cartons, containers, crates, etc. as soon as their contents have been removed. Collect and sort waste and deposit in designated locations.
- .2 At the completion of work in any area, clean all work keeping it free from dust, dirt, and debris. Check all equipment furnished under this Division for paint damage. Repair any factory-finished paint that has been damaged to match the adjacent areas. Any equipment item, cabinet or enclosure that has been deformed shall be replaced with new material and painted to match adjacent areas.
- .3 Lubricate mechanical equipment installed under this Division.
- .4 Test and adjust control devices, instrumentation, valves, dampers, etc. installed under this Division after cleaning of systems and leave in perfect order ready for operation.
- .5 Remove from the premises upon completion of work of this Division, debris, surplus, and waste materials resulting from operations.

END OF SECTION

1 GENERAL

1.1 RELATED SECTIONS

- .1 The General Conditions of the Contract, Supplementary Conditions, and General Requirements are a part of this specification and shall be used in conjunction with this section as a part of the contract documents. Consult them for further instructions pertaining to this work.
- .2 The following sections but not limited constitute related work:
 - .1 Section 20 01 01 - General Requirements
 - .2 Section 20 90 50 – Mechanical-Electrical Equipment
 - .3 Section 23 05 14 – Variable Frequency Drives
 - .4 Section 23 21 23 – Hydronic Pumps
 - .5 Section 23 52 15 – Boilers, Condensing
 - .6 Section 23 82 00 – Terminal Heat Transfer Units
 - .7 Section 25 05 00 - Common Work Results
 - .8 Section 25 90 00 - Sequence of Operations
- .3 Products furnished but not installed under this section:
 - .1 Temperature & Pressure Sensor Wells and Sockets

1.2 DESCRIPTION

- .1 General: The control system shall be provided with the latest software from the manufacturer, and consist of a high-speed, peer-to-peer network of DDC communicating on a BACnet internetwork. Each mechanical system and control device will be depicted by point-and-click graphics. Systems using gateways to route proprietary devices and objects to BACnet are not acceptable.
- .2 The existing boiler along with its circulator pumps and heating water distribution pumps is to be replaced with two (2) new condensing boilers, duty stand-by pumps for building heating water distribution (see drawings and specifications), and new circulation pump for east wing portables and wallfin elements. The scope of work of Division 25 but not limited to shall include the provisions of controls to expend the existing BAS system in the building to new boilers and heating water pumps as required to achieve the control sequence as specified in section 25 90 00. The work shall also include the provision of dedicated east-wing portables circualtor pump along with hydronic wallfin. The web based 3D graphics interface for all new systems shall be provided along with any new control components as required to meet the requirements as described in construction documents.
- .3 For Local Area Network installations provide access to the control system via the internet. The owner shall provide a connection to the internet via high speed cable modem, ADSL, ISDN, T1 or through the facility ISP. The owner shall pay for all monthly internet access fees and connection charges. The site shall be accessed via the internet using web base operating system software as per the following item.
- .4 The control system shall be supplied with a complete web enabled package. The system shall support unlimited users using standard web browsers such as Internet Explorer and Firefox. The web server software shall operate on standard industry PC servers. Proprietary servers or “black boxes” are not acceptable. Web browser software shall be manufactured by the control system manufacturer and shall have the same look and feel as the operating system. Third party web software is not acceptable.
- .5 System Object Capacity. The system size shall be expandable to at least twice the number of input/output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The Operator Workstations installed for this project shall not require any hardware additions or software revisions in order to expand the system.

1.3 APPROVED CONTROL SYSTEM CONTRACTORS AND MANUFACTURERS

- .1 The manufacturer shall be Delta Controls by Durell Control Systems Inc.

1.4 QUALITY ASSURANCE

- .1 Contractor/Manufacturer Qualifications

- .1 The system shall be designed and installed, commissioned and serviced by factory trained personnel. BAS contractor shall have an in-place support facility within 100 km of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment. The BAS contractor shall provide full time, on site, experienced project manager for this work, responsible for direct supervision of the design, installation, start up and commissioning of the BAS. The Bidder shall be regularly engaged in the installation and maintenance of BAS systems and shall have a minimum of ten (10) years of demonstrated technical expertise and experience in the installation and maintenance of BAS systems that are similar in size and complexity to this project.
- .2 All products used in this installation shall be new, currently under manufacture, and shall be applied in standard off the shelf products. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner in writing. Spare parts shall be available for at least 5 years after completion of this contract.
- .3 The BAS contractor shall be the Manufacturer, No Distributors are allowed.

1.5 CODES AND STANDARDS

- .1 All work, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of the local, state, and federal authorities. Such codes, when more restrictive, shall take precedence over these plans and specifications. As a minimum, the installation shall comply with the current editions in effect 30 days prior to receipt of bids of the following codes:
 - .1 National Electric Code (NEC)
 - .2 Uniform Building Code (UBC)
 - .1 Section 608, Shutoff for Smoke Control
 - .2 Section 403.3, Smoke Detection Group B Office Buildings and Group R, Division 1 Occupancies
 - .3 Section 710.5, Wiring in Plenums
 - .4 Section 713.10, Smoke Dampers
 - .5 Section 1106 Refrigeration Machinery Room
 - .6 Section 1107, Refrigeration Machinery Room Ventilation
 - .7 Section 1108, Refrigeration Machinery Room Equipment and Controls
 - .8 Section 1120, Detection and Alarm Systems
 - .3 Uniform Mechanical Code (UMC)
 - .4 ASHRAE 135-2001
 - .5 FCC Regulation, Part 15- Governing Frequency Electromagnetic Interference
 - .6 Underwriters Laboratories UL916

1.6 SYSTEM PERFORMANCE

- .1 Performance Standards.
 - .1 The system shall conform to the following:
 - .1 Graphic Display. The system shall be dashboard based, and also capable of displaying a graphic with 20 dynamic points/objects with all current data within 10 seconds.
 - .2 Graphic Refresh. The system shall update a graphic with 20 dynamic points/objects with all current data within 8 seconds
 - .3 Object Command. The maximum time between the command of a binary object by the operator and the reaction by the device shall be less than 2 seconds. Analog objects should start to adjust within 2 seconds
 - .4 Object Scan. All changes of state and change of analog values will be transmitted over the high-speed Ethernet network such that any data used or displayed at a controller or workstation will have been current within the previous 2 seconds
 - .5 Alarm Response Time. The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed 45 seconds
 - .6 Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 1 second. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control

- .7 Performance. Programmable controllers shall be able to execute DDC PID control loops at a frequency of at least once per second. The controller shall scan and update the process value and output generated by this calculation at this same frequency
 - .8 Multiple Alarm Annunciation. All workstations on the network must receive alarms within 5 seconds of each other
 - .9 Reporting Accuracy. The system shall report all values with an end-to-end accuracy as listed or better than those listed in Table 1
 - .10 Stability of Control. Control loops shall maintain measured variable at setpoint within the tolerances listed in Table 2
- .2 TABLE 1: Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±0.5°C [±1°F]
Ducted Air	±0.5°C [±1°F]
Outside Air	±1.0°C [±2°F]
Dewpoint	±1.5°C [±3°F]
Water Temperature	±0.5°C [±1°F]
Delta-T	±0.15°C[±0.25°F]
Relative Humidity	±5% RH
Water Flow	±5% of full scale
Airflow (terminal)	±10% of full scale (see Note 1)
Airflow (measuring stations)	±5% of full scale
Air Pressure (ducts)	±25 Pa [±0.1 "W.G.]
Air Pressure (space)	±3 Pa [±0.01 "W.G.]
Water Pressure	±2% of full scale (see Note 2)
Electrical (A, V, W, Power factor)	5% of reading (see Note 3)
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO ₂)	±50 ppm
Note 1: 10%-100% of scale	
Note 2: For both absolute and differential pressure	
Note 3: Not including utility-supplied meters	

.3 TABLE 2: Control Stability and Accuracy

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±50 Pa [±0.2" w.g.] ±3 Pa [±0.01" w.g.]	0-1.5 kPa [0-6" w.g.] -25 to 25 Pa [-0.1 to 0.1" w.g.]
Airflow	±10% of full scale	
Temperature	±0.5°C [±1.0°F]	
Humidity	±5% RH	

Controlled Variable	Control Accuracy	Range of Medium
Fluid Pressure	±10 kPa [±1.5 psi]	0-1 kPa [1-150 psi]
“ “ differential	±250 Pa [±1.0" w.g.]	0-12.5 kPa [0-50"w.g.]

1.7 SUBMITTALS

- .1 Product Data and Shop Drawings: Contractor shall provide a copy of shop drawings and/or other submittals on all hardware, software, and installation to be provided. No work may begin on any segment of this project until submittals have been reviewed for conformity with the design intent. The shop drawings shall ensure that identifying numbers on the shop drawings correspond to equipment identification, as specified elsewhere in the Specifications. The locations of all equipment shall be identified. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Submittals shall include:
 - .1 All automatic temperature, pressure and humidity control components, including maintenance of all equipment and service manuals.
 - .2 Provide a detailed network layout indicating the type of controller and model number, location, power source (panel and breaker I.D.) and routing of wiring
 - .3 Identified schematic control diagrams for all systems, each diagram indicating control component catalogue numbers, operation sequence, and interlocking.
 - .4 Descriptive data and sequence of operation for all systems.
- .2 Project Record Documents: Upon completion of installation, submit electronic copy of record (as built) documents. The documents shall be submitted for approval prior to final completion and shall include Project Record Drawings which shall be as-built versions of the submittal shop drawings; Testing and Commissioning Reports and Checklists; Electrical Safety Authority Final Inspection Certificate; and other materials needed for inclusion in the Operation and Maintenance (O & M) Manual.

1.8 WARRANTY

- .1 Warrant all work as follows:
 - .1 Labor and materials for the control system specified shall be warranted free from defects for a period of 12 months after final completion and acceptance. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner. The Contractor shall provide 24/7 support, respond to the Owner's request for one year standard warranty service within 24 hours during normal business hours.
 - .2 At the end of the final start-up, testing, and commissioning phase, if equipment and systems are operating satisfactorily to the Owner, the Owner shall sign certificates certifying that the control system's operation has been tested and accepted in accordance with the terms of this specification. The date of acceptance shall be the start of warranty.
 - .3 Operator workstation software, project-specific software, graphic software, database software, and firmware updates which resolve known software deficiencies as identified by the Contractor shall be provided at no charge during the warranty period. Any upgrades or functional enhancements associated with the above mentioned items also can be provided during the warranty period for an additional charge to the Owner by purchasing an in-warranty technical support agreement from the Contractor. Written authorization by the Owner must, however, be granted prior to the installation of any of the above-mentioned items.
 - .4 Exception: The Contractor shall not be required to warrant reused devices, except for those that have been rebuilt and/or repaired. The Contractor shall warrant all installation labor and materials, however, and shall demonstrate that all reused devices are in operable condition at the time of Owner's acceptance.

1.9 OWNERSHIP OF PROPRIETARY MATERIAL

- .1 All project-developed software and documentation shall become the property of the Owner. These include, but are not limited to:
 - .1 Project graphic images
 - .2 Record drawings
 - .3 Project database
 - .4 Project-specific application programming code
 - .5 All documentation

2 PRODUCTS

- .1 Section includes:
 - .1 Materials
 - .2 Communication
 - .3 Operator Workstation and Dashboard Widgets
 - .4 Controller Software
 - .5 Building Controllers
 - .6 Advanced Application Controllers
 - .7 Application Specific Controllers
 - .8 Auxiliary Control Devices
 - .9 Wiring and Raceways

2.1 MATERIALS

- .1 All products used in this project installation shall be new, currently under manufacture, and shall be applied in similar installations for a minimum of two years. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner's Representative in writing. Spare parts shall be available for at least five years after completion of this contract.

2.2 COMMUNICATION

- .1 All control products provided for this project shall comprise a BACnet internetwork. Communication involving control components (i.e., all types of controllers and Operator Workstations) shall conform to ANSI/ASHRAE Standard 135-2008, BACnet.
- .2 Each BACnet device shall operate on the BACnet Data Link/Physical layer protocol specified for that device as defined in this section.
- .3 The Contractor shall provide all communication media, connectors, repeaters, bridges, hubs, switches, and routers necessary for the internetwork.
- .4 All HVAC controllers shall be native BACnet Controllers that communicate on a Twisted Pair 10-BaseT BACnet/IP and/or BACnet over Ethernet network; each shall have a communication port of connections with the operator interfaces using the BACnet Data Link/Physical layer protocol.
- .5 All controllers shall have a communication port for connections with the Operator Workstations using the BACnet Data Link/ Physical layer protocol.
- .6 Communication services over the internetwork shall result in operator interface and value passing that is transparent to the internetwork architecture as follows:
 - .1 Connection of an Operator Workstation device to any one controller on the internet work will allow the operator to interface with all other controllers as if that interface were directly connected to the other controllers. Data, status information, reports, system software, custom programs, etc., for all controllers shall be available for viewing and editing from any one controller on the internetwork.
 - .2 All database values (e.g., objects, software variables, custom program variables) of any one controller shall be readable by any other controller on the internetwork. This value passing shall be automatically performed by a controller when a reference to an object name not located in that controller is entered into the controller's database. An operator/installer shall not be required to set up any communication services to perform internetwork value passing.
- .7 The time clocks in all applicable controllers shall be automatically synchronized daily. An operator change to the time clock in any controller shall be automatically broadcast to all controllers on the network.

2.3 CONTROLLER SOFTWARE

- .1 Furnish the following applications software for building and energy management. All software applications shall reside and operate in the system controllers. Editing of applications shall occur at the operator workstation
- .2 System Security
 - .1 User access shall be secured using individual security passwords and user names.
 - .2 Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.
 - .3 User Log On/Log Off attempts shall be recorded.
- .3 Scheduling.
 - .1 Provide the capability to schedule each object or group of objects in the system. Each schedule shall consist of the following:
 - .2 Provide an event scheduling system that allows the operator to specify a single event, multiple day event and/or recurring events. The event schedule specifies both the on/off times and the date in a calendar planning format similar to Microsoft Outlook®.
 - .3 Calendar Schedules. Provide the capability for the operator to define up to 99 special schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.
- .4 Alarm Reporting. The operator shall be able to determine the action to be taken in the event of an alarm. Alarms shall be routed to the appropriate workstations based on time and other conditions.
- .5 Remote Communication. The system shall have the ability to communicate out of the system to the internet in the event of an alarm using BACnet Point-To-Point attributes. Messaging capability shall include email service.
- .6 Maintenance Management. The system shall monitor equipment status and generate maintenance messages based upon user-designated run-time, starts, and/or calendar date limits.
- .7 Sequencing. Provide application software to properly sequence the start and stop of chillers, boilers, and pumps to minimize energy usage in the facility.
- .8 PID Control. A PID (proportional-integral-derivative) algorithm with direct or reverse action and anti-windup shall be supplied. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, setpoint, and PID gains shall be user-selectable.
- .9 Staggered Start. This application shall prevent all controlled equipment from simultaneously restarting after a power outage.
- .10 Energy Calculations. Provide software to allow instantaneous power (e.g., kW) or flow rates (e.g., L/s [GPM]) to be accumulated and converted to energy usage data. Provide an algorithm that calculates a sliding-window kW demand value.
- .11 Anti-Short Cycling. All binary output objects shall be protected from short cycling. This feature shall allow minimum on-time and off-time to be selected.
- .12 On/Off Control with Differential. Provide an algorithm that allows a binary output to be cycled based on a controlled variable and setpoint. The algorithm shall be direct-acting or reverse-acting, and incorporate an adjustable differential.
- .13 Run-time Totalization. Provide software to totalize run-times for all binary input objects. A high run-time alarm shall be assigned, if required, by the operator.

2.4 BUILDING CONTROLLERS

- .1 General. Provide an adequate number of BACnet® Building Controllers to achieve the performance specified in the Part 1 Article on "System Performance." Each of these panels shall meet the following requirements.
 - .1 The Control System shall be comprised of one or more independent, standalone, microprocessor-based Building Controllers to manage the global strategies described in the System Software section.
 - .2 The Building Controller shall have sufficient memory to support its operating system, database, and programming requirements.
 - .3 Data shall be shared between networked Building Controllers.
 - .4 The operating system of the Building Controller shall manage the input and output

communication signals to allow distributed controllers to share real and virtual object information, and allow central monitoring and alarms.

- .5 Controllers that perform scheduling shall have a battery or super-cap backed up real-time clock.
- .6 The Building Controller shall support the following BACnet Interoperability Building Blocks (BIBBs):

Data Sharing	Alarm & Event	Scheduling	Trending	Device & Network Mgmt.
DS-RP-A,B	AE-N-A	SCH-I-B	T-VM-I-B	DM-DDB-A,B
DS-RPM-A,B	AE-N-I-B	SCH-E-B	T-VM-E-B	DM-DOB-A,B
DS-WP-A,B	AE-N-E-B		T-ATR-B	DM-DCC-B
DS-WPM-B	AE-ACK-B			DM-TS-A,B
DS-COVU-A,B	AE-ASUM-B			DM-UTC-A,B
	AE-ESUM-B			DM-ATS-A
				DM-RD-B
	AE-INFO-B			DM-BR-B
				DM-R-B
				DM-OCD-B
				NM-CE-A

- .2 Communication:
 - .1 Each Building Controller shall support direct Ethernet or a communications card. The Building Controller shall be connected to the BACnet network using the ISO 8802-3 (Ethernet) Data Link/ Physical layer protocol, or BACnet IP (Annex J).
 - .2 Each Building Controller with a communications card shall perform BACnet routing if connected to a network of Custom Application and Application Specific Controllers.
 - .3 The controller shall provide a wireless interface allowing a service technician the ability to perform calibration, setup, commissioning and troubleshooting of that controller. Provide the technician complete, wireless access to the entire building network. This wireless access shall be completely independent from any other wireless network on site (including any Wi-Fi used for controller to controller communication).
 - .4 The Building Controller secondary communication network shall support BACnet MS/TP.
- .3 Environment. Controller hardware shall be suitable for the anticipated ambient conditions.
 - .1 Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures, and shall be rated for operation at 0°C to 40°C [32°F to 100°F] and 10 to 90% RH.
 - .2 Controllers used in conditioned space shall be mounted in dust proof enclosures, and shall be rated for operation at 0°C to 50°C [32°F to 120°F].
- .4 Building Controllers shall be fully peer to peer.
- .5 Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field- removable, modular terminal strips — or to a termination card connected by a ribbon cable.
- .6 Memory. The Building Controller shall have as a minimum standard SRAM of 256 KB, standard DRAM of 1MB and standard non-volatile 1 MB of flash memory in lieu of EPROM. Memory shall be user extendible through RAM chip sockets and SIMMs for future memory expansion.
- .7 Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. The Building Controller shall maintain all database information including BIOS and programming information in the event of a power loss for at least 72 hours. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m [3 ft].
- .8 Inputs/Outputs.
 - .1 Inputs. Controller input/output board shall support dry contact, 0-5 VDC and 0-10 VDC-voltage, 4-20 mA- current and thermistor-resistive signal types on an individual basis for connecting any status or sensing device. Analog resolution shall be minimum 10-bit A to D.
 - .2 Outputs. Controller input/output board shall support plug-and-play I/O modules or built in

- HAO modules configured with manual-auto-off override switch, potentiometer and input channel for feedback status or and unrelated analog or digital input. Output supported shall be 0-10 VDC. All HAO's shall be supervised.
- .3 Diagnostics. Controller input board shall have variable intensity LEDs providing input status indication. Outputs shall have variable intensity LEDs indicating the output voltage with Color indication of HAO's status when present.
 - .4 External Power. Controller input/output board shall have one on-board 24 VDC terminal for directly connected active transducers.
 - .5 Building Controller shall have the capability to create, delete and support the following BACnet Objects:
 - .1 ANALOG INPUT, ANALOG OUTPUT AND ANALOG VALUE: These objects shall have the following writeable properties: Object Name; Object Value; Description; COV Increment; Out of Service and Units. In addition, these objects shall support the properties: Device type; Reliability; Min./Max. Values; Update Interval and Resolution.
 - .2 BINARY INPUT, BINARY OUTPUT AND BINARY VALUE: These objects shall have the following writeable properties: Object Name; Object Value; Description; Polarity; Default Value; Min On/Off and Out of Service. In addition, these objects shall support the properties: Device Type; Reliability; Active/Inactive Texts; Update Interval; Resolution; Change-of-State Time; Count Times and Time Reset.
 - .3 CALENDAR: This object shall have the following writeable properties: Object Name; Object Value; Description; and Date List.
 - .4 DEVICE: This object shall have the following writeable properties: Object Name; Description; Location; and UTC Offset.
 - .5 EVENT ENROLMENT: This object shall have the following writeable properties: Object Name; Object Value; Description; Out-of-Service; Event & Notify Types; Parameters; Property Ref; Enable; and Notification Class.
 - .6 FILE: This object shall have the following writeable properties: Object Name; Description; File Type; and File Access.
 - .7 LOOP (PID): This object shall have the following writeable properties: Object Name; Object Value; Description; Polarity; Output and Input Refs.; Input Value & Units; Setpoint Value; PID Values; Bias; Write Priority and COV Increment. In addition, this object shall support the properties: Reliability; Update Interval; Proportional Constant & Units; Derivative Constant & Units.
 - .8 NOTIFICATION CLASS: This object shall have the following writeable properties: Object Name; Object Value; Description; Priority and Ack Required.
 - .9 PROGRAM: This object shall have the following writeable properties: Object Name; Object Value and Description. In addition, this object shall support the property Reliability.
 - .10 SCHEDULE: This object shall have the following writeable properties: Object Name; Object Value and Description; Effective period; Schedule; Exception; Controlled Properties and Write Properties.
 - .11 TREND LOG: This object shall have the following writeable properties: Object Name; Description; Log Enable; Start/stop Times; Log Device Object Property; Log Interval; Stop When Full; Buffer Size; and Record Count.

2.5 ADVANCED APPLICATION CONTROLLERS

- .1 General. Provide an adequate number of BACnet® Advanced Application Controllers to achieve the performance specified in the Part 1 Article on "System Performance." Each of these panels shall meet the following requirements.
 - .1 The Advanced Application Controller shall have sufficient memory to support its operating system, database, and programming requirements.
 - .2 Advanced Application Controllers shall be fully peer to peer.
 - .3 The operating system of the Controller shall manage the input and output communication signals to allow distributed controllers to share real and virtual object information, and allow central monitoring and alarms.
 - .4 All equipment that requires scheduling shall be scheduled in that equipments controller.

- .5 Both firmware and controller database shall be loadable over the network.
- .6 The controller shall have the option to be flash-loaded with the Modbus interface firmware allowing the RS-485 port to be used to communicate with Modbus RTU devices.
- .7 Advanced Application Controllers shall support the following BACnet Interoperability Building Blocks (BIBBs):

Data Sharing	Alarm & Event	Scheduling	Trending	Device & Network Mgmt.
DS-RP-A,B	AE-N-I-B	SCH-I-B	T-VM-I-B	DM-DDB-A,B
DS-RPM-B	AE-N-E-B	SCH-E-B	T-VM-E-B	DM-DOB-A,B
DS-WP-A,B	AE-ACK-B		T-ATR-B	DM-DCC-B
DS-WPM-B	AE-ASUM-B			DM-TS-B
DS-COV-A,B	AE-ESUM-B			DM-RD-B
	AE-INFO-B			DM-BR-B
				DM-R-B
				DM-OCD-B

- .2 Communication Each Advanced Application Controller shall reside on a BACnet network using the MS/TTP or Ethernet Data Link/ Physical layer protocol.
- .3 The controller shall provide a service communication port using BACnet Data Link/ Physical layer protocol for connection to portable operators workstation and allow access to the entire network.
- .4 Environment. Controller hardware shall be suitable for the anticipated ambient conditions.
- .5 Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures, and shall be rated for operation at 0°C to 40°C [32°F to 100°F].
- .6 Controllers used in conditioned space shall be mounted in dust proof enclosures, and shall be rated for operation at 0°C to 50°C [32°F to 120°F].
- .7 Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips — or to a termination card connected by a ribbon cable.
- .8 Memory. The Advanced Application Controller shall utilize non-volatile FLASH memory to maintain its operating system and backup all operator entered changes to setpoints, schedules, and commands.
- .9 Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m [3 ft].

2.6 APPLICATION SPECIFIC CONTROLLERS

- .1 General. Provide BACnet® Application Specific Controllers (ASCs) as required to execute the sequence of operations. ASC's are microprocessor-based DDC controllers which through hardware or firmware design are able to control a wide variety of equipment. They shall be fully user-configurable.
- .2 Each ASC shall be capable of standalone operation and shall continue to provide control functions without being connected to the network.
- .3 Each ASC will contain sufficient I/O capacity to control the target system.
- .4 Both firmware and controller database shall be loadable over the network
- .5 ASC's shall come with an integrated housing to allow for easy mounting and protection of the circuit board. Only wiring terminals shall be exposed.
- .6 Application Specific Controllers shall support the following BACnet Interoperability Building Blocks (BIBBs):

Data Sharing	Alarm & Event	Scheduling	Trending	Device & Network Mgmt.
DS-RP-B				DM-DDB-B
DS-RPM-B				DM-DOB-B
DS-WP-B				DM-DCC-B
DS-COV-B				DM-TS-B
				DM-RD-B

- .7 Communication: The controller shall reside on a BACnet network using the MS/TP or Ethernet Data Link/ Physical layer protocol or BACnet® over ZigBee protocol.
- .8 Each controller shall have a BACnet Data Link/ Physical layer compatible connection for a laptop computer or a portable operator's tool. This connection shall be extended to a space temperature sensor port where shown and allow access to the entire network.
- .9 Environment. The hardware shall be suitable for the anticipated ambient conditions.
- .10 Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures, and shall be rated for operation at -40°C to 65°C [40°F to 150°F] and/or suitably installed in a heated or fan cooled enclosure
- .11 Controllers used in conditioned space shall be mounted in dust proof enclosures, and shall be rated for operation at 0°C to 50°C [32°F to 120°F].
- .12 Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips.
- .13 Memory. The Application Specific Controller shall use non-volatile memory and maintain all BIOS and programming information in the event of a power loss.
- .14 Immunity to power and noise. ASC shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m [3 ft].
- .15 Transformer. Power supply for the ASC must be rated at minimum of 125% of ASC power consumption, and shall be fused or current limiting type.
- .16 Input/Output. ASC shall support as a minimum, directly connected, a combination of analog outputs and binary outputs and universal software selectable analog or digital inputs. ASC inputs shall support 0-5 VDC-voltage, 4-20mA-current, thermistor-resistance and dry contacts. ASC outputs shall support 0-10 VDC-voltage, digital triac rated at 0.5 amps at 24 VAC.

2.7 INPUT/OUTPUT INTERFERENCE

- .1 Hardwired inputs and output points/objects may be wired into the system through Building, Custom Application, or Application Specific Controllers.
- .2 All input and output points shall be protected such that shorting of the point to itself, to another point, or to ground, will cause no damage to the controller. All input and output points shall be protected from voltage up to 24 volts of any duration, such that contact with this voltage will cause no damage to the controller.
- .3 Digital inputs shall allow the monitoring of ON/OFF signals from remote devices. The digital inputs shall provide a current of at least 12 mA to be compatible with commonly available control devices, and shall be protected against the effects of contact bounce and noise. Digital inputs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.
- .4 Analog inputs shall allow the monitoring of 0-5 VDC, 0-10 VDC-voltage, 4-20 mA-current, or thermistors. Analog inputs shall be compatible, and be field configurable to commonly available sensing devices.
- .5 Digital outputs shall provide for ON/OFF operation. Digital outputs on Building and Custom Application Controllers shall have three-position override switches, Hand-Off-Auto with status lights. Outputs shall be selectable for either normally open or normally closed operation.
- .6 Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide a 0 to 10 VDC signal as required to provide proper control of the output device. Analog outputs on Building or Custom Application Controllers shall have status lights and a two-position (AUTO/MANUAL) switch and manually adjustable potentiometer for manual override. Analog

- outputs shall not exhibit a drift of greater than 0.4% of range per year.
- .7 Tri-State Outputs. Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point floating devices shall be limited to zone control and terminal unit control applications (VAV terminal units, duct mounted heating coils, zone dampers, radiation, etc.)
 - .8 Input/Output points/objects shall be universal type, i.e., controller input or output may be designated (in software) as either a binary or analog type point/object with appropriate properties. Application Specific Controllers are exempted from this requirement.
 - .9 Wireless sensors may be used as long as all communication between their associated controller and the rest of the network is BACnet® standard protocol.
 - .10 System Object Capacity. The system size shall be expandable to at least twice the number of input/output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The Operator Workstations installed for this project shall not require any hardware additions or software revisions in order to expand the system.

2.8 POWER SUPPLIES AND LINE FILTERING

- .1 Control transformers shall be UL Listed. Furnish Class 2 current-limiting type, or furnish over-current protection in both primary and secondary circuits for Class 2 service per NEC requirements. Limit connected loads to 80% of rated capacity.
 - .1 DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100 microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection, and shall be able to withstand a 150% current overload for at least 3 seconds without trip-out or failure.
 - .1 Unit shall operate between 0°C and 50°C [32°F and 120°F]. EM/RF shall meet FCC Class B and VDE 0871 for Class B, and MIL-STD 810C for shock and vibration.
 - .2 Line voltage units shall be UL Recognized and CSA Approved.
 - .3 24VAC/120VAC units shall be UL recognized CSA/Ontario Hydro approved - Durell CP15OR or equal.

2.9 AUXILIARY CONTROL DEVICES

- .1 Motorized control dampers, unless otherwise specified elsewhere, shall be furnished by the controls contractor.
- .2 Electric damper/valve actuators.
 - .1 The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator.
 - .2 Where shown, for power-failure/safety applications, an internal mechanical, spring-return mechanism shall be built into the actuator housing.
 - .3 All non-spring-return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring-return actuators with more than 7 N•m [60 in-lb] torque capacity shall have a manual crank for this purpose.
- .3 Binary Temperature Devices
 - .1 Low-limit thermostats. Low-limit thermostats shall be vapor pressure type with an element 6 m [20 ft] minimum length. Element shall respond to the lowest temperature sensed by any 30 cm [1 ft] section. The low-limit thermostat shall be manual reset only and be supplied as DPST.
- .4 Temperature sensors.
 - .1 Temperature sensors shall be thermistors.
 - .2 Space sensors shall be equipped with the following:
 - .3 Programmable buttons for setpoint adjustment and override 3-value, 96-segment LCD display
 - .4 Communication port connected to entire network
 - .1 Provide matched temperature sensors for differential temperature measurement.
- .5 Humidity sensors.
 - .1 Duct and room sensors shall have a sensing range of 20% to 80%. A combination sensor for room temperature and humidity shall be provided where it applies.

- .2 Duct sensors shall be provided with a sampling chamber.
- .3 Outdoor air humidity sensors shall have a sensing range of 20% to 95% RH.
- .4 They shall be suitable for ambient conditions of -40°C to 75°C [-40°F to 170°F]. Humidity sensor's drift shall not exceed 3% of full scale per year.
- .6 Flow switches.
 - .1 Flow-proving switches shall be either paddle or differential pressure type, as shown.
- .7 Relays.
 - .1 Control relays shall be UL Listed plug-in type with dust cover. Contact rating, configuration, and coil voltage suitable for application
 - .2 Time delay relays shall be UL Listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable $\pm 200\%$ (minimum) from setpoint shown on plans. Contact rating, configuration, and coil voltage suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.
- .8 Override timers.
 - .1 Override timers shall be spring-wound line voltage UL Listed, contact rating and configuration as required by application. Provide 0-to-6-hour calibrated dial unless otherwise specified; suitable for flush mounting on control panel face, located on local control panels or where shown.
- .9 Current transmitters
 - .1 AC current transmitters shall be self-powered combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 0 – 5vdc two-wire output. Unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A full scale, internal zero and span adjustment, and $\pm 1\%$ full scale accuracy at 500 ohm maximum burden
 - .2 Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.
- .10 Pressure transducers
 - .1 Transducer shall have linear output signal. Zero and span shall be field adjustable.
 - .2 Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage
 - .3 Water pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Transducer shall be complete with 1 - 5vdc or 4 to 20 mA output, required mounting brackets, and block and bleed valves.
 - .4 Water differential pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over-range limit (differential pressure) and maximum static pressure shall be 300 psi. Transducer shall be complete with 1 – 5vdc or 4 to 20 mA output, required mounting brackets, and five-valve manifold. Accuracy is better than 1% of full-scale reading.
 - .5 Standard of acceptance: Greystone or approved equal.
- .11 Differential pressure type switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application, or as shown.
- .12 Local control panels
 - .1 All indoor control cabinets shall be fully enclosed NEMA 1 construction with [hinged door], key-lock latch, removable sub-panels. A single key shall be common to all field panels and sub-panels.
 - .2 Interconnections between internal and face-mounted devices pre-wired with color coded stranded conductors neatly installed in plastic troughs and/or tie wrapped.
 - .3 Control terminations for field connection shall be individually identified per control drawings
 - .4 Provide 120v receptacle at each local panel location.

2.10 CARBON DIOXIDE (CO₂), TEMPERATURE AND HUMIDITY SENSORS

- .1 The sensors shall be equipped with the following:
 - .1 programmable buttons for setpoint adjustment and override
 - .2 3-value, 96-segement LCD display
 - .3 BACnet communication port connected to entire network
 - .4 Service port

- .2 CO2 Sensors
 - .1 Provide photo-acoustic type CO2 sensors with integral transducers and linear output. The devices shall read CO2 concentrations between 0 and 2000 ppm with full scale accuracy of at least plus or minus 100 ppm.
- .3 Temperature.
 - .1 Sensor shall be 10K thermistor.
- .4 Humidity.
 - .1 Sensor shall have a sensing range of 20% to 80%.
 - .2 Humidity sensor's drift shall not exceed 3% of full scale per year.

3 EXECUTION

- .1 SECTION INCLUDES
 - .1 Examination
 - .2 Protection
 - .3 Coordination
 - .4 General Workmanship
 - .5 Field Quality Control
 - .6 Wiring
 - .7 Actuators
 - .8 Identification of Hardware and Wiring
 - .9 Controllers
 - .10 Programming
 - .11 Control System Checkout and Testing
 - .12 Control System Demonstration and Acceptance
 - .13 Cleaning
 - .14 Training
 - .15 Sequences of Operation

3.1 EXAMINATION

- .1 The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the Architect/Owner for resolution before rough-in work is started
- .2 The Contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the Owner for resolution before rough-in work is started

3.2 PROTECTION

- .1 The Contractor shall protect all work and material from damage by its work or employees, and shall be liable for all damage thus caused
- .2 The Contractor shall be responsible for its work and equipment until finally inspected, tested, and accepted. The Contractor shall protect any material that is not immediately installed. The Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects

3.3 COORDINATION

- .1 Site
 - .1 Where the mechanical work will be installed in close proximity to, or will interfere with work of other trades, the Contractor shall assist in working out space conditions to make a satisfactory adjustment. If the Contractor installs its work before coordinating with other trades, so as to cause any interference with work of other trades, the Contractor shall make the necessary changes in its work to correct the condition without extra charge
 - .2 Coordinate and schedule work with all other work in the same area, or with work, which is dependent upon other work, to facilitate mutual progress.
- .2 Submittals. Refer to the "Submittals" Article in Part 1 of this specification for requirements
- .3 Test and Balance

- .1 The Contractor shall furnish all tools necessary to interface to the control system for test and balance purposes
- .2 The Contractor shall provide training in the use of these tools. This training will be planned for a minimum of 4 hours
- .3 In addition, the Contractor shall provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.
- .4 The tools used during the test and balance process will be returned at the completion of the testing and balancing
- .4 Life Safety
 - .1 Duct smoke detectors required for air handler shutdown are supplied and installed under Division 26. The Division 26 Contractor shall interlock smoke detectors to air handlers for shutdown.
- .5 Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the Contractor as follows:
 - .1 All communication media and equipment shall be provided as specified in Part 2: "Communication" of this specification.
 - .2 Each supplier of controls product is responsible for the configuration, programming, start-up, and testing of that product to meet the sequences of operation described in this section.
 - .3 The Contractor shall coordinate and resolve any incompatibility issues that arise between the control products provided under this Section and those provided under other sections or divisions of this specification.

3.4 GENERAL WORKMANSHIP

- .1 Install equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.
- .2 Provide sufficient slack and flexible connections to allow for vibration of piping and equipment
- .3 Install all equipment in readily accessible locations as defined by Chapter 1, Article 100, Part A of the National Electrical Code (NEC).
- .4 All wiring shall be verified for its integrity to ensure continuity and freedom from shorts and grounds
- .5 All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.5 FIELD QUALITY CONTROL

- .1 All work, materials, and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this specification
- .2 Contractor shall continually monitor the field installation for code compliance and quality of workmanship
- .3 Contractor shall have work inspected by local and/or state/provincial authorities having jurisdiction over the work

3.6 WIRING

- .1 All of the installation requirements, be they temporary or permanent, to comply with the Canadian Electrical Code & all local & Provincial codes.
- .2 The Contractor to supply, install & connect all conduits, boxes & wiring between the different components related to the Control System, including all required line voltage to the equipment. All power to be from appropriately sized dedicated circuits from the nearest electrical panel with space provided by the Contractor. Circuits to be identified inside each control panel & on Shop drawings using the same code. Provide circuit breaker lock-offs & clearly mark breaker(s) with "BAS".
- .3 All NEC Class 1 (line voltage) wiring shall be UL Listed in approved raceway per NEC and Division 26 requirement. All high voltage wiring, 50 volts or more, to be a minimum of No. 12 gauge copper stranded T90, run in conduit.
- .4 All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be sub

- fused when required to meet Class 2 current-limit.) All low voltage wiring, less than 50 volts, to be a minimum of No. 18 gauge copper stranded.
- .5 All MS/TP communications wiring for the local field panels to be 2 conductor, #24 shielded twisted LO CAP pairs, with ground drain wire. All drain wires to be grounded at the panel end. The other end to be protected from grounding with a dielectric material/electrical tape.
 - .6 Wiremold and/or raceway may not be used unless specifically approved by the Consultant. All wiring within mechanical, electrical room & exposed area to be in conduit.
 - .7 Two conductor #18 stranded unshielded , FT6 wiring is acceptable in all rooms except Mechanical & Electrical Rooms, & exposed areas (refer to reflected ceiling plans). Wiring to be neatly installed parallel to building lines tie rapped a minimum of every 4 feet (3.3M). Use 2 conductor #18 FT6 within a all Mechanical Rooms. Use 4 conductor #18 FT6 to all points that are outside of Mechanical Rooms ie: Space Temp.
 - .8 Use thin-walled Electrical Metallic Tubing (EMT) conduit complete with watertight steel connectors at all entrances to enclosures. Steel set screw connectors & couplings will be used in all other parts of the installations. Maximum of 60% conduit fill will be allowed.
 - .9 Flexible conduit to be sued only in areas where vibrations and/or expansion joints are present. The length of any run of flexible conduit not exceed 2 m.
 - .10 All conduit to be supported at least every 1.525 m, and in accordance with the Ontario Electrical Safety Code. Supports to also be located at all junction boxes along the length of the conduit.
 - .11 In damp or weather exposed areas, the conduit and related equipment to be suitable for the application.
 - .12 All conductors to be continuous from device to panel.
 - .13 High and low voltage wire to not be run in the same conduit.
 - .14 Sensor, power and control wiring to be run in separate conduit.
 - .15 Where wiring penetrates fire separation, use firestop sealant to maintain fire wall ratings.
 - .16 New DDC panels to be mounted adjacent to the existing control cabinets, where applicable.
 - .17 DDC controller to be mounted in same room as equipment being controlled. Where this is not practical, provide a communication interface at equipment location for communication to DDC panel.
 - .18 All conduit and wiring is to comply with requirements of Division 26 and General Conditions.

3.7 WIRING IDENTIFICATION

- .1 The two extremities of all wiring to be identified using the same code and cross referenced to the Record Drawings.
- .2 The terminal strips to be numbered. All Drawings to show wire identification codes and terminal numbers. Flex type terminal blocks are acceptable.
- .3 The identification to be done using 3 M or equivalent paper with adhesive backing labels.
- .4 The following colour code to apply to all wiring:
 - .1 Power White
 - .2 Neutral Red, Yellow, Blue
 - .3 Phase leads Black
- .5 All ground wiring to be green.
- .6 All 24 VAC to be brown - load side: yellow - neutral side of transformer.

3.8 PULL BOX AND JUNCTION BOX

- .1 All boxes to comply with the Canadian Electrical Code in reference to size, capacity, etc. All boxes to be fabricated to galvanized metal, unless otherwise warranted.
- .2 A pull box to be located every 30 m. The Contractor is responsible for the location and for obtaining any required approvals from the Consultant.
- .3 In suspended ceilings, all boxes to be installed on the structure.
- .4 All boxes to be clearly marked with "BCS" as part of the energy management system.

3.9 CABINETRY

- .1 All BC controllers will be mounted in a Nema 1 rated enclosure suitably sized to accommodate 10% I/O expansion in future. Provide a key lock type door. The door must come with mounting rails that provide the ability to fasten a mounting panel to the inside of the door if required.

- .2 Panel to be mounted 6'2 from top of panel to finished floor. The door must swing free of all obstacles and open fully. Coordinate location with division 1000 electrical.
- .3 All interface enclosures housing relays, transformers, EPT's, power supplies etc., will be Nema 1 type. The cabinet will have a removable backplate to mount devices on. The door will come with a latch to provide positive closure.
- .4 Relay interface enclosures will be mounted adjacent to the MCC or remote starter they are associated with. Coordinate with division 16 electrical.

3.10 NAMEPLATES

- .1 Identify each I/O device and panel with nameplate identifying the point descriptor using the approved naming convention.
- .2 In addition to identification as described above, show B.C.S. identification label for each piece of equipment with nameplate.
- .3 Index terminal strips and tag wires. Label exposed junction boxes including function and nature of service. Tag all wires within the junction boxes including purpose and nature of service.
- .4 Use self adhesive strip or clip on style plastic markers for wire tags. Secure tags to each individual wire at both ends.

3.11 SAFETY CONTROL DEVICES

- .1 Control all equipment in accordance with the manufacturer's recommendations.
- .2 All controls are to be connected to the control circuits of all equipment without bypassing any safety devices. The Contractor shall ensure that all equipment has the following safeties, as a minimum:
 - .1 Air Handling Equipment: Firestat and Freezestat.
- .3 Firestat shall be high limit thermostat to be normally closed SPDT, manual reset complete with cover and case. Switch to open on temperature rise. Provide on all air handlers and exhaust fans and wire to starter 120 volt control circuit, via 24 vac DPDT relay. Wire second pole to DDC panel for indication of fire status.
- .4 All wiring from firestat to starter to be 24 vac. (See detail drawing)
- .5 Freezestat shall be low limit thermostat to be normally closed DPDT, manual reset. Switch to break on temperature fall. Provide 6.1 m (20') capillary sensing element. Provide on all air handling units and wired to starter 120 volt control circuit via 24 vac DPDT relay. For air handlers wire second pole of 24 vac relay to DDC panel for indication of freeze status.
- .6 All wiring from freezestat to starter to be 24 VAC.

3.12 RELAYS AND CONTACTORS

- .1 All interfacing/control relays and contactors to be sized to match the application. Low voltage coils to be used wherever possible, except where it is financially beneficial to use high voltage coils.
- .2 For all non horsepower rated applications use mechanical 0-10 VDC coil type Feme relays or approved equal.

3.13 INSTALLATION

- .1 CONTROLLERS
 - .1 Provide a separate controller for each AHU or other HVAC system.
 - .2 Building Controllers and Advanced Application Controllers shall be selected to provide a minimum of 10% spare I/O point/object capacity for each point/object type found at each location. If input /objects are not universal, 10% of each type is required. If outputs are not universal, 10% of each type is required. A minimum of one spare is required for each type of point/object used.
 - .3 Future use of spare capacity shall require providing the field device, field wiring, point/object database definition, and custom software. No additional controller boards or point/object modules shall be required to implement use of these spare points

3.14 PROGRAMMING

- .1 Provide sufficient internal memory for the specified sequences of operation and trend logging. There shall be a minimum of 25% of available memory free for future use.
- .2 Point/object Naming: System point/object names shall be modular in design, allowing easy operator interface without the use of a written point/object index. Object names shall be case-sensitive and clearly spell out the function of each object. Submit naming scheme to owner for prior approval. Do not use cryptic abbreviations. Valid examples are:
 - .1 AHU-1 Supply Air Temperature
 - .2 B-1 Boiler Water Supply Temperature
 - .3 FC-1 Room Temperature
- .3 Software Programming
 - .1 Provide programming for the system and adhere to the sequences of operation provided. The Contractor also shall provide all other system programming necessary for the operation of the system, but not specified in this document. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation.
- .4 Operator Interface
 - .1 Standard Graphics. Provide graphics for all mechanical systems and floor plans of the building. This includes each air handler humidifier, electric heaters and all terminal equipment. Point/object information on the graphic displays shall dynamically update. Show on each graphic all input and output points/objects for the system. Also show relevant calculated points/objects such as setpoints
 - .2 Show terminal equipment information on a “graphic” summary table. Provide dynamic information for each point/object
 - .3 The Contractor shall provide all the labor necessary to install, initialize, start up, and troubleshoot all Operator Workstation software and their functions as described in this section. This includes any operating system software, the Operator Workstation database, and any third-party software installation and integration required for successful operation of the operator interface.

3.15 CONTROL SYSTEM CHECKOUT AND TESTING

- .1 Start-up Testing: All testing listed in this article shall be performed by the Contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the Owner’s Representative is notified of the system demonstration.
 - .1 The Contractor shall furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification
 - .2 Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight
 - .3 Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures per manufacturers’ recommendations
 - .4 Verify that all binary output devices (relays, solenoid valves, two position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct
 - .5 Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The Contractor shall check all control valves and automatic dampers to ensure proper action and closure. The Contractor shall make any necessary adjustments to valve stem and damper blade travel
 - .6 Verify that the system operation adheres to the Sequences of Operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops and optimum Start/Stop routines.
 - .7 Alarms and Interlocks
 - .1 Check each alarm separately by including an appropriate signal at a value that will trip the alarm
 - .2 Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
 - .3 Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action

3.16 CONTROL SYSTEM DEMONSTRATION

- .1 Demonstration
 - .1 Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed its own tests
 - .2 The tests described in this section are to be performed in addition to the tests that the Contractor performs as a necessary part of the installation, startup, and debugging process and as specified in the "Control System Checkout and Testing" Article in Part 3 of this specification. The Engineer will be present to observe and review these tests. The Engineer shall be notified at least 10 days in advance of the start of the testing procedures.
 - .3 The demonstration process shall follow that approved in Part 1: "Submittals." The approved checklists and forms shall be completed for all systems as part of the demonstration
 - .4 The Contractor shall provide at least two persons equipped with two way communication, and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point/object and system. Any test equipment required to prove the proper operation shall be provided by and operated by the Contractor.
 - .5 As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.
 - .6 Demonstrate compliance with Part 1: "System Performance
 - .7 Demonstrate compliance with Sequences of Operation through all modes of operation
 - .8 Demonstrate complete operation of Operator Workstation
 - .9 Additionally, the following items shall be demonstrated:
 - .1 DDC Loop Response. The Contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in setpoint, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the setpoint, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.
 - .2 Demand limiting. The Contractor shall supply a trend data output showing the action of the demand-limiting algorithm. The data shall document the action on a minute by minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting setpoint, and the status of shed-able equipment outputs.
 - .3 Optimum Start. The Contractor shall supply a trend data output showing the capability of the algorithm. The hour by hour trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas
 - .4 Interface to the building fire alarm system
 - .5 Operational logs for each system that indicate all setpoints, operating points, valve positions, mode, and equipment status shall be submitted to the Architect/Engineer. These logs shall cover three 48 hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats.
 - .6 Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The Contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.
- .2 Acceptance
 - .1 All tests described in this specification shall have been performed to the satisfaction of both the Engineer and Owner prior to the acceptance of the control system as meeting the requirements of Completion. Any tests that cannot be performed due to circumstances beyond the control of the Contractor may be exempt from the Completion requirements if stated as such in writing by the Engineer. Such tests shall then be performed as part of the warranty.
 - .2 The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in Part 1: "Submittals."

3.17 CLEANING

- .1 The Contractor shall clean up all debris resulting from its activities daily. The Contractor shall remove all cartons, containers, crates, etc., under its control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.
- .2 At the completion of work in any area, the Contractor shall clean all of its work, equipment, etc., keeping it free from dust, dirt, and debris, etc.
- .3 At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.18 TRAINING

- .1 General
 - .1 Provide a minimum of one onsite training class 8 hours in length during the construction period for personnel designated by the owner.
 - .2 Provide two additional training sessions at 2 and 12 months following building's turnover. Each session shall be 4 hrs in length and must be coordinated with the building Owner.
- .2 Train the designated staff of Owner's Representative and Owner to enable Day-to-day Operators to:
 - .1 Proficiently operate the system.
 - .2 Understand control system architecture and configuration.
 - .3 Understand DDC system components.
 - .4 Understand system operation, including DDC system control and optimizing routines (algorithms).
 - .5 Operate the workstation and peripherals.
 - .6 Log on and off the system.
 - .7 Access graphics, point/object reports, and logs.
 - .8 Adjust and change system setpoints, time schedules, and holiday schedules.
 - .9 Recognize malfunctions of the system by observation of the printed copy and graphical visual signals.
 - .10 Understand system drawings, and Operation and Maintenance manual.
 - .11 Understand the job layout and location of control components.
 - .12 Access data from DDC controllers and Application Specific Controllers (ASC's).
 - .13 Operate portable operator's terminals.
- .3 Train the designated staff of Owner's Representative and Owner to enable System Managers/Administrators to:
 - .1 Maintain software and prepare backups
 - .2 Interface with job-specific, third-party operator software
 - .3 Add new users and understand password security procedures
- .4 Provide course outline and materials as per "Submittals" Article in Part 1 of this specification. The instructor(s) shall provide one copy of training material per student.
- .5 The instructor(s) shall be factory-trained instructors experienced in presenting this material.

3.19 SEQUENCES

- .1 Refer to section 25 90 00.

3.20 POINT LIST

- .1 Refer to section 25 90 00.

END OF SECTION

1 GENERAL

1.1 GENERAL

- .1 Read and conform to:
 - .1 The Contract CCDC 2-2008, Stipulated Price Contract as amended.
 - .2 Section 20 01 01 General Requirements.

1.2 SECTION INCLUDES

- .1 Sequence of operation:
 - .1 Boiler Plant
 - .2 Existing HRVs
 - .3 Unit Heaters (Stand Alone)

1.3 SYSTEM DESCRIPTION

- .1 This Section defines the manner and method by which controls function.
- .2 Requirements for each type of control system operation are specified.
- .3 Equipment, devices, and system components required for control systems are specified in other Sections.

1.4 SUBMITTALS FOR REVIEW

- .1 Section 20 01 01: Procedures for submittals.
- .2 Shop Drawings: Indicate mechanical system controlled and control system components.
 - .1 Label with settings, adjustable range of control and limits. Include written description of control sequence.
 - .2 Include flow diagrams for each control system, graphically depicting control logic.
 - .3 Include draft copies of graphic displays indicating mechanical system components, control system components, and controlled function status and value.

1.5 SUBMITTALS AT PROJECT CLOSEOUT

- .1 Section 20 01 01: Submittals for project closeout.
- .2 Project Record Documents: Record actual locations of components and set points of controls, including changes to sequences made after submission of shop drawings.

1.6 QUALITY ASSURANCE

- .1 Design system under direct supervision of a Professional Engineer experienced in design of this Work and licensed in the Province of Ontario.

2 PRODUCTS

Not Applicable

3 EXECUTION

3.1 BOILER PLANT AND HEATING LOOP CONTROLS

- .1 Hot Water Boilers (B-1A & B-1B) and Boiler Circulator Pumps (BP-1A & BP-1B)
 - .1 System enable: The heating system will automatically start when the system enable is "on" based on outdoor air temperature set point (adjustable) or manually by building operator. When the system enable is "off", the heating system will be disabled.
 - .2 Reset the supply water temperature from the outside air temperature sensor, as per following schedule:

Outside Air Temperature (°F) (°C)	System Supply Air Temperature (°F) (°C)
65 (18) Adjustable	100 (38) Adjustable
0 (-18) Adjustable	180 (82) Adjustable

- .3 Water supply temperature to be kept as low as possible and maintain the boiler in condensing mode as much as possible for increased efficiency.
- .4 The hot water supply temperature reset sensor shall provide data to the boiler controllers which in turn will provide an output control signal to cycle/modulate the boiler to maintain the desired hot water temperature in the system. The associated circulator pump will start when the boiler is called to start and remain in operation until the boiler stops. Upon enabling the boiler plant the lead boiler will first run to 25% and as demand increases modulate to 50%. At this time Boiler #2 is enabled and after pre-purge of Boiler #2, both boilers will run to 25% and modulate up together as the demand increases. On decrease in demand, both boilers modulate down to 25%. Lead boiler goes off and lag boiler goes 50%. Lag boiler modulate down to 25% and then goes off. The boiler pump will run for more five (5) minutes after the boiler stop firing as set up by Manufacturer in the boiler's controller.
- .2 Building Heating Water Pump CP-1A & CP-1B (Duty/Standby) Variable Speed Operation: The hot water pump runs anytime a heating demand exists in perimeter radiation heating system. The pumps start, once the heating system is enabled or manually by building operator via BAS. Pumps have a user adjustable delay on start and stop appropriately set to allow for orderly system start-up, shutdown and sequencing. Pumps operate in a duty/standby fashion. Duty pump runs first. On failure of duty pump, standby pump runs and the duty pump turns off. Designated duty pump rotates as follows (user selectable): manually by software switch, pump runtime (adj.) is exceeded, or weekly. Once started, duty pump runs continuously and modulates capacity to maintain differential pressure set point as set during TAB process. The pump shall have a minimum speed at 25% and per manufacturer's recommendations. A modulating, fail-open 2-way control valve (sized for 25% of the flow) shall be normally closed. With the pump at its minimum speed, and the water loop pressure still higher than the set point, bypass modulating valve shall modulate open to maintain loop pressure set point. Pump status shall be monitored via a current sensor.
- .3 East Wing Portable Water Pump (CP-2): The hot water pump runs anytime a heating demand exists in East Wing Portable Perimeter heating system. The pumps start, once the heating system is enabled or manually started by building operator. Pumps have a user adjustable delay on start and stop appropriately set to allow for orderly system start-up, shutdown and sequencing. Once started, duty pump runs continuously and modulates capacity to maintain differential pressure set point as set during TAB process.

3.2 HEATING SYSTEM PUMPS

- .1 Provide start/stop control and status indication from a CSR for all pumps.
- .2 Totalize runtime and alarm when an operator predetermined time limit has been exceeded.
- .3 Provide rotating lead lag automatic control. Start the lag pump on a failure of the lead pump. Initiate an alarm on pump failure.

3.3 CABINET UNIT HEATER AND EXISTING UNIT HEATER (STAND ALONE CONTROLS NOT TIED TO BAS)

- .1 The unit shall maintain a heating set point of 70°F (adj.) by cycling fan on/off via wall mounted line voltage thermostat. The fan shall start when zone temperature drops below heating set point.

3.4 EXISTING HEAT RECOVERY VENTILATORS (HRV-1 & HRV-2)

- .1 Heat recovery fans shall be started and stopped per weekly schedule. Fan status is monitored from a CSR.

3.5 POINTS LIST

- .1 Points list attached.

END OF SECTION

DIGITAL POINTS LIST SCHEDULE																										
POINT DESCRIPTION	BINARY OUTPUTS				ANALOG OUTPUTS				BINARY INPUTS					ANALOG INPUTS			ALARMS/ FEATURES				REMARKS					
	ON/OFF	HI/MED/LO/OFF	RELAY	OTHER	TEMP.	DAMP. POS.	VALVE POS.	VFD SPEED	OTHER	STATUS	FREEZE	FIRE	FLOW SWITCH	ALARM	OTHER	TEMP.	REL. HUM.	PRESSURE	FLOW	CURRENT STATUS		OCC/SETPOINT	SCHEDULE	ALARM/ON/OFF	GREATER THAN	LESS THAN
BASE PRICE																										
Boiler B-1A	X				X																					
Boiler B-2A	X				X																					
Boiler Pump B-1A																										
Boiler Pump B-2A																										
Building Heat. Pump CP-1A	X						X													X						
Building Heat. Pump CP-1B	X						X													X						
Modulating Bypass 2-Way Valve						X																				
System Temp. Sensor															X											
Differential Pressure Sensor																	X									
Outside Air Temperature Sensor															X											
Wallfin (Classroom 113)						X									X											
Wallfin (Classroom 114)						X									X											
Wallfin (Classroom 115)						X									X											
Wallfin (Classroom 116)						X									X											
Differential Pressure Sensor																	X									
HRV-1	X								X																	
HRV-2	X								X																	
East-Wing Portables Heat. Pump CP-2	X						X																			
PAGE No. 1	REF. SECTION 25 90 00				PROJECT No. 15-199				TITLE: POINTS LIST					ST. ELIZABETH CATHOLIC SCHOOL												

1 GENERAL

1.1 SUBMITTAL

- .1 Each bidder for the work of Division 26: Electrical shall submit this Supplementary Bid Form to the consultant within twenty-four (24) hours of tender closing to the Consultant.
- .2 This document, on acceptance by the Consultant, will be included in the Contract Documents and shall govern the work of Division 26: Electrical.

1.2 LABOUR RATES

- .1 Indicate the unit labour rate required for additional work and/or work to be deleted in changes to the Contract under Part 6 of the General Conditions of the Stipulated Price Contract. Rates indicated shall include all allowances for foremen, supervision and office support but shall not include the Division 26 Contractor's overhead and profit margins and shall be based on regular working hours.
- .2 Labour rates for changes must be negotiated with the Owner prior to acceptance and use in pricing.

TRADE	HOURLY RATE
Labourer	\$
Electrician	\$

1.3 PRODUCTS

- .1 Indicate the name of the manufacturer of equipment items included in the Bid Price by submitting a copy of the appended Equipment List marked to indicate choices. Failure to indicate a specific manufacturer will be taken to mean that products of the first manufacturer named in the specifications are included in the Bid Price. This list shall in no way limit the extent of the Contract.
- .2 The Division 26 Bidder may propose the name of an alternative manufacturer for any equipment item in accordance with Section 26 03 00.

END OF SECTION

1 GENERAL

1.1 REFERENCES

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

1.2 APPLICATION

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

1.3 DEFINITIONS

- .1 The following are definitions of words found in electrical work Sections of the Specification and on associated drawings:
 - .1 “concealed” – means work hidden from normal sight in furred spaces, shafts, tunnels, ceiling spaces, underground, walls and partitions
 - .2 “exposed” – means work normally visible, including work in equipment rooms and similar spaces
 - .3 “provide” (and tenses of provide) – means supply and install complete
 - .4 “install” (and tenses of install) – means install and connect complete
 - .5 “supply” – means supply only
 - .6 “finished area” - means any area or part of an area which receives a finish such as paint, or is factory finished
 - .7 “governing authority” and/or “regulatory authority” and/or “Municipal authority” – means all government departments, agencies, standards, rules and regulations that apply to and govern the electrical work and to which the work must adhere
 - .8 “Consultant” – means the Architect or Consulting Engineer who has prepared the Contract Documents on behalf of the Owner
 - .9 “O&M” – means Operating and Maintenance
- .2 Wherever the words “indicated”, “shown”, “noted”, “listed”, or similar words or phrases are used in the specification they are understood, unless otherwise defined, to mean that the product referred to is “indicated”, “shown”, “listed”, or “noted” on the drawings.
- .3 Wherever the words “approved”, “satisfactory”, “as directed”, “submit”, “permitted”, “inspected” or similar words or phrases are used in the specification or on the drawings they are understood, unless otherwise defined, to mean that work or product referred to is “approved by”, “inspected by”, etc., the Consultant.
- .4 In the electrical specification, singular may be read as plural, and vice-versa.
- .5 “Owner”: means Building Owner as defined in the Contract or the Owner’s designated representative.
- .6 “Wet”: means wet areas requiring special materials. Where indicated on drawings and/or specified herein. Includes but not limited to pools, whirlpools, showers, etc.

1.4 METRIC AND IMPERIAL MEASUREMENTS

- .1 Both Metric and Imperial units of measurement are indicated in the electrical Specification.

1.5 EXAMINATION OF SITE AND DOCUMENTS

- .1 When estimating the cost of the work and prior to submitting a bid for the work, carefully examine all of the bid documents and visit the site to determine and review all existing site conditions that will or may affect the work, and include for all such conditions in the bid price.
- .2 Report to the Consultant, prior to bid submittal, any existing site condition that will or may affect performance of the work as per the drawings and specifications. Failure to do so will not be grounds for additional costs.

1.6 DRAWINGS AND SPECIFICATION

- .1 Read the electrical work drawings in conjunction with all other structural, architectural, sprinkler, mechanical, etc., drawings and, where applicable, the Code Consultant's report.
- .2 The electrical drawings are performance drawings, diagrammatic, and show approximate locations of equipment and connecting services. Any information regarding accurate measurement of the building are to be taken at the site. Do not scale the drawings, and do not use the drawings for prefabrication work.
- .3 The drawings are intended to convey the scope of work and do not show architectural and structural details. Provide, at no extra cost to this Contract, all offsets, fittings, transformations, and similar products required as a result of obstructions and other architectural and structural details but not shown on the drawings.
- .4 Adjust the location of materials and/or equipment as directed without adjustment to contract price, provided that the changes are requested before installation and do not affect material quantity. Note that outlets and/or equipment may be relocated up to 3 meters (10 feet) in any direction without a change to the contract.
- .5 Sections of the electrical specification are not intended to delegate functions nor to delegate work and supply of materials to any specific trade, but rather to generally designate a basic unit of work, and the Sections are to be read as a whole.
- .6 The electrical specification does not generally indicate the specific number of items or extent of material required. The specification is intended to provide product data and installation requirements. It is necessary to refer to drawing schedules, layouts, schematic diagrams, riser diagrams, and details to determine correct quantities.
- .7 The electrical drawings and specification are intended to be cooperative. Perform all work that is shown, specified, or reasonably implied on the drawings but not mentioned in the specification, or vice-versa, as though fully covered by both.
- .8 In the case of discrepancies or conflicts between the drawings and specification, the documents will govern in the following order:
 - .1 The specification
 - .2 Drawings of larger scale
 - .3 Drawings of smaller scale
 - .4 Drawings of later date when the scale of the drawings is the same
- .9 When the scale and date of the drawings are the same, or when the discrepancy exists within the specification, the most costly arrangement will take precedence.
- .10 In the case of discrepancies between the drawings and specifications, the documents will govern in the order specified in the General Conditions, however, when the scale and date of the drawings are the same, or where the discrepancy exists within the specification, the most costly arrangement will take precedence.
- .11 Provide all products and methods mentioned or shown in the Contract documents complete with incidentals necessary for a complete operating installation. Provide all tools, equipment and services required to do the work.
- .12 The electrical drawings and specifications have been prepared solely for the use by the party with whom the Consultant has entered into a contract and there are no representations of any kind made by the Consultant to any other party.

1.7 PLANNING AND LAYOUT OF THE WORK, AND ASSOCIATED DRAWINGS

- .1 Properly plan, coordinate, and establish the locations and routing of services with all subcontractors affected prior to installation such that the services will clear each other as well as any obstructions. Unless otherwise specified, the order of right-of-way for services is to be as follows:
 - .1 piping requiring uniform pitch
 - .2 piping 100 mm (4") dia. and larger
 - .3 large air ducts (main runs)
 - .4 electrical cable tray and bus duct
 - .5 conduit 100 mm (4") dia. and larger
 - .6 piping less than 100 mm (4") dia.
 - .7 smaller branch ductwork
 - .8 conduit less than 100 mm (4") dia.
- .2 Unless otherwise shown or specified, conceal all work in finished areas, and conceal work in partially

finished or unfinished areas to the extent made possible by the area construction. Install conduit, cable tray, and similar services as high as possible to conserve headroom and/or ceiling space. Notify the Consultant where headroom or ceiling space appears to be inadequate prior to installation of the work.

- .3 Revise or alter the arrangement of work that has been installed without proper coordination, study and review, even if it was completed in accordance with the Contract Documents, in order to conceal the work behind finishes, or to allow the installation of other work, at no additional cost. In addition, pay for the cost of alterations in other work required by the alterations to the electrical work.
- .4 All outlet boxes, junction boxes, pullboxes, equipment and similar products, particularly such products located above suspended ceilings, must be located for easy access for servicing and/or removal. Products which do not meet this location requirement are to be relocated to an accessible location at no additional cost.
- .5 Layout Drawings: Do not use the Contract Drawing measurements for prefabrication and layout of work. Locations and routing are to generally be in accordance with the Contract Drawings, however, layout drawings are to be prepared for all such work. Use established bench marks for both horizontal and vertical measurements. Coordinate with and make allowances for the work of other trades, accurately layout the work, and be entirely responsible for all work installed in accordance with layout drawings.
- .6 Interference Drawings: Prepare dimensioned working interference drawings, supplementary to the Contract Drawings for all areas where multiple services and/or equipment occur, or where the work due to architectural and structural considerations requires special study and treatment. Review interference drawings with the Consultant before the work is installed. Where this Contractor's work has been installed in such areas without preparation of interference drawings and conflicts occur, revise this work to suit at no additional cost.

1.8 COORDINATION OF THE WORK

- .1 Review all the Contract Documents and coordinate the work with the work of all subcontractors. Coordination requirements are to include, but not be limited to, the following:
 - .1 written notification of all concrete work such as housekeeping pads, bases, etc., required for electrical work, and including required dimensions, operating weight of equipment, location, etc.
 - .2 depth and routing of excavation required for electrical work, and requirements for bedding and backfill

1.9 PHASING OF THE WORK

- .1 Phasing of the work is required to maintain the existing building in operation, Coordinate with Mech Trades and owner. Include all costs for phasing the work including all required "off hours" premium time labour costs.

1.10 QUALITY ASSURANCE

- .1 All electrical work is to be done by journeyman tradesmen who perform only the work that their certificates permit, or by apprentice tradesmen under direct on site supervision of an experienced journeyman tradesman. The use of apprentice tradesmen is to be limited and the journeyman/apprentice ratio is subject to the Consultant's approval.
- .2 All journeyman tradesmen are to have valid trade certificates available at the site for review by the Consultant at any time.
- .3 An experienced and qualified superintendent is to be on-site at all times when electrical work is being performed.

1.11 EQUIPMENT AND MATERIALS

- .1 Unless otherwise specified, all equipment and materials are to be new.
- .2 All equipment is to be installed in accordance with the manufacturer's published instructions, unless specified otherwise in the specification or on the drawings.
- .3 Where price, quality, and local service facilities are equivalent, preference will be given to products

produced in the locality of the work or by producers located in the locality of the work. The decision as to the equality of products rests solely with the Owner.

1.12 EQUIPMENT AND MATERIAL MANUFACTURERS

- .1 Equipment and materials selected, scheduled or specified on the drawings or in the specification have been selected to establish a performance and quality standard, and, in some cases, a dimensional standard for the Project. In most cases acceptable manufacturers are listed for any product specified by manufacturer's name and model number. Bid Prices shall include only products specified or approved equivalents. Contractors may propose unsolicited alternatives to the products specified. Alternative proposals shall be submitted in sealed envelope at time of General Contract Bid submission and shall include full description and technical data, and a statement of the related increase or decrease in Bid Price should alternatives be accepted. All additional costs associated with unsolicited alternative proposals such as larger motor starters, larger power feeders, space revisions to associated equipment, controls, etc. shall be included in the alternative proposals. Prior approval by consultant is not required for unsolicited alternative proposals.
- .2 Where Contractor uses equipment other than that first named, on which the design is based, he shall be responsible for all details of installation including equipment size, arrangement, fit, and maintenance of all required clearances. Contractor shall prepare and submit revised layouts to indicate arrangement of all affected piping, ductwork, conduit, lighting, equipment, etc. Failure by Contractor to provide such drawings will be considered indication that original arrangements and space allocations are adequate. All additional costs associated with equivalent equipment such as larger motor starters, larger power feeders, space revisions to associated equipment, controls, etc. shall be included in Bid Price.
- .3 If products supplied by a manufacturer named as acceptable are used in lieu of the products specified by first named manufacturer's name and model number, ensure that the product is equivalent in performance and operating characteristics (including energy efficiency if applicable) to the specified product. Pay for any additional costs and changes to associated or adjacent work resulting from the use of products supplied by a manufacturer other than the first named specified manufacturer. In addition, in equipment spaces where products named as acceptable are used in lieu of the specified products and the dimensions of such products differ from the specified products, prepare and submit for review, accurately dimensioned layouts of the rooms affected to prove that all the equipment in the room will fit properly.
- .4 Do not supply products of different types that have been "bulked" by a supplier who has quoted a lump sum price for the "bulked" products.
- .5 The Consultant will review and evaluate unsolicited alternatives and substitutions proposed by the Contractor. Such review and evaluation work will be undertaken by the Consultant on an additional fee basis. The Contractor shall reimburse the Owner for all costs associated with such reviews and evaluations. The Contractor shall also reimburse the Owner for any and all costs incurred in updating Contract Documents to reflect such changes.

1.13 ELECTRICAL SUPPLEMENTARY BID FORM

- .1 Within 24 hours after award of a Contract, complete and submit to the Consultant for review, a completed Electrical Supplementary Bid Form to indicate the name of the manufacturer you propose to use for each item of equipment listed. If an acceptable manufacturer other than a first named specified manufacturer is listed for any product, ensure that the model number or series designation of the product is indicated so that the Consultant can determine its equivalency. If an alternate manufacturer is listed in the Electrical Supplementary Bid Form for any product, ensure that the model number or series designation of the product is indicated so that the Consultant can determine its equivalency.
- .2 Any product manufacturers listed by the Contractor on the Electrical Supplementary Bid Form that are not named as acceptable, or any acceptable manufacturer's product which, in the opinion of the Consultant, does not meet equivalency criteria specified will be rejected and must be replaced with a suitable product.
- .3 If the Electrical Supplementary Bid Form is not submitted within the time indicated above after award of a Contract, the products first named specified and scheduled by manufacturer's name and model

number and on which the Project is based are to be supplied. No substitutions whatsoever will be accepted unless previously approved in writing by the Consultant.

- .4 The Electrical Supplementary Bid Form is included as Section 26 00 01.

1.14 SUBSTITUTED OR ALTERNATIVE PRODUCTS

- .1 Products supplied by a manufacturer/supplier other than a manufacturer listed as acceptable may be considered for acceptance by the Consultant if requested in writing a minimum of ten (10) full working days prior to the bid closing date. Requests may be made by letter, by fax, or by email. Telephone requests will not be considered.
- .2 Each request for acceptance of a proposed substitution or alternative product must be accompanied by detailed catalogue and engineering data, fabrication information, and performance characteristics to permit the Consultant to make an informed decision.
- .3 Pay for any additional costs and changes to associated or adjacent work resulting from the use of products supplied by a substituted or alternative or other than first named manufacturer. In addition, in equipment spaces where substituted or alternative or other than first named products are used in lieu of the specified first named products and the dimensions of such products differ from the specified first named products, prepare and submit for review, accurately dimensioned layouts of the rooms affected to prove that all the equipment in the room will fit properly.
- .4 The Consultant's decision regarding any proposed substitution or alternative product is final.

1.15 CODES, REGULATIONS, AND STANDARDS

- .1 All Codes, Regulations, and Standards referred to in this Section are the latest edition of the Codes, Regulations, and Standards in effect at the time of tendering this Project.
- .2 All work is to be in accordance with requirements with Codes, Regulations, and Standards applied by governing authorities.
- .3 Where any governing Code, Regulation, or Standard requires preparation and submission of special details or drawings for review they are to be prepared and submitted. Pay all associated costs associated with these submittals.
- .4 All electrical items associated with mechanical equipment are to be certified and bear the stamp or seal of a recognized testing agency such as CSA, UL, ULC, ETL, etc., or bear a stamp to indicate special electrical utility approval.
- .5 Requirements of the Contract Documents are to take precedence when they are more stringent than codes, ordinances, standards, and statutes.

1.16 PERMITS, FEES, AND CERTIFICATES

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

1.17 WORKPLACE SAFETY

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

1.18 SHOP DRAWINGS AND PRODUCT DATA SHEETS

- .1 Prior to supplying any products to the site, submit for review, shop drawings and/or product data sheets indicating in detail the design, construction, and performance of products as requested in

- Sections of this Specification. The number of copies of shop drawings and/or product data sheets will be as later directed.
- .2 Wherever possible, shop drawings and/or product data sheets are to be 216 mm x 280 mm (8½" x 11"), 216 mm x 356 mm (8½" x 14"), or 356 mm x 432 mm (11" x 17") single side white bond paper with sufficient clear space for review stamps and comments.
 - .3 Each shop drawing or product data sheet is to be properly identified with the project name and the product drawing or specification reference, i.e. "Panelboard A", and all shop drawing or product data sheet dimensions are to be either SI or Imperial to match dimensions on the drawings.
 - .4 Where any item of equipment is required by Code or Standard or By-Law to meet a specific energy efficiency level, or any other specific requirement, ensure that this requirement is clearly indicated on the submission.
 - .5 Carefully review each shop drawing and product data sheet prior to submittal to ensure that the proposed product is correct, as per the Electrical Supplementary Bid Form as applicable, and meets with all requirements of the Project. Endorse each copy of each shop drawing or product data sheet "CERTIFIED TO BE IN ACCORDANCE WITH ALL REQUIREMENTS" and include the company name, the submittal date, and the signature of an officer of the company to indicate your review and approval as above.
 - .6 The Consultant will review shop drawings and product data sheets and will indicate the review status by stamping the shop drawings and product data sheets as follows:
 - .1 "Reviewed" or "Reviewed As Modified" to indicate that his review is final and no re-submittal is required
 - .2 "Revise and Resubmit" to indicate that the submission is rejected and is to be revised in accordance with comments marked on the shop drawings and product data sheets by the Consultant and re-submitted
 - .7 The Consultant will retain one or two copies of each shop drawing or product data sheet submission.
 - .8 The following is to be read in conjunction with the wording on the Consultant's review stamp applied to each and every electrical work shop drawing or product data sheet submitted:
 - .1 "This review is for the sole purpose of ascertaining conformance with the general design concept. This review does not approve the detail design inherent in the shop drawings, responsibility for which remains with the Contractor, and such review does not relieve the Contractor of the responsibility for errors or omissions in the shop drawings or of his responsibility for meeting all requirements of the Contract Documents. Be responsible for dimensions to be confirmed and correlated at the job site, for information that pertains solely to fabrication processes or to techniques of construction and installation, and for coordination of the work of all sub-trades."
 - .9 Submit preliminary short circuit study with distribution equipment shop drawings in sufficient detail to include and provide ratings for all components and wiring and be in conformance with Section 26 03 15.
 - .10 Provide final commissioning report with record drawings.
 - .11 Provide draft copy of all manuals 100 days prior to expected date of completion of work for review by Owner.
 - .12 Prepare copies of all schematics for training purposes and submit to Owner for review 30 days prior to demonstration and training purposes.

1.19 CHANGES OR REVISIONS TO THE WORK

- .1 Whenever the Consultant proposes in writing to make a change or revision to the design, arrangement, quantity or type of any work from that required by the Contract Documents, prepare and submit to the Consultant for approval, a quotation being your proposed cost for executing the change or revision.
- .2 The Contractor's quotation is to be a detailed and itemized estimate of all product, labour, and equipment costs associated with the change or revision, plus overhead and profit percentages and all applicable taxes and duties.
- .3 The following requirements apply to all quotations submitted:
 - .1 when the change or revision involves deleted work as well as additional work, the cost of the deleted work (less overhead and profit percentages but including taxes and duties) is to be subtracted from the cost of the additional work before overhead and profit percentages are

- applied to the additional work
- .2 material costs are not to exceed those published in local estimating price guides
- .3 costs for journeyman and apprentice labour must not exceed prevailing rates at the time of execution of the Contract and listed in the Supplementary Bid Form and must reflect the actual personnel performing the work
- .4 the cost for the site superintendent must not exceed 10% of the total hours of labour estimated for the change or revision, and the change or revision must be such that the site superintendent's involvement is necessary
- .5 costs for rental tools and/or equipment are not to exceed local rental costs
- .6 Refer to the General Conditions of the Contract, the Supplementary Conditions and all Sections of Division 01 for allowable percentages for overhead and profit.
- .7 the overhead percentage will be deemed to cover all quotation costs other than actual site labour and materials, and rentals
- .8 all quotations, including those for deleted work, must include a figure for any required change to the Contract time
- .4 Quotations submitted that are not in accordance with requirements specified above will be rejected and returned for re-submittal. Failure to submit a proper quotation to enable the Consultant to expeditiously process the quotation and issue a Change Order will not be grounds for any additional change to Contract time.
- .5 If, in the Contractor's opinion, changes or revisions to the work should be made, inform the Consultant in writing and, if the Consultant agrees a Notice of Change will be issued.
- .6 Do not execute any change or revision until written authorization for the change or revision has been obtained.

1.20 NOTICE FOR REQUIRED FIELD REVIEWS

- .1 Whenever there is a requirement for the Consultant to perform a field review prior to concealment of any work, to inspect/re-inspect the work for deficiencies prior to Substantial Performance, for commissioning demonstrations, and any other such field review, give the Consultant adequate notice in writing.
- .2 If the Consultant is unable to attend a field review when requested, arrange an alternative date and time.
- .3 Do not conceal work until the Consultant advises that it may be concealed.
- .4 When the Consultant is requested to perform a field review and the work is not ready to be reviewed, reimburse the Consultant for all time and travel expenses.

1.21 SCAFFOLDING, RIGGING, AND HOISTING

- .1 Unless otherwise specified or directed, supply, erect and operate all scaffolding, rigging, hoisting equipment and associated hardware required for the work of this Division. Immediately remove from the site all scaffolding, rigging, and hoisting equipment when no longer required.
- .2 Do not place major erection loads on any portion of the structure without approval from the Consultant.

1.22 TRIAL USAGE

- .1 When directed by the Consultant, promptly arrange, pay for, and perform site tests on any piece of equipment or any system for such reasonable lengths of time and at such times as may be required to prove compliance with the Specification and governing Codes and Regulations, prior to Substantial Performance of the work.
- .2 When, in the opinion of the Consultant, tests are required to be performed by a certified testing laboratory, arrange and pay for such tests.
- .3 All tests are not to be construed as evidence of acceptance of the work, and it is agreed and understood that no claim for damage will be made for injury or breakage to any part or parts of the equipment or system due to the test where such injuries or breakage were caused by faulty parts and/or workmanship of any kind.
- .4 When, in the Consultant's opinion, tests indicate that equipment, products, etc., are defective or deficient, immediately remove such equipment and/or products from the site and replace them with

acceptable equipment and/or products, at no additional cost.

1.23 PROJECT CLOSEOUT SUBMITTALS

- .1 Prior to application for Substantial Performance of the Project, submit all required documentation specified, including the following:
 - .1 Operating and Maintenance Manuals
 - .2 as-built record drawings and associated data
 - .3 extended warranties for equipment as specified
 - .4 identified keys for mechanical equipment and/or panels for which keys are required
 - .5 other data or products specified

1.24 OPERATING AND MAINTENANCE MANUALS

- .1 Submit, prior to application for Substantial Performance, 3 hard copies of operating and maintenance manuals consolidated in black hardcover 3 "D" ring binders, each binder sized to include approximately 25% spare space for future data, and identified permanently on binder spine with the Project name, "ELECTRICAL OPERATING AND MAINTENANCE MANUAL" wording, and the date. Manuals are to include the following:
 - .1 an Introduction sheet listing the Consultant's, Contractor's, and Subcontractor names, street addresses, telephone and fax numbers, and e-mail addresses. Include special telephone numbers for service departments on normal and emergency call basis.
 - .2 a Table of Contents sheet, and corresponding index tab sheets. Use plastic tab indices for all sections of the manual with separate sections for each different type of equipment item.
 - .3 a copy of each "Reviewed" or "Reviewed As Modified" shop drawing or product data sheet, with manufacturer's/supplier's name, telephone and fax numbers, email address, and the email address for local source of parts and service
 - .4 operating data, which is to include:
 - .1 Description of each system and its controls
 - .2 System schematic wiring diagrams; mark correct operating settings for each device on these diagrams
 - .3 Operation instruction for each system and each component
 - .4 Description of actions to be taken in event of equipment failure; step by step procedure to follow in putting each piece of equipment into service.
 - .5 Drawings of each control panel completely identifying all components on the panels and their functions.
 - .6 Include Owner's equipment numbers on all equipment submitted.
 - .7 Diagram of the electrical system indicating the wiring of all related electrical components such as fuses, interlocks, electrical switches and relays
 - .5 Maintenance data, which is to include:
 - .1 manufacturer's maintenance instructions, servicing maintenance, operation and trouble-shooting instructions for each item of equipment; list parts numbers and lists, name of supplier and maintenance and lubrication instructions
 - .2 schedules of tasks, frequency, tools required, and task time
 - .3 complete parts lists with numbers
 - .4 balancing and testing reports
 - .5 where fuses with maximum let-through current are indicated, provide manufacturer's fuse curve data in Operating and Maintenance Manuals showing fuse coordination with system interrupting capacity at that location in the system
 - .6 performance data, which is to include:
 - .1 equipment and system start-up data sheets
 - .2 equipment performance verification test results, and commissioning report
- .2 Submit, prior to application for Substantial Performance, four digital versions of the hard copy manual using the latest version of Adobe Acrobat Portable Document Format and enhanced with bookmarks, internet links, and internal document links. The digital copies are to be copied to CDR with custom labels which indicate the project name, date, the Consultant's name, and "Operating & Maintenance Manual for Electrical Systems". Provide one additional digital version copy for Consultant's use.

1.25 RECORD "AS-BUILT" DRAWINGS

- .1 Obtain PDF's from the Consultant for the production of record "AS-BUILT" drawings and pay for costs of reproduction and transmission costs. As work progresses at the site, clearly mark in red in a neat and legible manner on a set of white prints of the drawings, all significant changes and deviations from the routing of services and locations of equipment shown on the Contract Drawings and resulting from the issue of Addenda, Site Instructions, Change Orders, and job conditions. Use notes marked in red as required. Maintain the white print red line as-built set at the site for the exclusive use of recording as-built conditions, keep the set up-to-date at all times, and ensure that the set is always available for periodic review. The as-built set is also to include the following:
 - .1 the location of all work such as junction boxes and pullboxes concealed in inaccessible locations
 - .2 the locations of control devices with identification for each
 - .3 for underground work, record dimensions, invert elevations, all offsets, fittings, and locate dimensions from benchmarks that will be preserved after construction is complete
 - .4 the location of all concealed services terminated for future extension
- .2 When work on site is complete, transfer all the as-built red line information from the site as-built drawings to a recordable and identified CAD disc with CAD work of equal quality to the Contract Drawings. Obtain a CAD disc as described below.
- .3 The electrical drawings have been prepared on a computer aided drafting system. Obtain and pay for an electronic version of the drawings from the Consultant for use in producing final as-built drawings.
- .4 Prior to inspection for Total Performance of the work, submit for review, the red line site as-built white prints, a CAD disc of the as-built drawings, and a bound set of white prints (of equal quality to the Contract Drawings) made from the disc. The Consultant will review the drawings and, if necessary, return the disc and the marked-up white prints for corrections or further revisions, in which case complete the corrective and/or revision work and resubmit the disc and white prints until they are determined to be acceptable.

1.26 PROGRESS PAYMENT BREAKDOWN

- .1 Within 15 working days of written notification of award of contract submit a breakdown of the cost of the electrical work to assist the Consultant in reviewing and approving monthly progress payment claims.
- .2 The payment breakdown is subject to the Consultant's approval and progress payments will not be processed until an approved breakdown is in place. The breakdown is to include one time claim items such as mobilization and demobilization, insurance, bonds (if applicable), shop drawings and product data sheets, commissioning including testing, and project closeout submittals.

1.27 REQUIREMENTS FOR CONTRACTOR RETAINED ENGINEERS

- .1 All professional engineers retained by this Contractor to perform consulting services with regard to his work are to be members in good standing with the local Association of Professional Engineers, and are to carry and pay for errors and omissions professional liability insurance in compliance with requirements of the governing authorities in the locale of the work.
- .2 This Contractor's retained engineer's professional liability insurance is to protect his Consultants and Sub-Consultants, and their respective servants, agents, and employees against any loss of damage resulting from the professional services rendered by his Consultants, Sub-Consultants, and their respective servants, agents, and employees in regards to the work of this Contract.
- .3 Liability insurance requirements are as follows:
 - .1 coverage is to be a minimum of \$1,000,000.00 inclusive of any one occurrence, or as indicated in the Owners documents.
 - .2 the insurance policy is not to be cancelled or changed in any way without the insurer giving the Owner a minimum of thirty days written notice
 - .3 liability insurance is to be obtained from an insurer registered and licensed to underwrite such insurance in the location of the work
 - .4 evidence of the required liability insurance in such forms as may be required is to be issued to the Owner, the Owner's Consultant, and Municipal Authorities as required prior to commencement of your Consultant's services

1.28 GENERAL RE: INSTALLATION OF EQUIPMENT

- .1 Unless otherwise specified all equipment is to be installed in accordance with the equipment manufacturer's recommendations and instructions, and requirements of governing Codes, Standards, and Regulations.
- .2 Ensure that proper access and code required service clearances are maintained around equipment, and, where applicable, access space for future equipment removal or replacement is not impeded.

1.29 EXTENDED WARRANTIES

- .1 All extended warranties specified in electrical work Sections of the Specification are to be full parts and labour warranties, at the site, and in accordance with requirements of the Contract warranty, but direct from the equipment manufacturer/supplier to the Owner. Submit signed and dated copies of extended warranties which clearly state requirements specified above.

1.30 CONTRACTOR'S MATERIAL AND TEST CERTIFICATES

- .1 Submit Contractor's Material and Test Certificates for each system installed. Certificates shall include:
 - .1 description of the system (designation and type),
 - .2 description of the tests conducted and results observed, including re-testing where necessary,
 - .3 description of any corrective measures undertaken,
 - .4 description of materials used,
 - .5 list of witnesses for each test conducted,
 - .6 date system left ready for service,
 - .7 signature of installing Contractor.
- .2 Where certificates are prescribed by regulations, codes or standards, they shall conform to the requirements of those documents (eg. NFPA Standards, Electrical Safety Authority (ESA) Standards). A copy of each certificate shall be included in the Operating and Maintenance manuals.

1.31 PRODUCT DELIVERY, HANDLING AND STORAGE

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

1.32 WARRANTY

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

1.33 PROTECTION

- .1 Protect finished and unfinished work by tarpaulins, or other covering, from damage due to execution of work under this Division.
- .2 Repair to satisfaction of Consultant, damage to building resulting from failure to provide such protection.

1.34 EQUIPMENT AND SYSTEM MANUFACTURER'S CERTIFICATION

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

equipment/system manufacturer's instructions.

1.35 EQUIPMENT AND SYSTEM START-UP

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

1.36 EQUIPMENT AND SYSTEM COMMISSIONING

- .1 After successful start-up and prior to Substantial Performance, commission the electrical work. Commissioning work is the process of the Contractor demonstrating to the Owner and Consultant, for the purpose of final acceptance by means of successful and documented functional performance testing, that all systems and/or subsystems are capable of being operating and maintained to perform in accordance with requirements of the Contract Document, as further described below.
 - .1 Operational Performance Testing: The Contractor is to test, adjust and operate components, equipment, systems and /or subsystems after start-up but before functional performance testing, to confirm that all components, equipment, systems and/or subsystems operate in accordance with requirements of the Contract Documents, including all modes and sequences of control and monitoring, interlocks ,and responses to emergency conditions. The Contractor is to complete commissioning data sheets to document successful operational performance testing.
 - .2 Functional Performance Testing: The Contractor is to repeat successful operational performance testing with complete commissioning data sheet documentation by the Contractor in the presence of the Consultant and Owner to validate and verify that the equipment, systems and subsystems are complete in all respects, function correctly, and are ready for acceptance.
 - .3 Submittals: The Contractor is to submit final commissioning data sheets, and other required submittals.

1.37 EQUIPMENT AND SYSTEM O & M DEMONSTRATION AND TRAINING

- .1 Refer to equipment and system operational and maintenance training requirements specified in Division 01.
- .2 Train the Owner's designated personnel in all aspects of operation and maintenance of equipment and systems as specified in electrical work Sections of the Specification. All demonstrations and training is to be performed by qualified technicians employed by the equipment/system manufacturer/supplier.
- .3 For each item of equipment and for each system for which training is specified, prepare training modules as specified below. Operating and Maintenance Manuals are to be used during the training sessions, and training modules are to include:
 - .1 Operational Requirements and Criteria: Requirements and criteria are to include but not be limited to equipment function, stopping and starting, safeties, operating standards, operating characteristics, and limitations.
 - .2 Troubleshooting: Troubleshooting is to include but not be limited to diagnostic instructions, test and inspection procedures.
 - .3 Documentation: Documentation is to include but not be limited to equipment/system warranties, and manufacturer's supplier's parts and service facilities, telephone numbers, email addresses, and the like.
 - .4 Maintenance: Maintenance requirements are to include but not be limited to inspection instructions, types of cleaning agents to be used as well as cleaning methods, preventative maintenance procedures, and use of any special tools.
 - .5 Repairs: Repair requirements are to include but not be limited to diagnostic instructions, disassembly, component removal and repair instructions, instructions for identifying parts and

- components, and review of any spare parts inventory.
- .4 Assemble the training modules into a training manual and submit a copy to the Consultant for review prior to scheduling training. Ensure that each participant in each training session has all required training material.
 - .5 Schedule demonstrations and training at mutually agreed to times with a minimum of seven working days notice.
 - .6 Training Session DVD: For equipment/system demonstration and training sessions as specified in electrical work Sections, submit an identified DVD of the session prepared by a professional photographer with construction project technical training session experience.
 - .7 Demonstration and Training Confirmation: Obtain from the Consultant, a list of personnel to receive demonstration and training, and have each participant sign the list to confirm that he/she understood the demonstration and training session.

1.38 SPECIAL TOOLS AND SPARE PARTS

- .1 Identify spare parts containers as to contents and replacement parts number.
- .2 Provide one set of special tools required to service equipment as recommended by manufacturers.
- .3 Prepare a complete itemized list of special tools and spare parts and submit to consultant for review. List will be used as a checklist and should include provision for sign off by Owner on receipt.

2 PRODUCTS
Not Applicable

3 EXECUTION
Not Applicable

END OF SECTION

1 GENERAL

1.1 APPLICATION

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

1.2 SUBMITTALS

- .1 Submit the following for review:
 - .1 Product data sheets: submit for:
 - .1 Firestopping and smoke seal products
 - .2 Waterproofing seal assemblies
 - .3 Electrical work identification products
 - .2 Sleeve and formed opening location drawings: upon notification of award of Contract begin to prepare accurately dimensioned drawings to locate all required electrical work sleeves, formed openings, and recesses in poured concrete work, and submit the drawings prior to concrete work commencing. Provide a copy of approved sleeving drawings to the reinforcement detailer well in advance of planned pours.
 - .3 Access door locations: submit white prints of architectural reflected ceiling plan drawings and elevation drawings to indicate proposed access door locations in walls and ceilings in finished areas
 - .4 Samples: submit a sample of each proposed type of access door, and samples of materials and any other items as specified in electrical work Sections of the Specification
 - .5 List of equipment nameplates: submit a list of equipment identification nameplates indicating proposed wording and sizes
 - .6 Waste management and reduction plan: submit a waste management and reduction plan prior to commencing work and as per requirements specified in this Section
 - .7 Additional submittals: submit any other submittals specified in this Section or other electrical work Sections of the Specification

2 PRODUCTS

2.1 SLEEVES

- .1 Galvanized Sheet Steel: Minimum #16 gauge galvanized steel with an integral flange at one end to secure the sleeve to formwork construction.
- .2 Polyethylene: Factory fabricated, flanged, high density polyethylene sleeves with reinforced nail bosses.
- .3 Galvanized Steel Pipe – Waterproof: Schedule 40 mild galvanized steel pipe with a welded-on square steel anchor and water stop plate at the sleeve midpoint.
- .4 Galvanized Steel or Cast Iron Pipe: Schedule 40 mild galvanized steel pipe, or Class 4000 cast iron pipe, cut to length.

2.2 FIRESTOPPING AND SMOKE SEAL MATERIALS

- .1 Asbestos-free elastomeric materials tested, listed and labelled by ULC in accordance with CAN4-S115 and CAN/ULC-S01 for installation in ULC designated firestopping and smoke seal systems to provide a positive fire, water and smoke seal, and a fire-resistance rating (flame, hose stream and temperature) not less than the fire resistance rating of surrounding construction.
- .2 Materials are to be compatible with abutting dissimilar materials and finishes and complete with primers, damming and back-up materials, supports and anchoring devices in accordance with the firestopping manufacturer's recommendations and the ULC tested assembly.

2.3 ESCUTCHEON PLATES

- .1 One-piece chrome plated brass or #4 finish type 302 stainless steel plates with matching screws for

attachment to the building surface, each plate sized to completely cover the sleeve or building surface opening, and to fit tightly around the conduit or cable.

2.4 ACCESS DOORS

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

2.5 ELECTRICAL WORK IDENTIFICATION MATERIALS

- .1 Equipment Nameplates: Minimum 3 mm (1/8") thick 2-ply laminated, engraved, coloured plastic plates, minimum 12 mm x 50 mm (1/2" x 2") for smaller items such as single phase starters and disconnect switches, minimum 25 mm x 65 mm (1" x 2 1/2") for equipment, and minimum 50 mm x 100 mm (2" x 4") for panelboards and similar items. Additional requirements are as follows:
 - .1 Unless otherwise specified or required, nameplates are to be white with black wording, except for emergency power system equipment nameplates which are to be red with white wording
 - .2 Each nameplate is to be complete with bevelled edges and wording is to be as large as possible and completely identify the equipment and its use with no abbreviations
 - .3 Wording is generally to be as per the drawings, i.e. LIGHTING PANEL A, and is to include the building area/zone served, but must be reviewed and approved by the Consultant prior to engraving
 - .4 Supply stainless steel self-tapping screws for securing nameplates in place
 - .5 Nameplates for equipment suspended above floor level or generally not within easy viewing from floor level are to be increased in size so as to be easily readable from floor level
- .2 Self-Adhesive Labels: Equal to Brother "P-Touch" or Thomas & Betts Canada Ltd. "EZCODE" Model EZL500 electronic labelling system self-adhesive labels with size and colour as directed, and permanently printed circuit identification nomenclature which is to be approved by the Consultant prior to producing the labels.
- .3 Warning Signs: Equal to Thomas & Betts Canada Ltd. "BP" Series 250 mm x 355 mm (10" x 14") semi-rigid vinyl signs with corner screw holes, the required printed wording (generally red on a white background with black trim) and pressure sensitive adhesive pads on the back.
- .4 Conduit and Armoured Cable Identification: Equal to Brady Canada minimum 50 mm (2") wide self-adhesive coloured vinyl tape.
- .5 Conductor Terminations: Equal to Electrovert Ltd. slip-on "Z" type.

2.6 WALL MOUNTING EQUIPMENT BACKBOARDS

- .1 Construction grade fir plywood, G1S, 20 mm (3/4") thick, with width and length as indicated on the drawings or as required for the equipment to be mounted. Each backboard is to be coated on all surfaces with a white flame retardant primer for a flame spread rating in accordance with Code requirements.

2.7 FASTENING AND SECURING HARDWARE

- .1 Concrete Inserts: Zinc alloy cast-in-place or "wood-knocker" type formwork anchors for single or double runs of conduit, cable tray, etc., and for equipment, and Unistrut Ltd. or equal multi type inserts for runs of three or more conduits, etc., or where a grid support system is required.
- .2 Concrete Fasteners: Equal to wej-it Fastening Systems anchors or self-drilling anchors, or, for light

- loads, lead plugs and screws.
- .3 Masonry Fasteners: Equal to wej-it Fastening Systems expansion shields and machine bolts, or, for light loads, lead plugs and screws.
- .4 Gypsum Board Fasteners: Two-wing spring toggles, for light loads only.
- .5 Structural Steel: Equal to Erico International Corp. "CADDY" beam clamps to suit the application.

2.8 ELECTRICAL ENCLOSURES

- .1 Unless otherwise specified herein or on the drawings, NEMA, EEMAC, and CSA enclosures for transformers, switchgear, switchboards, panelboards, disconnect switches, starters, motor control centres, and similar equipment are to be as follows:
 - .1 Indoor in sprinklered areas – type 2
 - .2 Indoor in high humidity/washdown areas – type 4 water-tight
 - .3 Indoor in non-hazardous areas except as noted above – type 1

3 EXECUTION

3.1 GENERAL

- .1 Manufacturer's Instructions: For all materials and equipment, ensure that the manufacturers' installation instructions are followed unless otherwise specified herein or on the drawings, and unless such instructions contradict governing codes and regulations.
- .2 Cleaning: Clean all conduit and equipment prior to installation. Temporarily cap or plug ends of conduits/ducts which are open and exposed during construction.
- .3 Surfaces to Receive Your Work: Inspect surfaces and structure prepared by other trades before performing your work. Verify that surfaces or the structure to receive your work have no defects or discrepancies which could result in poor application or cause latent defects in installation and workmanship. Report defects in writing. Installation of your work will constitute acceptance of such surfaces as being satisfactory.
- .4 Repair of Finished Surfaces: For factory applied finishes, repaint or refinish all surfaces damaged during shipment and installation. The quality of the repair work is to match the original finish. This requirement also applies to galvanized finishes.
- .5 Work In High Humidity Areas: Where electrical work is located in high humidity areas or other "wet" areas where ferrous metal products will be subject to corrosion and protection for such products is not specified, provide finishes on the products to protect against corrosion or provide products which will not corrode in the environment, i.e. galvanized hanger and support hardware, aluminium cable tray, etc.
- .6 Accessibility: Locate all work to permit easy access for service or maintenance as required and/or applicable. Locate all junction boxes and pull boxes, and any other equipment which will or may need access, maintenance or repairs and which are installed in accessible construction so as to be easily accessible from access doors. Where boxes and similar conduit and conductor system accessories occur in vertical services in shafts, conduit/conductor spaces or partitions, locate the accessories at the floor level.

3.2 GENERAL CONDUIT & CONDUCTOR SYSTEM INSTALLATION REQUIREMENTS

- .1 Unless otherwise specified, locate and arrange horizontal conduit and conductors above or at the ceiling on floors on which they are shown, arranged so that under consideration of all other work in the area, the maximum ceiling height and/or usable space is maintained.
- .2 Unless otherwise specified, install all conduit and conductors concealed in finished spaces, and concealed to the degree possible in partially finished and unfinished spaces. Refer to and examine the Architectural drawings and room finish schedules to determine finished, partially finished, and unfinished areas. Note that walls which are painted are considered finished.
- .3 Conduit and main distribution conductors may be exposed in electrical and mechanical rooms unless otherwise specified or indicated on the drawings or specified in the Specification.
- .4 Install all exposed conduit and conductors parallel to building lines and to each other. Neatly group and arrange all exposed work.

- .5 Do not install conduit and conductors within 150 mm (6") of "hot" piping or equipment unless the conduit and conductors are associated with the equipment.
- .6 All conduit and conductors must be supported from the structure, not from ceiling hangers, piping, ductwork, cable tray, and similar mechanical or electrical products.

3.3 INSTALLATION OF SLEEVES

- .1 Where conduits, round ducts, and armoured cables pass through concrete and/or masonry surfaces provide sleeves as follows:
- .2 In poured concrete slabs, unless otherwise specified - minimum 16 gauge flanged galvanized steel or, where permitted by governing authorities, factory fabricated plastic sleeves
- .3 In concrete or masonry walls - Schedule 40 galvanized steel pipe or Class 4000 cast iron pipe, cut to length
- .4 Size sleeves, unless otherwise specified, to leave 12 mm (½") clearance around the conduit, duct, or cable.
- .5 Pack and seal the void between the sleeves and the conduit, duct, or cable for the length of the sleeves as follows:
 - .1 Fire rated construction: pack sleeves in fire rated construction as specified in the article below entitled "INSTALLATION OF FIRESTOPPING AND SMOKE SEAL MATERIALS"
 - .2 Non-fire rated construction: pack sleeves in non-fire rated interior construction with mineral wool and seal both ends of the sleeves with non-hardening silicone base caulking compound
 - .3 Exterior walls above grade: pack sleeves in exterior walls above grade with mineral wool and seal both ends of the sleeves water-tight with approved non-hardening silicone base caulking compound unless mechanical type seals have been specified
 - .4 Exterior walls below grade: seal sleeves in exterior walls below grade (and any other wall where water leakage may be a problem) with link type mechanical seals as specified below
- .6 Where sleeves are required in masonry work, accurately locate and mark the sleeve location, and hand the sleeves to the mason for installation.
- .7 Terminate piping used for sleeves that will be exposed so that the sleeve is flush at both ends with the building surface concerned so that the sleeve may be completely covered by an escutcheon plate, except for sleeves in waterproof floors which are to terminate 100 mm (4") above the finished floor.
- .8 "Gang" type sleeving will not be permitted.

3.4 INSTALLATION OF WATERPROOF MECHANICAL SEALS

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

3.5 INSTALLATION OF FIRESTOPPING AND SMOKE SEAL MATERIALS

- .1 Where electrical work penetrates fire rated construction, provide ULC listed and labelled firestopping and smoke seal materials installed in accordance with requirements of CAN4-S115 and CAN/ULC-S101-M to seal the penetrations.
- .2 Work is to be performed only by a specialist company using tradesmen experienced in firestopping and smoke seal work.
- .3 When firestopping and smoke seal work is complete, obtain from the specialist firm who performed the work a letter certifying that all required firestopping and smoke seal work has been completed in strict accordance with requirements of the Building Code, ULC requirements, any other applicable local Municipal Codes or Regulations, and the instructions of the firestopping and smoke seal manufacturer. Submit the letter to the Consultant.

3.6 INSTALLATION OF ESCUTCHEON PLATES

- .1 Provide escutcheon plates suitable secured over all exposed conduit, duct, and armoured cable passing through finished building surfaces. A finished building surface is any surface with a factory

finish or that receives a site applied finish.

- .2 Install the plates so that they are tight against the building surface concerned, and ensure that the plates completely cover sleeves and/or openings, except where waterproof sleeves extend above floors, in which case the plate is to fit tightly around the sleeve.

3.7 INSTALLATION OF FASTENING AND SECURING HARDWARE

- .1 Provide all fastening and securing hardware required for electrical work to maintain installations attached to the structure or to finished floors, walls and ceilings in a secure and rigid manner capable of withstanding the dead loads, live loads, superimposed dead loads, and any vibration of the installed products.
- .2 Use fasteners compatible with structural requirements, finishes and types of products to be connected. Do not use materials subject to electrolytic action or corrosion where conditions are liable to cause such action.
- .3 Where the floor, wall or ceiling construction is not suitable to support the loads, provide additional framing or special fasteners to ensure proper securement to the structure that is to support the products. Provide reinforcing or connecting supports where required to distribute the loading to the structural components.
- .4 Obtain written consent before using explosive actuated fastening devices. If consent is obtained, comply with requirements of CSA Standards CAN3-Z166.1 and 2.
- .5 Do not attach fasteners to steel deck without written consent from the Consultant.

3.8 SUPPLY OF ACCESS DOORS

- .1 Supply access doors to give access to all electrical work which may need maintenance or repair but which is concealed in inaccessible construction, except as otherwise specified herein or on the drawings.
- .2 Locate access doors as inconspicuously as possible in walls and partitions and arrange electrical work such that it is clearly within view and accessible for inspection and servicing, and to suit access door locations shown on the reviewed and approved white prints of reflected ceiling plan and elevation drawings submitted as per Part 1 of this Section.
- .3 Group work wherever possible to ensure the minimum number of access doors is required. Access doors will be installed by the trades responsible for the particular type of construction in which the doors are required.
- .4 Submit a sample of each proposed access door for review prior to ordering.

3.9 ELECTRICAL WORK IDENTIFICATION

- .1 General: The following requirements apply to electrical work identification:
 - .1 The size and wording of identification nameplates must be approved by the Consultant prior to manufacture. Provide shop drawings of all nameplates and labels for review and comment
 - .2 Identification wording for equipment is to follow drawing nomenclature for the equipment, unless otherwise specified
 - .3 Secure nameplate to equipment with stainless steel screws unless such a practice is prohibitive, in which case use epoxy cement applied to cleaned surfaces
 - .4 Locate equipment nameplates in the most conspicuous and readable location
 - .5 For multi-cell or multiple component equipment, provide a main nameplate and a smaller nameplate for each component to identify its name and service
 - .6 Colour code: comply with OESC-4-036.
- .2 Distribution Equipment: Provide identification nameplates for new each piece of equipment, including items such as substations, switchgear, switchboards, distribution panels, and similar products. Identification to include registration plates, ULC and CSA approvals, size, equipment model, manufacturers name, serial number, voltage, phase.
- .3 Terminal Cabinets, Pull Boxes, Junction Boxes, Etc.: Clearly identify main pull and junction boxes by spray painting the outside surface of the covers. Paint colours are to be as specified below for conduit and conductor identification. For communication systems, i.e. intercom, TV, etc., provide a nameplate on the painted cover to identify the system involved.
- .4 Branch Circuit Panels: Provide a nameplate to identify the panelboard, the source from which it is fed,

- and the voltage, and provide identification labels for each circuit breaker.
- .5 Motor Starters and Disconnect Switches: Provide a 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 supplied by this Division, and on each disconnect switch provided as part of the electrical work for motorized equipment provided as part of the mechanical work. Nameplates are to identify the equipment being controlled, and the voltage.
 - .6 Lighting Switches and Receptacles: Unless otherwise specified identify the source panel and circuit number by means of an identification label applied to the wall above the device and inside the outlet box for each device.
 - .7 Warning Signs: Provide appropriately worded warning signs, secured with stainless steel screws or similar stainless steel hardware, in locations as follows:
 - .1 On all doors into transformer vaults
 - .2 On all doors into high voltage switchgear rooms
 - .3 On collector bus enclosure
 - .4 On pad mounted transformer enclosures
 - .8 Conduit & Cable: Colour code conduit and armoured cable by means of 25 mm (1") wide primary colour plastic adhesive backed tape or neatly applied suitable paint with, where scheduled, a 20 mm (3/4") wide auxiliary colour at points where the conduit or cable enters a wall, ceiling or floor, at least once in each room or accessible ceiling space, at each access door location, and elsewhere at maximum 15 m (45') intervals. Unless otherwise specified herein or on the drawings, colours are to be as follows:

SERVICE	PRIMARY COLOUR	SECONDARY COLOUR
Up to 250 volts	Yellow	
Up to 600 volts	Yellow	Green
Up to 5 kV	Yellow	Blue
Up to 15 kV	Yellow	red
Up to 28 kV	Yellow	Black
Telephone	Green	
Other communication systems	Green	Blue
Fire Alarm	Red	
Emergency Voice	Red	Blue
Security Systems	Red	Yellow
Isolated Power	Orange	

- .10 Wire and Cable Terminations: Identify both ends of wire and cable terminations with the same unique number. Where numbers are not indicated or specified, assign a number and record them.

3.10 INSTALLATION OF TERMINAL BACKBOARDS

- .1 Provide suitably sized, identified, painted 19 mm (3/4") GIS plywood backboards for wiring terminals where shown and/or specified and/or required.
- .2 Wall mount the backboards and secure in place with stainless steel screws.

3.11 FINISH PAINTING OF ELECTRICAL WORK

- .1 Finish paint exposed electrical work as specified and/or scheduled in accordance with requirements of the painting Section in Division 09.

3.12 GENERAL ELECTRICAL WORK TESTING

- .1 In addition to tests required by Codes and Regulations, or tests specified in other electrical work sections of the specification, perform the following:
 - .1 After all luminaires, switches, receptacles, motors, signals, and similar electrical items are installed, whether as part of the electrical work or as part of the work of other sections of the specification (telephone system excepted), test all work to ensure that there are no grounds or crosses
 - .2 Establish proper motor rotation, measure full load running currents, and check overload elements, and report any discrepancies to the Consultant
 - .3 Demonstrate to the Consultant that branch circuit voltage drop is within specified limits
 - .4 Ensure that all devices are commissioned and operable

3.13 BRANCH CIRCUIT BALANCING

- .1 Connect all branch circuits to panelboards so as to balance the actual loads (wattage) to within 5%. If required, transpose branch circuits to achieve this requirement.
- .2 When requested by the Consultant, and after the building is occupied, perform tests to demonstrate that branch circuit balancing has been achieved.

3.14 ELECTRICAL WIRING WORK FOR MECHANICAL WORK

- .1 Unless otherwise specified or indicated, the following electrical wiring work for mechanical equipment is to be done as part of the electrical work:
 - .1 "Line" side power wiring to motor starters or disconnects, and "load" side wiring from the starters or disconnects to the equipment
 - .2 "Line" side power wiring to pre-wired power and control panels and variable frequency drives, and "load" side power wiring from the panels and VFD's to the equipment
 - .3 Provision of receptacles for plug-in equipment
 - .4 Provision of disconnect switches for all motors that are in excess of 10 m (30') from the starter location, or that cannot be seen from the combination disconnect/starter location, and all associated power wiring
 - .5 All motor starter interlocking in excess of 24 volts
 - .6 Provision of dedicated 120 volt, 15A-1P circuits terminated in junction boxes in mechanical equipment rooms for automatic control and building automation system wiring connections to be made as part of the automatic controls work
 - .7 120 volt power connections to electrical receptacles integral with small ceiling exhaust fans, including wiring through light switches or speed controllers
 - .8 120 volt wiring connections to lighting fixture/switch combinations integral with air handling units
 - .9 120 volt wiring connections to duplex receptacles integral with air handling unit control panels
 - .10 120/208 volt wiring connections to electric heating units integral with air handling units.
- .2 Mechanical wiring work not listed above or specified herein or on the drawings to be done as part of the electrical work will be done as part of the mechanical work.

3.15 INTERRUPTION TO AND SHUT-DOWN OF ELECTRICAL SERVICES AND SYSTEMS

- .1 Co-ordinate all shut-down and interruption to existing electrical systems with the Owner. Generally, shut-downs may be performed only between the hours of 12:00 midnight until 6:00 a.m.
- .2 Upon award of a Contract, submit a list of anticipated shut-down times and their maximum duration.
- .3 Prior to each shut-down or interruption, inform the Owner and Consultant in writing [3] [5] working days in advance of the proposed shut-down or interruption and obtain written approval to proceed. Do not shut-down or interrupt any system or service without such written approval.
- .4 Perform work associated with shut-downs and interruptions as continuous operations to minimize the shut-down time and to reinstate the systems as soon as possible, and, prior to any shut-down, ensure that all materials and labour required to complete the work for which the shut-down is required are available at the site.
- .5 Coordinate with the Owner all start-up of existing electrical systems which have been shut-down.
- .6 Include in Bid Price for all overtime or premium time hours necessary to minimize duration of service interruptions.

3.16 EQUIPMENT BASES, SUPPORTS AND CURBS

- .1 Structural Steel Stands/Supports: For equipment not designed for base mounting, where required, provide welded, cleaned and prime coat painted structural steel stands or supports conforming to the following requirements:
 - .1 All stands and supports, except those for small equipment, are to be designed by a structural engineer registered in the jurisdiction of the work, and stamped and signed design drawings with calculations are to be submitted as shop drawings for review
 - .2 All steel stands are to be flange bolted to concrete housekeeping pads

3.17 CUTTING, DRILLING, AND PATCHING FOR ELECTRICAL WORK

- .1 Provide all cutting, drilling and patching of the building for the installation of the work. Perform all cutting and drilling with proper tools and equipment. Confirm the exact location of cutting and drilling with the Consultant prior to commencing the cutting and/or drilling work.
- .2 Patch surfaces, where required, to exactly match existing finishes using tradesmen skilled in the particular trade or application worked on.
- .3 Where new conduits, conductors, etc., pass through existing construction, core drill an opening. Size openings to leave 12 mm (1/2") clearance around the conduit conductor, etc.
- .4 Prior to drilling or cutting an opening in poured concrete construction, determine the location, if any, of existing services concealed in the construction to be drilled or cut. X-ray or Ferro Scan test the walls or slabs required.
- .5 The contractor will be responsible for the repair of any damage to existing services, exposed or concealed, caused as a result of this cutting or drilling work.
- .6 Where drilling is required in waterproof slabs, size the opening to permit snug and tight installation of a sleeve which is sized to leave 12 mm (1/2") clearance around the conduit, duct, etc. Provide a sleeve in the opening. Sleeves are to be Schedule 40 galvanized steel pipe with a flange at one end and a length to extend 100 mm (4") above the slab. Secure the flange to the underside of the slab and caulk the void between the sleeve and slab opening with proper non-hardening silicone base caulking compound to produce a water-tight installation.
- .7 Ensure that cutting and patching of roofs and reinforced concrete structures is executed by specialists familiar with the materials affected, and is performed in a manner to neither damage nor endanger the work. Coordinate and supervise such cutting and patching.

3.18 PACKING AND SEALING CORE DRILLED OPENINGS

- .1 Pack and seal the void between the conduit, conductor, etc., opening and the conduit, conductor, etc., for the length of the opening as follows:
 - .1 non-fire rated interior construction: pack openings in non-fire rated interior construction with mineral wool and seal both ends of the opening with non-hardening silicone base caulking compound to produce a water-tight seal
 - .2 Fire rated construction: pack and seal openings in fire rated walls and slabs as specified in this Section

3.19 INSTRUCTIONS TO OWNER

- .1 Instruct the Owner's designated representatives in all aspects of the operation and maintenance of electrical systems and equipment, on two separate occasions.
- .2 Arrange and pay for the services at the site, for the length of time required, of qualified technicians and other manufacturer's representatives to instruct on specialized portions of the installation.
- .3 Ensure each instruction period includes, but is not limited to the following;
 - .1 A classroom seminar with operating manuals, product and system drawings and such other audio/visual aids as may be appropriate,
 - .2 Instruction during the classroom seminar by the manufacturer's representative regarding the proper operating and maintenance procedures for each item of equipment,
 - .3 Demonstration of the proper operating procedures for each item of equipment,
 - .4 Explanation of the purpose and function of all safety devices provided,
 - .5 Demonstration of all measures required for safe and proper access for operation and

- maintenance.
- .4 Provide a period of follow-up instruction (on two occasions) approximately one month after completing Owner's instruction to clarify and reinforce earlier instructions.
- .5 Submit, prior to Substantial Performance, a complete list of systems for which instructions were given, stating for each system:
 - .1 Date instructions were given to the Owner's staff
 - .2 Duration of instruction
 - .3 Names of persons instructed
 - .4 Other parties present (manufacturer's representatives, etc.)
- .6 Obtain the signatures of the Owner's staff to verify they properly understood the system installation, operation and maintenance requirements and have received operating and maintenance manuals and record drawings.

3.20 CLEANING ELECTRICAL WORK

- .1 Refer to cleaning requirements specified in Division 01.
- .2 Clean all electrical work prior to application for Substantial Performance of the work.

3.21 MAINTAINING EQUIPMENT PRIOR TO ACCEPTANCE

- .1 Maintain all equipment in accordance with the manufacturer's printed instructions prior testing and commissioning.

3.22 CONNECTIONS TO OTHER EQUIPMENT

- .1 Carefully examine the Contract Documents during the bidding period and include for electrical work connections to equipment requiring such connections.

3.23 EQUIPMENT AND SYSTEM COMMISSIONING

- .1 Commissioning shall conform to the following standards:
- .2 Prior to Substantial Performance, test, adjust, and commission the electrical work. Commissioning work is the process of the Contractor demonstrating to the Owner and Consultant, for the purpose of final acceptance, by means of successful and documented functional performance testing, that all systems and/or subsystems are capable of being operated and maintained to perform in accordance with requirements of the Contract Documents, as further described below.
 - .1 Operational Performance Testing: the contractor is to test, adjust and operate components, equipment, systems and/or subsystems after start-up but before functional performance testing, to confirm that all components, equipment, systems and/or subsystems operate in accordance with requirements of the contract documents, including all modes and sequences of control and monitoring, interlocks, and responses to emergency conditions
 - .2 Functional Performance Testing: The Contractor is to repeat successful operational performance testing with documentation by the Contractor in the presence of the Consultant and Owner to validate and verify that the equipment, systems and subsystems are complete in all respects, function correctly, and are ready for acceptance.
 - .3 Submittals: The Contractor is to submit final commissioning reports, project closeout documents, and other required submittals.

3.24 WASTE MANAGEMENT AND DISPOSAL

- .1 Separate and recycle waste materials in accordance with requirements of Canadian Construction Association Standard Document CCA 81, A Best Practices Guide to Solid Waste Reduction.
- .2 Prepare a waste management and reduction plan and submit a copy for review prior to work commencing at the site.
- .3 Place materials defined as hazardous or toxic waste in designated containers.
- .4 Ensure emptied containers are sealed and stored safely for disposal.

3.25 REQUIREMENTS FOR BARRIER FREE ACCESS

- .1 Include for all applicable requirements for barrier free access in accordance with requirements of the OBC, whether shown on the drawings or not.

END OF SECTION

1 GENERAL

1.1 APPLICATION

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

2 PRODUCTS

Not Applicable

3 EXECUTION

3.1 DISCONNECTION AND REMOVAL AND/OR RELOCATION OF EXISTING ELECTRICAL WORK

- .1 Where indicated on the drawings, disconnect and remove existing obsolete electrical work. Disconnect at the point of supply, remove obsolete connecting services and conductors, and make the system safe. Cut back obsolete conduit behind finishes and cap water-tight unless otherwise specified.
- .2 Relocate existing items as indicated. Include for new boxes, conduit, conductors, etc., as required, and test all relocated work as for new work. Provide blank coverplates on existing obsolete boxes which are to remain in position. Material and finish of blank coverplates is to match existing coverplates in the area.
- .3 The scope and extent of the demolition or revision work is only generally indicated on the drawings. Determine the scope, extent and cost of the work at the site during the bidding period site visit(s). Claims for extra costs for demolition work not shown or specified but clearly visible or ascertainable at the site during bidding period site visits will not be allowed.
- .4 If any re-design is required due to discrepancies between the electrical drawings and site conditions, notify the Consultant who will issue a Site Instruction. If, in the opinion of the Consultant, discrepancies between the electrical drawings and actual site conditions are of a minor nature, the required modifications are to be done at no additional cost.
- .5 Where existing electrical services extend through or are in an area to serve items which are to remain, maintain the services in operation. Include for rerouting existing services concealed behind existing finishes and which become exposed during the renovation work, so as to be concealed behind new or existing finishes.
- .6 Under all conditions and circumstances, existing electrical systems and services serving operating portions of the building must be maintained in service. Include for all work to comply with this requirement.
- .7 If and where new openings for doors, windows, etc., are to be cut in existing building surfaces, be present when the work is done and should any damage occur to existing systems required to remain in operation, repair the damage immediately and report the incident to the Consultant.
- .8 Unless otherwise specified, remove from the site and dispose of all existing materials which have been removed and are not to be relocated or reused. Refer to waste management and disposal requirements specified in the Basic Electrical Materials and Methods Section.
- .9 Where existing panelboard breakers are removed, replaced, or otherwise revised, provide new typed panelboard circuit directories.
- .10 Before beginning Work and admittance of any workers on the site, furnish the Consultant with a report in the form of a deficiency list, covering all fittings, fitments, fixtures, surfaces, and any other building component in the existing buildings and exterior building surfaces or site work where Work is being done, whose proximity to alteration Work renders it vulnerable to damage.
- .11 Existing raceways shall not be used for new and/or relocated wiring unless otherwise noted and/or approved in writing by the Consultant.
- .12 Existing items to be relocated shall be cleaned and repaired or altered as required to suit new location. All damaged or ineffective parts shall be replaced and the item made "as new".
- .13 Make good all surfaces and finishes in areas from which items have been removed and in which items are relocated. Cap all existing services required to be severed to effect alterations and do all other work necessary to make good such areas to satisfaction of consultant.

- .14 Openings in existing floor assemblies and vertical fire separations necessitated by installation of equipment and systems or construction in general to be temporarily sealed with fire barrier materials such as mineral wool or other noncombustible insulation.
- .15 Existing equipment and systems that are shut down due to work of this project, shall be tested and proper operation verified when returned to service.
- .16 All existing dead wiring and conduit in renovated areas shall be removed in its entirety where accessible. Where not accessible, wiring only shall be removed and conduit shall remain.
- .17 Disconnect and remove any electrical equipment in ceiling space or walls that causes interferences during renovation work. All equipment shall be reinstalled and reconnected upon completion of renovation work.

3.2 HAZARDOUS MATERIALS AND/OR WASTE

- .1 Be advised that items such as oil filled transformers, capacitors and old lighting fixture ballasts may contain hazardous waste. Governing Codes and Regulations, and caution is to be taken when disconnecting and removing/storing these items.
- .2 If hazardous waste not listed in the Specification is found, notify the Owner and Consultant immediately and await directions.
- .3 Asbestos, Mould, Lead Paint, Etc.: If at any time during the course of the work asbestos containing materials, black mould, lead paint, or any other such materials are encountered or suspected, immediately report the discovery to the Consultant and cease all work in the area in question. Do not resume work in affected areas until the situation has been properly corrected and without written approval from the Owner.

3.3 INTERRUPTION TO AND SHUT-DOWN OF ELECTRICAL SERVICES AND SYSTEMS

- .1 Co-ordinate all shut-down and interruption to existing electrical systems with the Owner. Generally, shut-downs may be performed only between the hours of 12:00 midnight until 6:00 a.m.
- .2 Upon award of contract, submit a list of anticipated shut-down times and their maximum duration.
- .3 Prior to each shut-down or interruption, inform the Owner in writing [3] [5] working days in advance of the proposed shut-down or interruption and obtain written approval to proceed. Do not shut-down or interrupt any system or service without such written approval.
- .4 Perform work associated with shut-downs and interruptions as continuous operations to minimize the shut-down time and to reinstate the systems as soon as possible, and, prior to any shut-down, ensure that all materials and labour required to complete the work for which the shut-down is required are available at the site.
- .5 Coordinate all start-up of existing electrical systems which have been shut-down with the Owner.
- .6 Include in Bid Price for all overtime or premium time hours necessary to minimize duration of service interruptions.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- .1 Product Data: Submit product data sheets for all products specified in this Section. Indicate compatibilities and limitations, and application instructions and include data to confirm that the product proposed meets all requirements of the Specification.
- .2 Samples: If requested, submit identified conductor samples.
- .3 MSDS Sheets: Submit Material Safety Data Sheets for conductor pulling lubricants.

2 PRODUCTS

2.1 DISTRIBUTION AND BRANCH CIRCUIT CONDUCTORS

- .1 Minimum gauge: #12 AWG, unless specifically noted otherwise. Conductors #12 and #10 AWG are to be solid. Conductors #8 AWG and larger are to be stranded. Use #14 AWG for control wiring unless noted otherwise. All conductors are to be constructed from 98% conductive copper and are to be approved for 600 volts. Conductors are to be colour coded, factory identified on the insulation with the manufacturer's name, conductor size and metal, voltage rating, and CSA type and designation. Conductors are to be as follows:
 - .1 "T-90 Nylon" single copper conductor in accordance with CSA C22.2 No. 75, Thermoplastic-Insulated Wires and Cables, 90° C (194° F) rated, PVC insulated and nylon covered for #10 AWG and smaller.
 - .2 "RW-90" single copper conductor in accordance with CAN/CSA C22.2 No 38, Thermoset-Insulated Wires and Cables, 90°C (194° F) rated, X-link polyethylene insulated for #8 AWG and larger.
 - .3 Equal to Nexans Canada "Corflex II" RA90 flexible cable in accordance with requirements of CSA C22.2 No. 123, Aluminum Sheathed Cable, consisting of single or multiple copper conductors with X-link polyethylene insulation enclosed in a liquid and vapour-tight solid corrugated aluminum sheath and, an overall PVC jacket

2.2 CONNECTORS

- .1 Conductors In Conduit: Except as noted, equal to Ideal Industries Inc. "Wing Nut" CSA certified, 600 volt rated pressure type twist connectors.
- .2 Conductors 3/0 AWG and Larger: Long barrel, double crimp, compression type lug connectors, unless otherwise specified.
- .3 Corflex/Teck Cable: Connector and termination hardware supplied by the cable manufacturer to suit the application.

2.3 CONDUCTOR PULLING LUBRICANT

- .1 Equal to Ideal Industries Inc. "Yellow 77" or ClearGlide", as required.

3 EXECUTION

3.1 GENERAL RE: CONDUCTOR INSTALLATIONS

- .1 Conform to the following conductor installation requirements:
 - .1 Conductor Routing: Conductor routing indicated on the drawings is schematic and approximate. Determine exact routing and conductor lengths at the site. Route conductors to avoid interference with other work. Unless otherwise specified or shown install conductors parallel to building lines.
 - .2 Securing/Supporting Conductors: Conform to the following requirements:
 - .1 Neatly secure exposed conductors in equipment enclosures with proper supports and/or ties
 - .2 Support flexible armoured cable in ceiling spaces and stud walls with steel two hole cable straps to Code requirements
 - .3 Conductor Splicing: Generally conductor splicing is not permitted unless otherwise approved by the Consultant, and if approved, splicing is subject to the following conditions:

- .1 Splicing is permitted to extend existing conductors
- .2 For thermoplastic insulated conductors, splices are to be made within an approved electrical box with mechanical compression connectors to suit the type and size of conductors, and the box(es) are to be properly identified and locations are to be indicated on "as-built" drawings

3.2 INSTALLATION OF DISTRIBUTION AND BRANCH CIRCUIT CONDUCTORS

- .1 Provide all required conductors.
- .2 Non-Fire Rated Conductors: Unless otherwise specified herein or on the drawings, non-fire rated conductors are to be as follows:
 - .1 Conductors underground inside or outside the building, and in non-climate controlled areas – TWU
 - .2 For isolated power system wiring – RW90
- .3 Conductor Sizing: Generally, conductor sizes are indicated on the drawings. Unless otherwise specified, do not use conductors smaller than No. 12 AWG in systems over 30 volts. Unless otherwise specified, do not use conductors smaller than No. 6 AWG for exterior luminaire wiring. Conductor sizes indicated on the drawings are minimum sizes and must be increased, where required, to suit length of run and voltage drop in accordance with the voltage drop schedule found at the end of this Section.
- .4 Conductor Colour Coding: Unless otherwise specified, colour code conductors to identify phases, neutral, and ground by means of self-laminating coloured vinyl tape, coloured conductor insulation, or properly secured coloured plastic discs. Colours are to be as follows:
 - .1 phase A – red
 - .2 phase B – black
 - .3 phase C – blue
 - .4 neutral – white
 - .5 control – orange

3.3 MAXIMUM BRANCH WIRING DISTANCE FOR 120 VOLT SYSTEM AT 2% VOLTAGE DROP

Wire Size	Breaker Size (Amperes)	15	20	30	40	50	60	70	80	100
	Max. Load at 80% (Amperes)	12	16	24	32	40	48	56	64	80
No. 12	---	15.0	12.0	---	---	---	---	---	---	---
No. 10	---	25.0	19.0	12.0	---	---	---	---	---	---
No. 8	---	39.0	30.0	20.0	15.0	---	---	---	---	---
No. 6	---	62.0	47.0	32.0	23.0	19.0	16.0	---	---	---
No. 4	---	99.0	73.0	50.0	38.0	30.0	24.0	21.0	17.0	---
No. 2	---	---	114.0	77.0	57.0	47.0	38.0	33.0	28.0	22.0
No. 1	---	---	---	96.0	73.0	57.0	47.0	42.0	34.0	27.0
No. 1/10	---	---	---	---	85.0	68.0	56.0	48.0	41.0	33.0
No. 2/0	---	---	---	---	102.0	80.0	67.0	57.0	50.0	40.0
No. 3/0	---	---	---	---	---	95.0	79.0	68.0	59.0	47.0
No. 4/0	---	---	---	---	---	---	92.0	79.0	70.0	56.0
250 MCM	---	---	---	---	---	---	102.0	86.0	76.0	60.0
300 MCM	---	---	---	---	---	---	---	100.0	82.0	70.0

NOTE: DISTANCES INDICATED IN METERS FROM PANEL TO LOAD FOR SINGLE PHASE.

3.4 MAXIMUM BRANCH WIRING DISTANCE FOR 120 VOLT SYSTEM AT 3% VOLTAGE DROP

Wire Size	Breaker Size (Amperes)	15	20	30	40	50	60	70	80	100
	Max. Load At 80% (Amperes)	12	16	24	32	40	48	56	68	80
No.12	---	22.0	16.0	---	---	---	---	---	---	---
No.10	---	36.0	27.0	18.0	---	---	---	---	---	---
No.8	---	59.0	44.0	30.0	22.0	---	---	---	---	---
No.6	---	91.0	70.0	47.0	35.0	28.0	23.0	---	---	---
No.4	---	---	109.0	73.0	54.0	42.0	35.0	30.0	25.0	---
No.2	---	---	---	114.0	85.0	68.0	57.0	50.0	41.0	35.0
No.1	---	---	---	---	103.0	85.0	73.0	61.0	50.0	43.0
No.1/0	---	---	---	---	128.0	102.0	85.0	73.0	60.0	48.0
No.2/0	---	---	---	---	---	121.0	100.0	86.0	74.0	60.0
No.3/0	---	---	---	---	---	---	118.0	102.0	88.0	70.0
No.4/0	---	---	---	---	---	---	---	120.0	102.0	83.0
250 MCM	---	---	---	---	---	---	---	---	114.0	91.0
300 MCM	---	---	---	---	---	---	---	---	---	103.0

NOTE: DISTANCES INDICATED IN METERS FROM PANEL TO LOAD FOR SINGLE PHASE.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- .1 Submit the following for review:
- .2 Product data sheets: submit for special conduit as the Consultant directs
- .3 Additional submittals: submit any other submittals specified in this Section of the Specification

2 PRODUCTS

2.1 EMT

- .1 Galvanized electrical metallic tubing (EMT) to CSA C22.2 No. 83, complete with an interior coating, factory made bends where site bending is not possible, and joints and terminations made with steel couplers and set-screw type connectors with insulated throats, concrete tight where required.

2.2 RIGID GALVANIZED STEEL CONDUIT

- .1 Rigid galvanized steel to CSA C22.2 No. 45, Rigid Metal Conduit, with an interior enamel coating, galvanized threads where factory cut, red lead coated threads where site cut, factory made bends where site bending is not possible, factory made and threaded fittings and connectors, and terminations made with rigid couplings, concrete tight where required.

2.3 FLEXIBLE GALVANIZED STEEL LIQUID-TIGHT CONDUIT

- .1 Flexible galvanized steel liquid-tight conduit to CSA C22.2 No. 56, Flexible Metal Conduit and Liquid-Tight Flexible Metal, complete with conduit connectors to suit the application.

2.4 FISH CORD

- .1 Polypropylene rope.

3 EXECUTION

3.1 CONDUIT INSTALLATION REQUIREMENTS

- .1 General: Refer to the article entitled General Conduit and Conductor Installation Requirements in Part 3 of the Section entitled Basic Electrical Materials and Methods.
- .2 Conduit Types: Unless otherwise specified, provide conduit for all conductors except armoured cable, and except where cable duct or tray or similar product is used. Conduit is to be as follows:EDIT NOTE: Ref. subparagraphs below. Edit to suit the project and delete subparagraphs that do not apply. Revise subparagraphs if required to suit particular requirements of a project. Ensure that conduit required as per edited subparagraphs is specified in Part 2 of this Section.
 - .1 For main distribution wiring in electrical rooms and similar areas – rigid galvanized steel
 - .2 For exposed conduit from floor level to 1.2 m (4') above the floor in mechanical and other service rooms – rigid galvanized steel
 - .3 For concealed conduit in exterior walls – rigid galvanized steel
 - .4 For explosion-proof wiring – rigid galvanized steel
 - .5 For conduit exposed outside the building except where rigid PVC conduit is permitted – rigid galvanized steel
 - .6 For conduit associated with pool area outlets and equipment but not under water – rigid galvanized steel
 - .7 For conduit in corrosive areas – epoxy coated rigid galvanized steel
 - .8 For short (minimum 450 mm (18"), maximum 600 mm (24") with a 180° loop wherever possible) runs of conduit to motors, distribution transformers, and vibration isolated equipment – flexible galvanized steel liquid-tight conduit
 - .9 At points where conduit crosses building expansion joints – flexible galvanized steel conduit

- .10 For branch circuit conductors underground inside the building, and underground outside the building beneath structures and concrete or asphalt paving – rigid PVC
- .11 For branch circuit conductors outside the building at roof level – rigid PVC
- .12 For concealed branch circuit conductors associated isolated power systems – rigid PVC
- .13 For underwater conduit - rigid bronze
- .14 For all conduit except as specified above – EMT
- .15 For fire alarm and other communication system conductors – colour coated EMT with colours as selected
- .3 Conduit Fittings: Unless otherwise specified, conduit fittings are to be constructed of the same material as the conduit and are to be suitable in all respects for the application. Provide proper adaptors for joining conduits of different materials.
- .4 Conduit Sizes: Generally, conduit is sized on the drawings. Conduit not sized on the drawings is to be sized in accordance with the Ontario Electrical Safety Code. The sizes of branch circuit conductors specified are minimum sizes and must be increased to suit length of run and voltage drop as specified, therefore, when conductor sizes are increased to suit length of run and voltage drop, increase the conduit size to suit. Sizes indicated do not include allowance regarding percentage conduit fill for bonding and grounding conductors unless noted otherwise. Increase conduit size as necessary to comply with OESC-12-1014(4). Conductors in conduit. Do not install conduit less than 12 mm ($\frac{1}{2}$ " dia.
- .5 Conduit Bends: Site made bends for all conduit must be made using proper bending equipment, bends must maintain the full conduit diameter with no kinking, and conduit finishes must not flake or crack when the conduit is bent.
- .6 Site Cutting Conduit: Cut square and ream all site made conduit ends. Plug or seal ends of roughed-in conduit which are open and exposed during construction.
- .7 Threading Conduit: Site cut threaded rigid conduit using proper threading equipment located in an approved area and where protection for adjacent building surfaces is in place. Clean threads and lubricate. Coat rigid conduit threads with red lead or other zinc rich coating. Field threads must be of sufficient length to draw conduits up tight.
- .8 Empty Conduit: Ensure that all conduit left empty for future wiring is clean, capped, and suitably identified. Provide end bushings and fish cord in all such conduit.
- .9 Support of Conduit: Conduit support requirements are as follows:
 - .1 Support underground conduit on a well tamped bed of earth or sand, free from rocks or other protrusions of any kind
 - .2 Support and secure surface mounted and suspended single or double runs of metal conduit at support spacing in accordance with the Ontario Electrical Safety Code by means of galvanized steel pipe straps, conduit clips, ring bolt type hangers with galvanized steel hanger rod, or by other approved manufactured devices
 - .3 Support multiple metal conduits by means of conduit racks and galvanized steel rod with spacing to suit the requirements of the smallest dia. conduit in the group
 - .4 Perforated pipe straps not acceptable
- .10 Expansion Facilities: Include for the following conduit expansion facilities:
 - .1 Wherever concealed or surface mounted conduit extends across a building expansion joint, provide expansion facilities to permit free movement without imposing additional stress or loading on the support system, and to prevent excessive movement at joints and connections.
 - .2 Provide manufactured expansion joint fittings in rigid PVC conduit at spacing recommended by the expansion joint fitting manufacturer
 - .3 Install underground flexible polyethylene conduit "snaked" in the trench

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- .1 Shop Drawings and Product Data: Submit shop drawings and product data sheets for motor starters and accessories. Ensure that the shop drawings and product data sheets indicate all features of the starters to confirm that the equipment is in accordance with requirements of this Section.

2 PRODUCTS

2.1 MOTOR STARTERS AND ACCESSORIES

- .1 General: All motor starters are to be CSA Certified; EEMAC rated, must be capable of starting the associated motors under the imposed loads, and must be suitable in all respects for the motor. Confirm that starter voltages match the motors prior to ordering. IEC and half size starters and contactors are not acceptable.
- .2 Magnetic starters and contactors to be complete with 100VA or larger 120V individual control transformers protected by control fuses.
- .3 Three phase starters and contactors minimum EEMAC size 1.
- .4 Single phase starters and contactors minimum EEMAC size 0.
- .5 All three phase starters shall be complete with single phase protection.
- .6 Starters For Single Phase Motors: Unless otherwise specified, starters for single phase motors are to be 120 volt, thermal overload protected manual starting switches, each with a neon pilot light, a surface or recess mounting enclosure to suit the application and mounting location, and, where automatic operation is required, a "hand-off-automatic" switch in an enclosure to match the starter enclosure.
- .7 Starters For Three Phase Motors Less Than 30 HP: Unless otherwise specified, starters for three phase motors less than 30 HP are to be combination "quick-make" and "quick-break" fused door interlock disconnects and full voltage non-reversing across-the-line starters, each complete with solid-state overload relay per phase, an enclosure to suit the application, and, a "hand-off-automatic" switch, pilot lights, control transformer, auxiliary contacts, and other accessories as per the motor starter schedule.
- .8 Starters for 2-Speed Double Winding Motors: Generally as specified above but suitable for the motor and equipped with a 45 second time delay to permit the equipment to coast down to low speed before it is operated at low speed.
- .9 Starters For 2-Speed Single Winding Motors: Generally as specified above but suitable for the motor and equipped with a 45 second time delay to permit the equipment to coast down to low speed before it is operated at low speed.
- .10 Motor Starter Enclosures: Unless otherwise specified, motor starter enclosures are to be in accordance with the following NEMA/EEMAC ratings:
 - .1 all enclosures located in sprinklered areas – Type 2
 - .2 all enclosures exposed to the elements – Type 3R, constructed of stainless steel
 - .3 all enclosures inside the building in wet areas – Type 3R, constructed of stainless steel
 - .4 all enclosures in explosion rated area – Type 7 with exact requirements to suit the area and application
 - .5 all enclosures except as noted above – Type 1
 - .6 all enclosures located in finished areas – as above but recess type with brushed stainless steel faceplate
- .11 Acceptable Manufacturers: Acceptable manufacturers are:
 - .1 Rockwell Automation (Allen-Bradley)
 - .2 Schneider Electric Ltd. (Square D)
 - .3 Siemens Canada
 - .4 Eaton Corp. (Cutler-Hammer)

3 EXECUTION

3.1 INSTALLATION OF MOTOR STARTERS AND ACCESSORIES

- .1 Provide motor starters for mechanical equipment, except for starters integral with packaged equipment, and starters factory installed in equipment power and control panels. Refer to Mechanical/Electrical Equipment Schedule.
- .2 Three Phase Motor Starters on Motor Starter Panels: Where three phase starters are indicated and/or scheduled to be mounted on a motor starter panel, provide the panel and mount the starters.
- .3 Single Phase Motor Starters: Unless otherwise specified or shown on the drawings, mount single phase motor starters adjacent to the equipment they serve and connect complete.
- .4 Electrical Wiring for Mechanical Work: Refer to the Section entitled Electrical Wiring For Mechanical Work.
- .5 Set ramp-up and ramp-down times for soft-start type starters as site directed.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- .1 Shop Drawings and Product Data: Submit shop drawings and product data sheets for disconnect switches and accessories. Ensure that the shop drawings and product data sheets indicate all features of the disconnects to confirm that the equipment is in accordance with the requirements of this Section.

2 PRODUCTS

2.1 DISCONNECT SWITCHES

- .1 Heavy-duty, CSA certified, quick-make/quick break action switches complete with a handle suitable for padlocking in the "off" position and arranged so that the door cannot be opened with the handle in the "on" position and an EEMAC enclosure. Fusible units are to be complete with fuse clips to suit fuse types specified below, without adaptors.
- .2 Fuses: Unless otherwise scheduled or specified fuses are to be equal to English Electric Ltd. HRC fuses, Form I Class "J" for constant running equipment and Form II Class "C" for equipment that cycles on and off.
- .3 Enclosures: Unless otherwise specified, enclosures are to be in accordance with the following NEMA/EEMAC ratings:
 - .1 All enclosures located in sprinklered areas – Type 2
 - .2 All enclosures exposed to the elements – Type 3R, constructed of stainless steel
 - .3 All enclosures inside the building in wet areas – Type 3R, constructed of stainless steel
 - .4 All enclosures in explosion rated area – Type 7 with exact requirements to suit the area and application
 - .5 All enclosures except as noted above – Type 1
 - .6 All enclosures located in finished areas – as above but recessed type with brushed stainless steel faceplate
- .4 Acceptable Manufacturers: Acceptable manufacturers are:
 - .1 Rockwell Automation (Allen-Bradley)
 - .2 Eaton Corp. (Cutler-Hammer)
 - .3 Siemens Canada
 - .4 Schneider Electric Ltd. (Square D)

3 EXECUTION

3.1 INSTALLATION OF DISCONNECT SWITCHES

- .1 Provide all required disconnect switches in accordance with drawing plans, schedules, details, and requirements of the Specification.
- .2 Provide fuses for fusible disconnects.
- .3 Refer to the Section titled, Wiring Requirements For Mechanical Equipment.

END OF SECTION

1 GENERAL

1.1 PRODUCT DATA COORDINATION

- .1 Shop Drawings and Product Data: If required, review shop drawings and product data sheets for mechanical equipment requiring wiring connections as part of the electrical work to ensure that all connection requirements are performed.

2 PRODUCTS

2.1 WIRING PRODUCTS

- .1 Wiring products such as conduit, conductors, boxes, etc., are to be as specified in appropriate Sections of this Division of the Specification.

3 EXECUTION

3.1 WIRING CONNECTIONS FOR MECHANICAL WORK

- .1 Unless otherwise specified or indicated, perform the following electrical wiring work:
 - .1 "Line" side power wiring to motor starters or disconnect switches in motor control centres and "load" side wiring from the starters or disconnects to the equipment
 - .2 "Line" side power wiring to motor starters or disconnect switches on motor starter panels and "load" side wiring from the starters or disconnects to the equipment
 - .3 "Line" side power wiring to individual wall mounted starters, and "load" side wiring from the starters to the equipment
 - .4 "Line" side power wiring to pre-wired power and control panels and "load" side power wiring from the panels to the motors
 - .5 "Line" side power wiring to variable frequency drives and "load" side power wiring from the VFD's to the motors
 - .6 Provision of receptacles for plug-in equipment
 - .7 Provision of disconnect switches for all motors that are in excess of 10 m (30') from the power supply/starter location, or that cannot be seen from the power supply/starter location, and all associated power wiring
 - .8 All motor starter interlocking in excess of 24 volts
 - .9 Wiring from motor winding thermistors in motors 30 HP and larger to motor starter contacts
 - .10 Provision of dedicated 120 volt, 15A-1P circuits terminated in junction boxes in mechanical equipment rooms for automatic control and building automation system wiring connections to be made as part of the automatic controls work
 - .11 120 volt power connections to electrical receptacles integral with small ceiling exhaust fans, including wiring through light switches or speed controllers
- .2 Mechanical wiring work not listed above or specified herein or on the drawings to be done as part of the electrical work will be done as part of the mechanical work.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- .1 Shop Drawings and Product Data: If requested, submit shop drawing and product data sheets for products specified in this Section. Include data to confirm that the product proposed meets all requirements of the Specification.
- .2 Samples: If requested, submit samples of products specified in this Section.

2 PRODUCTS

2.1 OUTLET BOXES

- .1 Each box is to be CSA certified, suitable in all respects for the application, and be complete with suitable securing lugs, connectors suitable for the connected conduit, knockouts, and, where necessary, suitable plaster rings, concrete rings, covers and any other required accessory. Unless otherwise specified, outlet boxes are to be as follows:
 - .1 Stamped, electro-galvanized steel outlet boxes

2.2 PULL BOXES AND JUNCTION BOXES

- .1 Each box is to be CSA certified, sized to suit the number and size of conduit and conductors, and complete with connecting and securing facilities. Unless otherwise specified, pull boxes and junction boxes are to be as follows:
 - .1 Galvanized or prime coat plated steel, suitable in all respects for the application and complete with screw-on or hinged covers as required and connectors suitable for the connected conduit
 - .2 "Condulet", threaded galvanized cast iron or cast aluminum pull boxes and junction boxes of an exact type to suit the application, each complete with screw-on gasketed cover

3 EXECUTION

3.1 INSTALLATION OF OUTLET BOXES AND BACK BOXES

- .1 Provide an outlet box or back box for each luminaire, wiring device, telephone outlet, fire alarm system component, communications systems components, and all other such outlets.
- .2 Stamped Galvanized Steel: Outlet boxes flush mounted in interior construction, surface mounted in concealed interior locations, and surface mounted in exposed interior locations where the connecting conduit is EMT, are to be stamped galvanized steel outlet boxes unless otherwise noted.
- .3 "FS and "FD" Series Boxes: Outlet boxes for surface mounted exterior lighting, receptacles, and other device outlets, boxes flush mounted in exterior building surfaces, and boxes mounted in interior device locations where the connecting conduit is rigid, and for boxes in perimeter walls where insulation and vapour barrier is present, are to be "FS" or "FD" Series cast boxes unless otherwise noted, cast iron inside the building, cast aluminum outside the building.
- .4 Outlet boxes for special wiring devices, for special equipment and special applications if required, are specified hereinafter in other Sections or on the drawings.
- .5 The size and arrangement of outlet boxes are to suit the device which they serve.
- .6 Generally, mounting heights and locations for outlets are indicated on the drawings, however, confirm the exact location and arrangement of all outlets prior to roughing-in. Architectural drawings and the Consultant's instructions have precedence over electrical drawing diagrammatic layouts and specified mounting height and locations. In addition, abide by the following requirements:
 - .1 Locate flush mounting boxes in masonry wall to require cutting of the masonry unit corner only and, coordinate masonry cutting to achieve a neat opening
 - .2 Position outlet boxes to locate luminaires as shown on reflected ceiling plans
 - .3 Coordinate mounting heights and locations of outlets mounted above counters, benches and backsplashes
- .7 Do not install outlet or back boxes "back-to-back" in walls and partitions. Stagger such outlets and seal against noise transmission with acoustic insulation. "Thru-wall" type boxes will not be permitted

- for any application.
- .8 Where boxes are multi-ganged or grouped together, mount boxes level and spaced consistently.
 - .9 Temporarily pack all open boxes located in concrete and masonry to prevent debris from entering the box. Remove packing on completion of work.
 - .10 Include all costs for installed boxes that have not been covered by wall/ceiling finishes, to be relocated up to 1m (3') to suit final device location coordination.

3.2 INSTALLATION OF PULL BOXES AND JUNCTION BOXES

- .1 Provide pull boxes in conduit systems wherever shown on the drawings, and/or wherever necessary to facilitate conductor installations. Generally, conduit runs exceeding 30 m (100') in length, or with more than three 90° bends, are to be equipped with a pull box installed at a convenient and suitable intermediate accessible location.
- .2 Provide junction boxes wherever required and/or indicated on the drawings.
- .3 Unless otherwise specified, boxes are to be as follows:
 - .1 In rigid conduit and EMT inside the building – stamped galvanized or prime coated steel
 - .2 In exterior rigid conduit – “Condulet” cast aluminum gasketed boxes unless otherwise noted
 - .3 In plastic conduit – rigid PVC boxes
 - .4 In bronze underwater conduit – cast bronze boxes
- .4 All pull boxes and junction boxes must be accessible after the work is complete.
- .5 Accurately locate and identify all concealed pull boxes and junction boxes on “built” record drawings.
- .6 Cover boxes in fire walls with aluminum tape and seal with caulking.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- .1 Shop Drawings and Product Data: Submit shop drawings and product data sheets for wiring devices. Ensure that the sheets indicate all features of the devices to confirm that the devices are in accordance with requirements of this Section, including colours and faceplate finishes.
- .2 Wiring Device Samples: if requested, submit samples of products specified in this Section.

1.2 QUALITY ASSURANCE

- .1 All wiring devices are to be CSA certified as a minimum, in accordance with the following standards, as applicable:
 - .1 CAN/CSA C22.2 No 42, General Use Receptacles, Attachment Plugs and Similar Wiring Devices
 - .2 CAN/CSA C22.2 No 42.1, Cover Plates for Flush Mounted Devices
 - .3 CSA C22.2 No. 111, General Use Snap Switches
- .2 Wherever possible, all wiring devices are to be supplied by the same manufacturer.
- .3 Acceptable Manufacturers: Unless otherwise specified in this Section or on the drawings, acceptable manufacturers are:
 - .1 Hubbell Canada
 - .2 Cooper Industries (Arrow Hart)
 - .3 Legrand/Pass & Seymour
 - .4 Leviton Canada

1.3 WIRING DEVICE AND PLATE COLOURS

- .1 Unless otherwise specified, wiring device colours will be as specified in Part 3 of this Section.

2 PRODUCTS

2.1 SWITCHES

- .1 Unless otherwise specified, Specification Grade, Premium Quality, back and side wired, 20 ampere, 120-277 volt A.C. quiet action toggle switches, single pole, 2-pole, 3-way, 4-way or key type as indicated on the drawings, each complete with a nickel plated steel ground terminal, brass power wiring terminals and screws, silver cadmium oxide contacts with a moveable brass contact arm, and nylon toggle with colour as specified below. Switch types are as follows:
 - .1 Standard Wall Toggle Switches: As above.
 - .2 Illuminated Handle Standard Wall Toggle Switch: As above for standard switches but with a clear red, or green polycarbonate toggle which is illuminated when the switch is on or off. Confirm toggle colour and position when illuminated prior to ordering.
 - .3 Door Switch: Box, switch and plate assemblies with a 125 volt 3 ampere illuminated switch which is on or off when the door is open (confirm prior to ordering), a 34 mm x 94 mm x 40 mm (1 11/32" x 3 11/16" x 1 1/2") box, cover plate, and mounting screws.
 - .4 Motor Control Snap Action Switch: Illuminated handle snap action horsepower rated switch CSA certified for motor control and sized to suit the application.

2.2 DEVICE FACEPLATES

- .1 Device faceplates are to be ULC listed and CSA certified and, unless otherwise specified, supplied by the device manufacturer. Where two or more devices are installed in a common box, a common one-piece faceplate is to be used. Faceplate colours are specified in Part 3. Faceplates, unless otherwise specified, are to be as follows:
 - .1 Type 302/304 stainless steel switch and receptacle faceplates, satin finish as directed, with stainless steel screws

3 EXECUTION

3.1 GENERAL RE: INSTALLATION OF WIRING DEVICES

- .1 Provide all required wiring devices and faceplates.
- .2 Confirm exact locations, including mounting heights, prior to roughing-in.
- .3 Ensure that switches located adjacent to doors are located at the strike side of the door. Confirm door swings prior to roughing-in.
- .4 Install single throw switches with the handle in the up position when the switch is closed.
- .5 Confirm all switch, receptacle and faceplate types, colours and finishes prior to ordering.
- .6 Provide a separate insulated ground conductor for each isolated ground receptacle
- .7 Faceplates for computer equipment receptacles are to be permanently identified with "Computer Equipment Only" wording.
- .8 Faceplates for housekeeping receptacles are to be permanently identified with "Housekeeping Only" wording.
- .9 Do not install faceplates for flush devices until wall, etc., finishing work is complete.
- .10 Where devices are to be installed in casework, millwork, or similar construction, carefully coordinate device installations and device openings with the trade providing the casework, millwork, etc.

3.2 TESTING

- .1 When installation is complete, test operation of all devices.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- .1 Shop Drawings / Product Data: Submit shop drawings and product data sheets for products specified in this Section. Ensure that the drawings and sheets indicate all features of the equipment to confirm that the equipment is in accordance with requirements of this Section.
- .2 Panelboard Door Keys: Submit identified keys (minimum 6) for panelboards doors.

2 PRODUCTS

2.1 BRANCH CIRCUIT PANELBOARDS

- .1 General Re: Panelboards: Branch circuit panelboards are to be dead front, factory assembled panelboards designed for sequence phase connection of branch circuit breakers, as per the drawing schedule and plans, and in accordance with requirements of CAN/CSA-C22.2 No. 29, Panelboards and Enclosed Panelboards Industrial Products. Comply with OESC Rule 14-014 with regards to series rated combinations of over-current protective devices and ensure that equipment in which the lower rated devices are installed are marked with a series combination interrupting rating at least equal to the available fault current. Each panelboard is to be complete with:
 - .1 Silver plated, electrical grade, 95% conductivity copper bus mains for the full length of each enclosure
 - .2 Main and branch circuit conductor solderless set-screw type lugs approved for copper conductors
 - .3 Copper neutral bus and main lugs at the same end, and a removable cover for main lugs
 - .4 Dedicated copper ground bus
- .2 Panelboard Enclosures: Panelboard enclosures, unless otherwise specified, are to be EEMAC 2 sprinkler-proof, flush or surface mounted as indicated, constructed of Code gauge galvanized sheet steel, equipped with drip shields, and factory cleaned, primed, and finished with ASA-61 light gray equipment enamel. Each enclosure is also to be equipped with:
 - .1 Wiring gutter space on all sides in accordance with CAN/CSA-C22.2 No. 29 requirements
 - .2 Space for future breakers as applicable and as per the drawing panel schedules
 - .3 A concealed hinged door and flush latch with keyed alike lock, and a frame with acetate cover and a circuit directory card on the inside face of the panel door
- .3 Circuit Breakers: Breakers are to be moulded case, bolt-on breakers in accordance with CSA-C22.2 No. 5, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures, calibrated for operation in a 40° C (105° F) ambient temperature, sized in accordance with the drawing schedules, and as follows:
 - .1 Thermal magnetic type circuit breaker, quick-make, quick-break for manual and automatic operation for general purpose.
 - .2 Current limiting, time-limit type quick-make, quick-break for manual and automatic operation for motor protection
 - .3 Branch circuit breaker interrupting capacity is to suit the panelboard voltage and be as scheduled, and in accordance with OESC requirements to suit the application
 - .4 For ground fault breakers, CSA Class A, Group 1 combination thermal magnetic trip breakers with solid-state ground fault interrupters
 - .5 For dedicated breakers, handle lock devices
 - .6 As scheduled or shown, spare breakers and space for future breakers
- .4 Modifications & Accessories: Where indicated on the drawings or scheduled, panelboards are to be factory equipped with modifications and accessories as follows:
 - .1 a factory installed, maintenance free surge protective device (SPD) in accordance with ANSI/UL 1449 3rd Edition, connected to the bussing through a disconnect device and equipped with a diagnostic package with status indicators on each phase, LCD six digit surge counter display, EMI/RFI filtering, audible alarm with silence button, and Form C alarm contacts
 - .2 200% neutrals for panelboards equipped with SPD units and other panels as scheduled

- .3 Isolated ground bus for panelboards feeding electrically sensitive equipment and as scheduled
- .4 Insulated ground bus assembly
- .5 Sub-feed lugs
- .6 Through-feed lugs
- .7 A non-automatic or automatic (as scheduled) main breaker
- .8 A shunt trip for the main breaker
- .5 Acceptable Manufacturers: Acceptable manufacturers are:
 - .1 Schneider Electric (Square D)
 - .2 Eaton Corp. (Cutler-Hammer)
 - .3 Siemens Electric Ltd.

3 EXECUTION

3.1 INSTALLATION OF BRANCH CIRCUIT PANELBOARDS

- .1 Provide branch circuit panelboards where shown. Ensure adequate operation and maintenance clearance on all sides of each panelboard as per Code requirements.
- .2 Wall mount panelboards independent of connected conduit. Accurately install with reference to wall finish and confirm exact locations prior to roughing-in.
- .3 Where two or more panelboards are installed in one enclosure equip the panelboards with double lugs and increase gutter capacity to accommodate additional cabling.
- .4 In each panelboard adjacent to mechanical equipment spaces, provide a dedicated 15A-1P breaker with lock-on device, and 12 mm (½”) dia. EMT and two #12 AWG plus ground terminated in an identified junction box in the equipment space.
- .5 Provide additional devices and accessories for panelboards as indicated and/or scheduled.
- .6 For each GFI breaker demonstrate in the presence of the Consultant that the protected circuit will trip when a simulated ground fault is applied to the “load” side of the breaker, and megger the “load” side neutral to ensure that the neutral is not grounded on the “load” side of the GFI.

END OF SECTION

1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with General Requirements of Section 26 03 00.

1.2 MECHANICAL-ELECTRICAL EQUIPMENT SCHEDULE

- .1 The following Mechanical-Electrical Equipment Schedule is provided to assist the Contractor in coordinating the efforts of sub-trades. The assignment of work among subcontractors is the Contractor's responsibility and the Contractor is free to amend the schedule as he sees fit.
- .2 The Mechanical-Electrical Equipment Schedule also describes work that is required and may or may not be described elsewhere. All work indicated in the Mechanical-Electrical Equipment Schedule shall be included in the Bid Price.
- .3 The Mechanical-Electrical Equipment Schedule shall not limit the extent of the Contract in any way. Work indicated elsewhere or otherwise needed for a complete and functioning installation shall be provided whether or not shown in the Mechanical-Electrical Equipment Schedule.

1.3 RESPONSIBILITY CODES

- .1 Responsibility Codes in the Mechanical-Electrical Equipment Schedule shall be interpreted as follows
 - .1 "Supplied by Div." means that the equipment is to be supplied to the site under the Division described by number.
 - .2 "Installed by Div." means that the equipment is to be received from the supplier, handled, set in place and installed at the site under the Division described by number.
 - .3 "Wired and connected by Div." means that the equipment and its associated devices are to be wired and connected to the various electrical systems in accordance with the equipment manufacturer's installation instructions and wiring diagrams under the Division described by number.

No.	Item	Equipment		Location	Controls			Responsibility		
		Characteristics			Type	Location	Manufacturer's Reference	Supplied by Div.	Installed By Div.	Wired & Connected by Div.
1	B-1A HOT WATER BOILER	HP	FHP	MECHANICAL ROOM	Disconnect	At Unit	See Elec Spec	26	26	26
		Voltage	120		Starter	At unit	See Mech Spec	23	23	26
		Phases	1		Boiler Controls	At Boiler	See Mech Spec	23	23	25
		Freq.	60		BAS		See Mech Spec	25	25	25
					Control wiring from boiler control panel to boiler circ. pump by Div. 25. Boiler disconnect at +5'-0". Do not gang with light switch. Clearly identify with red lamacoid label.					
2	B-1B HOT WATER BOILER	HP	FHP	MECHANICAL ROOM	Disconnect	At Unit	See Elec Spec	26	26	26
		Voltage	120		Starter	At unit	See Mech Spec	23	23	26
		Phases	1		Boiler Controls	See Dwgs.	See Mech Spec	23	23	25
		Freq.	60		BAS		See Mech Spec	25	25	25
					Control wiring from boiler control panel to boiler circ. pump by Div. 25. Boiler disconnect at +5'-0". Do not gang with light switch. Clearly identify with red lamacoid label.					

No.	Equipment			Controls			Responsibility			
	Item	Characteristics		Location	Type	Location	Manufacturer's Reference	Supplied by Div.	Installed By Div.	Wired & Connected by Div.
3	BOILER PUMP BP-1A	HP	FHP	MECHANICAL ROOM	Disconnect	At Pump	In starter	26	26	26
		Voltage	120		Starter	Near Unit	AB 512 Series	26	26	26
		Phases	1		Other Controls	See mech spec	See mech spec	23	23	25
		Freq.	60							
4	BOILER PUMP BP-1B	HP	FHP	MECHANICAL ROOM	Disconnect	At Pump	In starter	26	26	26
		Voltage	120		Starter	Near Unit	AB 512 Series	26	26	26
		Phases	3		Other Controls	See mech spec	See mech spec	23	23	25
		Freq.	60							
5	BUILDING HEATING LOOP PUMP CP-1A	HP	1 1/2	MECHANICAL ROOM #2	VFD c/w Disconnect	See Drawings.	See Mech. Spec	23	23	26
		Voltage	208		Other Controls	See mech spec	See mech spec	23	23	25
		Phases	3		BAS	See mech spec	See mech spec	25	25	25
		Freq.	60							
6	BUILDING HEATING LOOP PUMP CP-1B	HP	1 1/2	MECHANICAL ROOM	VFD c/w Disconnect	See Drawings.	See Mech. Spec	23	23	26
		Voltage	208		Other Controls	See mech spec	See mech spec	23	23	25
		Phases	3		BAS	See mech spec	See mech spec	25	25	25
		Freq.	60							
7	PORTABLES' HEATING LOOPCP-2	HP	1	MECHANICAL ROOM	VFD c/w Disconnect	See Drawings.	See Mech. Spec	23	23	26
		Voltage	208		Other Controls	See mech spec	See mech spec	23	23	25
		Phases	3		BAS	See mech spec	See mech spec	25	25	25
		Freq.	60							
8	CABINET UNIT HEATER	HP	1/2	PORTABLES CORRIDOR EXIT DOOR	Disconnect/Starter	At Unit	See Spec.	23	23	26
		Voltage	120		Thermostat	See mech drawings	See mech spec	23	26	26
		Phases	1							
		Freq.	60							

END OF SECTION


File: j:\Drawings\15-199 St.Elizabeth catholic school\3-Working Documents\E-1-2-3-4-ELEC.DWG
April 18, 2016 - 10:33am Plotted by: janicez

LEGEND		
THIS LEGEND OF SYMBOLS REPRESENTS VANDERWESTEN RUTHERFORD MANTECON INC. STANDARD/GENERIC LEGEND. ALL SYMBOLS MAY NOT APPEAR ON THE DRAWINGS.		
SYMBOL	DESCRIPTION	MTG HT Ⓞ
	FLUORESCENT FIXTURE	AS NOTED
	SPECIAL RECEPTACLE (REFER TO DRAWINGS)	AS NOTED
	DIRECT CONNECTION (REFER TO DRAWINGS)	AS NOTED
	ELECTRICAL PANEL	1981 (78") TO TOP
	MOTOR CONNECTION (SINGLE OR THREE PHASE)	---
	MOTOR/DISCONNECT CONNECTION (SINGLE OR THREE PHASE)	---
	DISCONNECT SWITCH	1270 (50")
	MANUAL MOTOR STARTER	1170 (46")
	MAGNETIC MOTOR STARTER	1170 (46")
	COMBINATION STARTER AND DISCONNECT	1270 (50")
	MOTORIZED DAMPER	---
	THERMOSTAT	1040 (41")
	HUMIDISTAT	1040 (41")
	JUNCTION BOX (REFER TO DRAWINGS)	---
	15AMP 125VOLT U-GROUND DUPLEX RECEPTACLE	457 (18")
ER	EXISTING TO BE REMOVED	
EX	EXISTING TO REMAIN	
REL	EXISTING TO BE RELOCATED	

GENERAL NOTES (RENOVATION NOTES)	
1.	DO NOT SCALE DRAWINGS FOR INSTALLATION PURPOSES. OBTAIN ALL DIMENSIONS FROM ARCHITECTURAL PLANS, MANUFACTURER'S SHOP DRAWINGS, AND ON SITE INSPECTIONS.
2.	PRIOR TO INSTALLATION OF BOXES IN WALLS, VERIFY THAT NO INTERFERENCES EXIST. CHECK ARCHITECTURAL PLANS AND ELEVATIONS.
3.	MECHANICAL AND ELECTRICAL TRADES SHALL WORK IN CONJUNCTION WITH ONE ANOTHER SO AS TO AVOID INTERFERENCES BETWEEN PIPING, DUCTWORK, CONDUIT, LIGHTING FIXTURES, ETC.
4.	WORK IN CONJUNCTION WITH ARCHITECTURAL REFLECTED CEILING PLAN WHEN LOCATING LIGHT FIXTURES.
5.	ALL EXISTING DEAD WIRING AND CONDUIT IN RENOVATED AREAS SHALL BE REMOVED IN ITS ENTIRETY WHERE ACCESSIBLE. WHERE NOT ACCESSIBLE, WIRING ONLY SHALL BE REMOVED AND CONDUIT SHALL REMAIN.
6.	REWORK ALL EXISTING WIRING, CONDUIT, ETC. REMAINING IN USE AND FALLING WITHIN EXISTING WALLS WHICH ARE BEING REMOVED, TO NEAREST EXISTING WALLS REMAINING. ALL REWORKED WIRING SHALL BE CONCEALED.
7.	DISCONNECT AND REMOVE ANY ELECTRICAL EQUIPMENT IN CEILING SPACE OR WALLS THAT CAUSES INTERFERENCES DURING RENOVATION WORK. ALL EQUIPMENT SHALL BE REPLACED AND RECONNECTED UPON COMPLETION OF RENOVATION WORK.
8.	ELECTRICAL EQUIPMENT BEING REMOVED AND NOT BEING REUSED WILL BE STORED ON SITE AND REMAIN THE PROPERTY OF THE OWNER. ANY SUCH EQUIPMENT THE OWNER DOES NOT WISH TO RETAIN WILL BE REMOVED FROM SITE AND DISPOSED OF BY THIS TRADE.
9.	REVIEW ARCHITECTURAL, MECHANICAL, AND STRUCTURAL DRAWINGS AND PROVIDE ON SITE INSPECTIONS TO DETERMINE FULL EXTENT OF PROJECT PRIOR TO SUBMITTING BID.
10.	POWER AND CONTROL WIRING MUST RISE TO ROOFTOP EQUIPMENT WITHIN CURB OF UNIT UNLESS OTHERWISE APPROVED BY CONSULTANT. CONFIRM EXACT LOCATION ON SITE WITH CONSULTANT BEFORE INSTALLATION.

ELECTRICAL DRAWING LIST	
E-1	ELECTRICAL DRAWING LIST, LEGENDS, NOTES AND SCHEDULES
E-2	BOILER ROOM FLOOR PLAN - ELECTRICAL DEMOLITION, NEW PANEL SCHEDULE
E-3	BOILER ROOM FLOOR PLAN - ELECTRICAL NEW, PARTIAL SERVICE RISER
E-4	FLOOR PLAN - ELECTRICAL DEMO + NEW

1	ISSUED FOR TENDER	APRIL 18, 2016
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 VRM #15-199 VANDERWESTEN RUTHERFORD MANTECON INC. CONSULTING STRUCTURAL/MECHANICAL/ELECTRICAL ENGINEERS LONDON • HAMILTON • WINDSOR • OTTAWA 7242 COLONEL TALBOT ROAD, LONDON, ONTARIO, N6L 1H8 PHONE: (519)652-5047 • FAX: (519)652-5058 • www.vrmeng.com	Project: SCCDSB - ST. ELIZABETH CATHOLIC SCHOOL - BOILER REPLACEMENT	Drawn By: JZ	Checked By: MGJ
	Drawing Title: ELECTRICAL DRAWING LIST, LEGENDS, NOTES AND SCHEDULES	Date: APR.18, 2016	Scale: N.T.S.

File: j:\Drawings\15-199 St.Elizabeth catholic school\3-Working Documents\E-1-2-3-4-ELEC.DWG
April 18, 2016 - 10:49am Plotted by: janicez

PANEL 'C'		225AMP 120/208V 3Ø 4W					SURFACE	
		NQ TYPE MECH 101 BEHIND DOOR						
WATTS FOR	P	AMP	CCT	CCT	AMP	P	FOR	WATTS
EXH FAN #2	1	15	1	2	15	1	DOOR OPERATOR	
EXH FAN #3	1	15	3	4	15	1	R.A. COOLER	
AIR COMPRESSOR	2	15	5	6	15	1	FRIDGE	
			7	8	*	1	HEATER	
BOILER RM HEAT	1	15	9	10				
* 1860 BOILER B-1A	1	20	11	12	15	3	CIRC PUMP CP-1A, 1.5 HP, 208V 3Ø	2400
HRV's	1	15	13	14				
TEMP CONTROL	1	15	15	16	15	1	SPARE	
* 1860 BOILER B-1B	1	20	17	18	15	2	OUTDOOR LIGHTING	
SPARE	1	15	19	20				
HOT WATER	1	15	21	22	15	1	RM #117 REC	
EMERG LIGHTS W	1	15	23	24				
500 BOILER PUMP BP-1A	1	15	25	26	15	3	CIRC PUMP CP-1A, 1.5 HP, 208V 3Ø	2400
500 BOILER PUMP BP-1B	1	15	27	28				
			29	30	15	1	SPARE	
1270 CIRC PUMP CP-2, 0.75HP, 208V,3Ø	3	15	31	32	15	1	SPARE	
			33	34	15	1	SPARE	
SPARE	1	15	35	36	15	1	SPARE	
SPARE	1	15	37	38	15	1	SPARE	
SPARE	1	15	39	40	15	1	SPARE	
SPARE	1	15	41	42	15	1	SPARE	

* CONFIRM BREAKER SIZE BEFORE ORDERING AND PROVIDE. RECONNECT EXISTING ITEMS (INDICATED IN LIGHTER TEXT). DARKER TEXT INDICATES NEW CONNECTIONS.

DEMOLITION NOTES

ELECTRICAL SYSTEMS SHOWN ON DEMOLITION PLANS ARE BASED ON INFORMATION OBTAINED FROM SITE VISIT. THESE DRAWINGS ARE NOT BASED ON 'AS-BUILT RECORDS' OR ON EXHAUSTIVE FIELD MEASUREMENT AND ARE PROVIDED TO ASSIST THE CONTRACTOR IN DETERMINING THE EXTENT OF WORK REQUIRED. THE CONTRACTOR SHALL MAKE ALLOWANCE IN THEIR TENDER PRICE FOR THE REMOVAL OF ADDITIONAL ABANDONED SERVICES AND THE PROTECTION OF EXISTING SERVICES THAT MUST REMAIN. RECORD THE LOCATION OF ALL EXISTING SERVICES THAT REMAIN ON AS-BUILT RECORD DRAWINGS.

NOTES:

1. WORK IN CONJUNCTION WITH PHASING AND SEQUENCING OF BOILER REMOVAL AND REINSTALLATION. COORDINATE WITH BUILDING OWNER AND MECH TRADE.
2. REMOVE WIRING BACK TO SOURCE. REMOVE CONDUIT BACK TO CONCEALED LOCATION.
3. REMOVE ABANDONED STARTERS AND DISCONNECTS AT THE WIREWAY, FOR PUMPS BEING REMOVED.

DISCONNECT EXISTING BP FOR REMOVAL BY MECH. REMOVE WIRING BACK TO SOURCE. REMOVE CONDUIT BACK TO CONCEALED LOCATION

EXISTING UNIT HEATER TO REMAIN

WATER HEATER TO REMAIN

EXISTING BOILER TO BE REMOVED BY MECH TRADES

EXISTING FIRE ALARM DEVICES TO REMAIN

EX EXISTING TO REMAIN

ER EXISTING TO BE REMOVED


EXISTING LIGHTING TO REMAIN; ALLOW FOR REMOVAL AND REINSTALL/ RECONNECT TO FACILITATE MECHANICAL INSTALLATIONS. CONFIRM LTG ON SITE

NOTE 3

DISCONNECT EXISTING CIRC PUMP CP-2 FOR REMOVAL BY MECH TRADES. REMOVE WIRING BACK TO SOURCE. REMOVE CONDUIT BACK TO CONCEALED LOCATION

DISCONNECT EXISTING CIRC PUMP CP-1, FOR REMOVAL BY MECH TRADES. REMOVE WIRING BACK TO SOURCE. REMOVE CONDUIT BACK TO CONCEALED LOCATION

EXISTING PANEL C (TAYLOR 120/240V 1Ø 3W) TO BE DISCONNECTED, REMOVED AND EXISTING LOADS THAT REMAIN IN USE RECONNECTED.


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Project:
SCCDSB - ST. ELIZABETH
CATHOLIC SCHOOL - BOILER
REPLACEMENT

Drawing Title:
BOILER ROOM FLOOR PLAN -
ELECTRICAL DEMOLITION,
NEW PANEL SCHEDULE

Drawn By:
JZ

Date:
APR.18, 2016

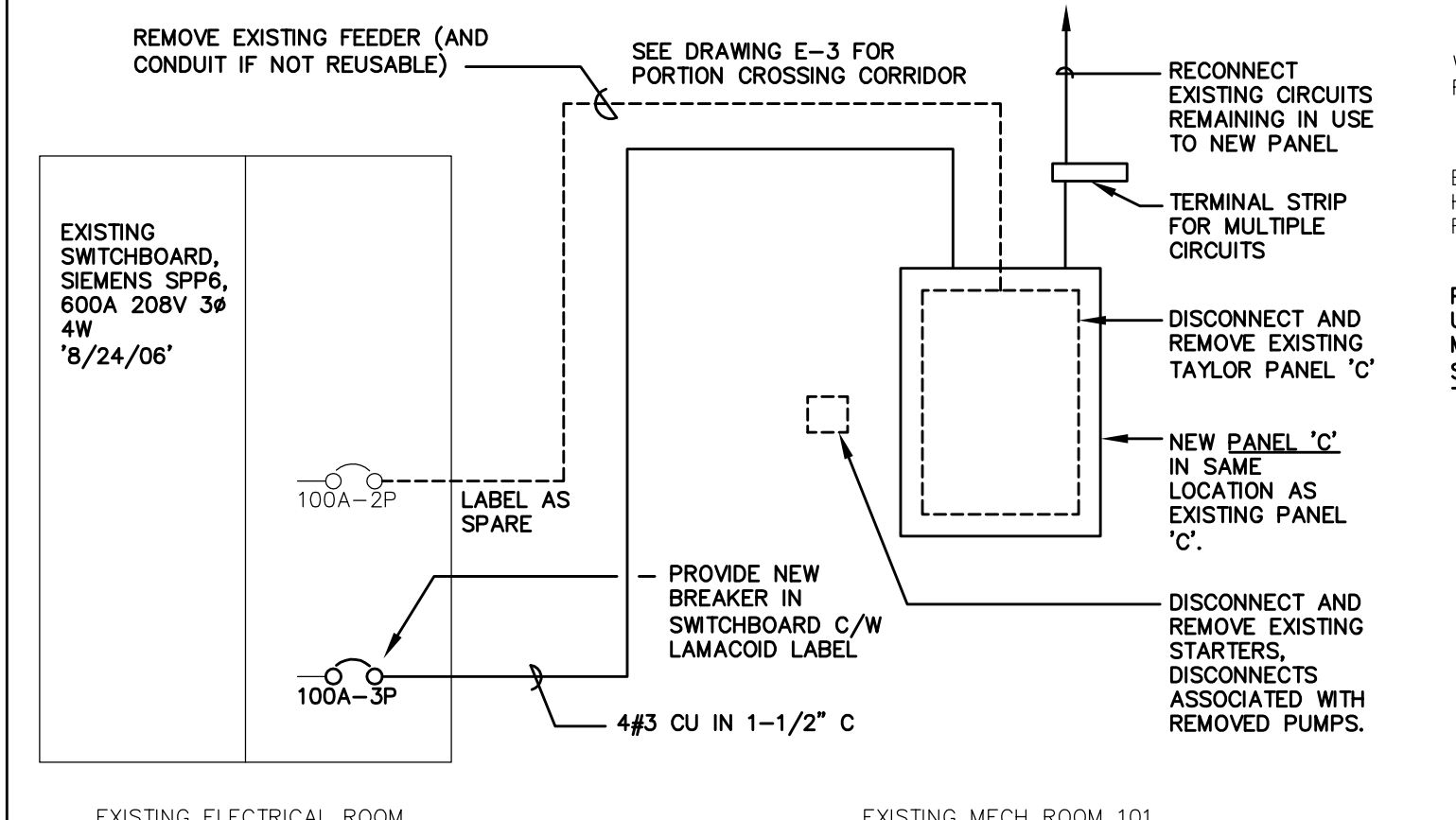
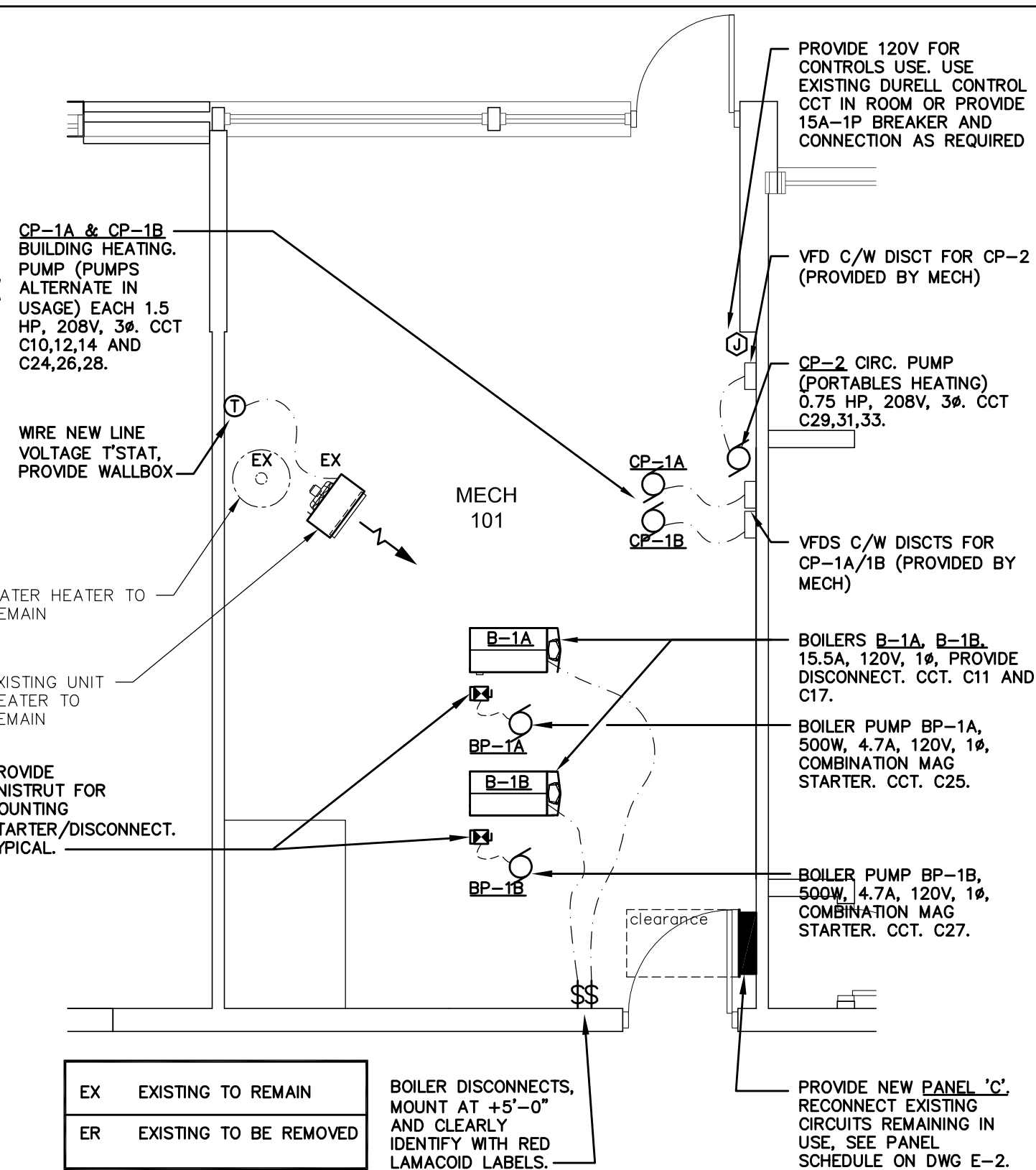
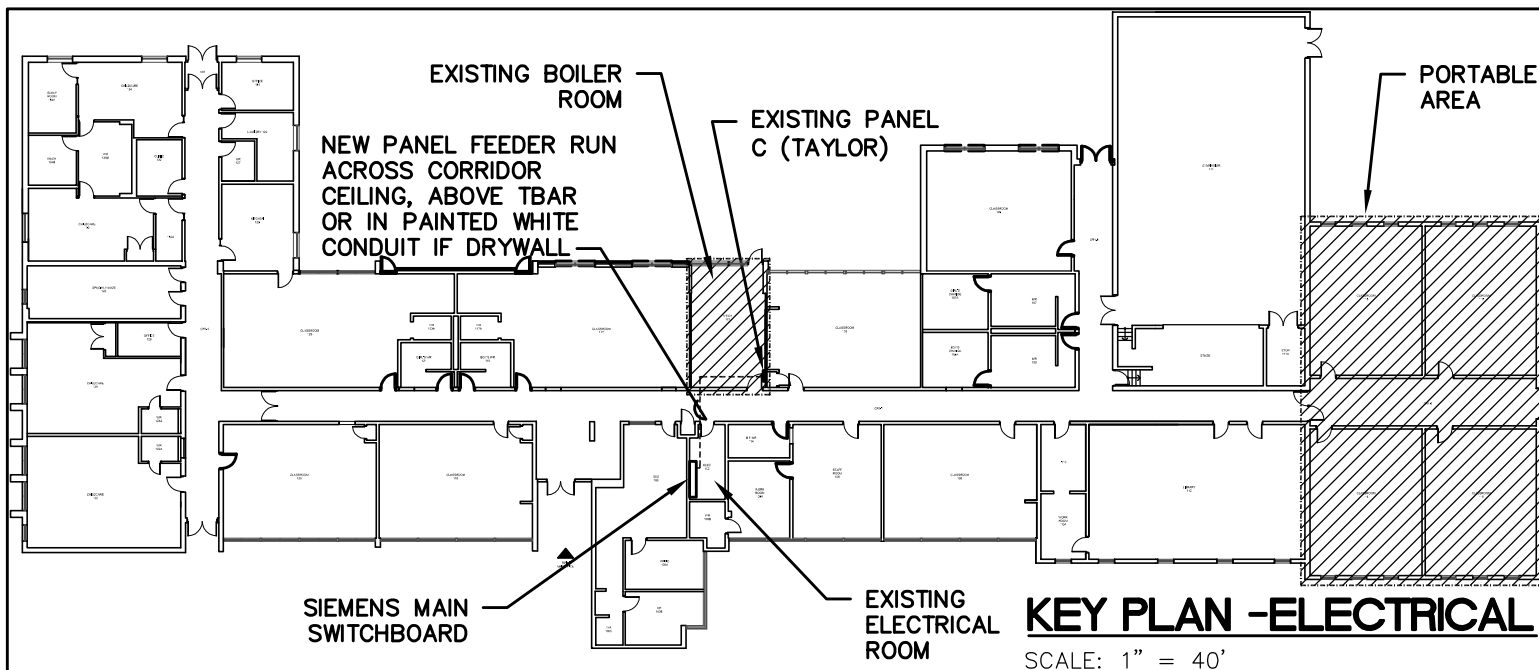
Drawing No.:

Checked By:
MGJ

Scale:
1/4"=1'-0"

E-2

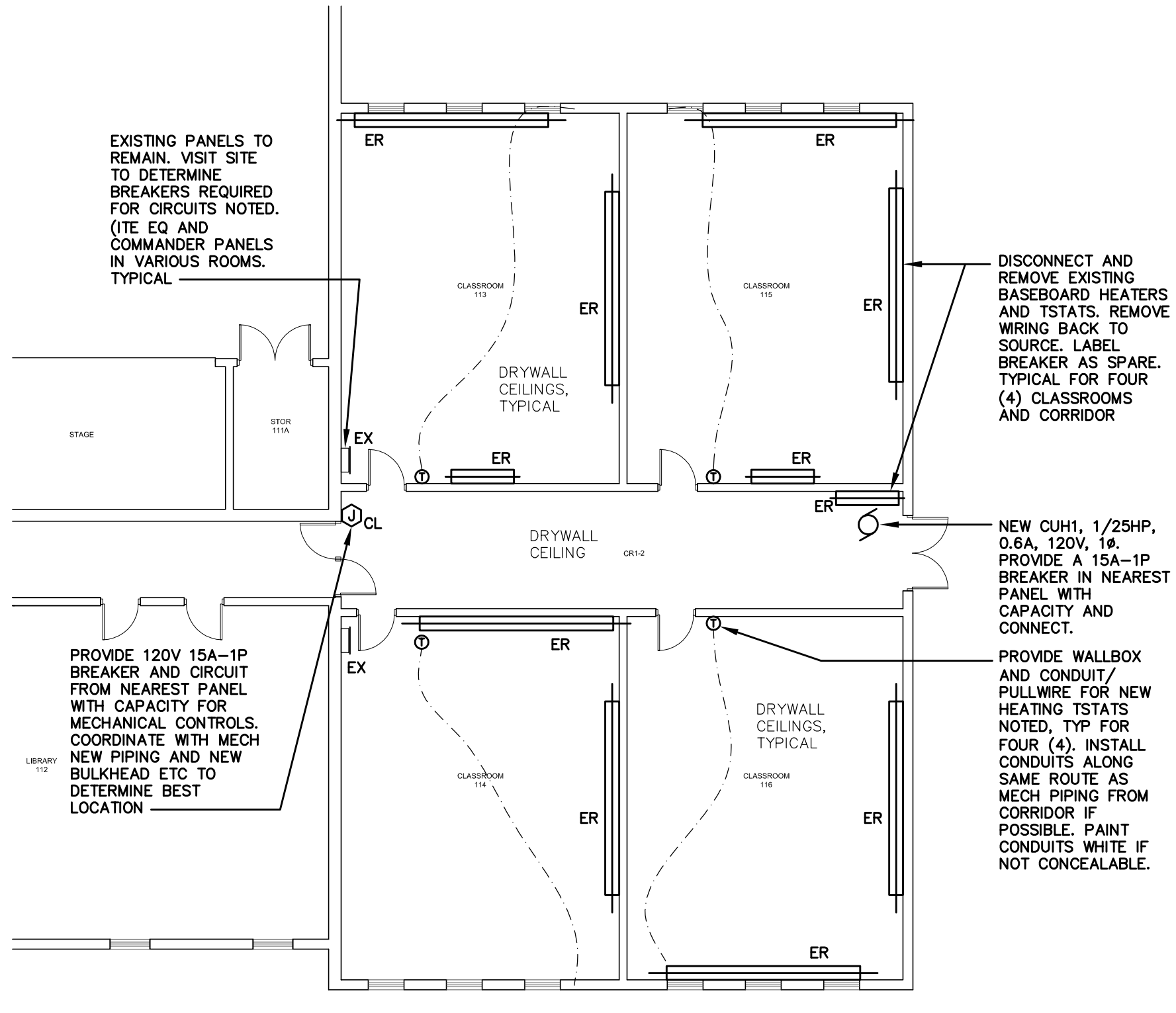
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April 18, 2016 - 10:42am Plotted by: janicez




EX	EXISTING TO REMAIN
ER	EXISTING TO BE REMOVED

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				Drawing Title: BOILER ROOM FLOOR PLAN - ELECTRICAL NEW	Date: APR.18, 2016	Scale: 1/4"=1'-0"
				Drawing No.: E-3		

File: j:\Drawings\15-199 St.Elizabeth catholic school\3-Working Documents\E-1-2-3-4-ELEC.DWG
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EX	EXISTING TO REMAIN
ER	EXISTING TO BE REMOVED

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				Drawing No.: E-4		

File: j:\Drawings\15-199 St.Elizabeth catholic school\3-Working Documents\M-1-5-HVAC.dwg
April 18, 2016 - 09:46am Plotted by: stephenvm

LEGEND OF SYMBOLS - HVAC

SYMBOL	DESCRIPTION
	EXISTING PIPING TO BE REMOVED
	EXISTING PIPING TO REMAIN
	HOT WATER HEATING SUPPLY
	HOT WATER HEATING RETURN
	PIPING RISER UP
	PIPING DROP
	INLINE PUMP
	STRAINER
	2-WAY CONTROL VALVE
	ISOLATING (SHUT-OFF) VALVE
	CIRCUIT BALANCING VALVE
	CHECK (FLOW CONTROL)
	SAFETY (S) OR RELIEF (R) VALVE
	DRAIN COCK
	BACKFLOW PREVENTOR
	THERMOMETER
	PRESSURE GAUGE
	AUTOMATIC AIR VENT
	FLOW SWITCH
	LOW WATER CUTOFF DEVICE
	PET COCK
	THERMOSTAT
	CONNECT TO EXISTING
	GAS PIPING
	CAPPED PIPE

NOTE: NOT ALL SYMBOLS MAY BE USED ON THIS PROJECT.

THE MECHANICAL CONTRACTOR IS TO ACT AS A GENERAL CONTRACTOR FOR ALL WORK ASSOCIATED WITH THIS CONTRACT. GENERAL CONTRACTOR (MECH. CONTRACTOR) TO COORDINATE ALL DIVISIONAL AND SUB-TRADE WORK, AND ENSURE THAT ALL WORK IS COMPLETED BY AN APPROVED SUB-TRADE.

GENERAL NOTES

1. THE CONTRACTOR SHALL HAVE PENETRATIONS MADE OR REPAIRED SEALED BY AN APPROVED CONTRACTOR.
2. DO NOT SCALE DRAWINGS FOR INSTALLATION PURPOSES. OBTAIN ALL DIMENSIONS FROM MANUFACTURER'S SHOP DRAWINGS AND SITE INSPECTIONS.
3. MECHANICAL AND ELECTRICAL TRADES SHALL WORK IN CONJUNCTION WITH ONE ANOTHER SO AS TO AVOID INTERFERENCES
4. PROPERLY SUPPORT EQUIPMENT AND ANY OTHER MECHANICAL SYSTEMS INDEPENDENT OF CEILING SUPPORT SYSTEM.
5. ALL INSTALLATIONS SHALL BE IN ACCORDANCE WITH CODES, AMENDMENTS, BULLETINS ETC. AND REQUIREMENTS OF ALL INSPECTION AUTHORITIES FOR THE CITY OF CHATHAM.
6. EXISTING MECHANICAL SERVICES SHOWN ON THESE DRAWINGS WERE TAKEN FROM THE ORIGINAL DRAWINGS. THE CONTRACTOR SHALL VERIFY EXACT SIZE AND LOCATION OF ALL EXISTING SERVICES ON SITE AND SHALL REMOVE ALL REDUNDANT SERVICES IN THE AREAS OF CONSTRUCTION.
7. ALL PLUMBING PIPING SYSTEMS AND EQUIPMENT SHALL BE INSTALLED AS PER ONTARIO BUILDING CODE.
8. ALL CONDENSATE LINES TO BE TRAPPED AT UNITS. PROVIDE MIN. 2% SLOPE ON ALL HORIZONTAL CONDENSATE LINES
9. ALL WORK DONE WITHIN THIS PROJECT TO BE COORDINATED WITH OTHER ONGOING WORK WITHIN THE BUILDING AND BOILER ROOM.

MECHANICAL DRAWING LIST

- M-1 MECHANICAL DRAWING LIST, LEGENDS, NOTES AND SCHEDULES
- M-2 BOILER ROOM FLOOR PLAN - HVAC DEMOLITION
- M-3 BOILER ROOM FLOOR PLAN - HVAC NEW
- M-4 FLOOR PLAN - HVAC NEW
- M-5 BOILER ROOM PIPING SCHEMATIC
- M-6 MECHANICAL DETAILS
- M-7 MECHANICAL SCHEDULES



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Project:
SCCDSB - ST. ELIZABETH
CATHOLIC SCHOOL - BOILER
REPLACEMENT

Drawn By:
ND

Checked By:
SVM

Date:
FEB 12, 2016

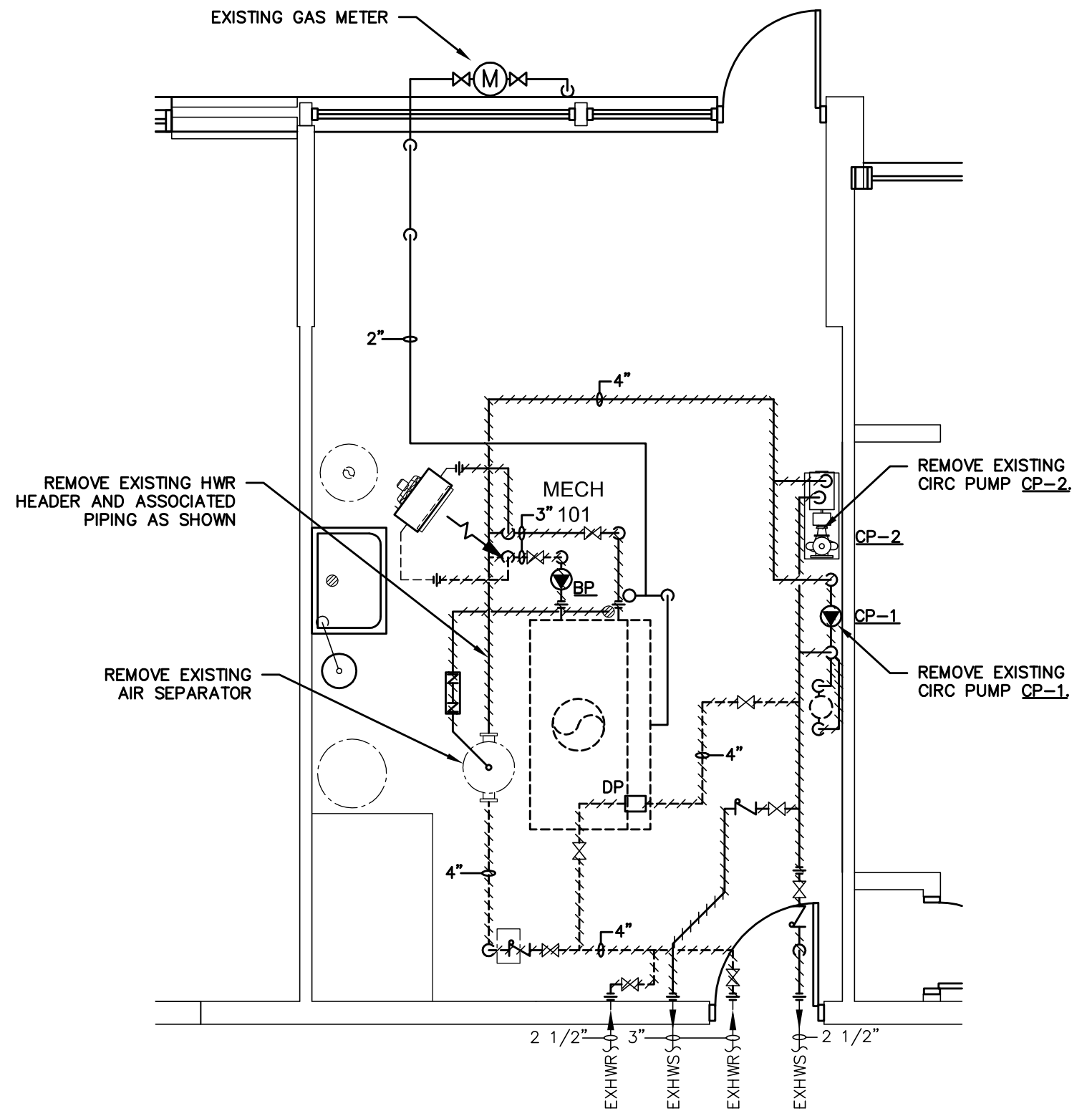
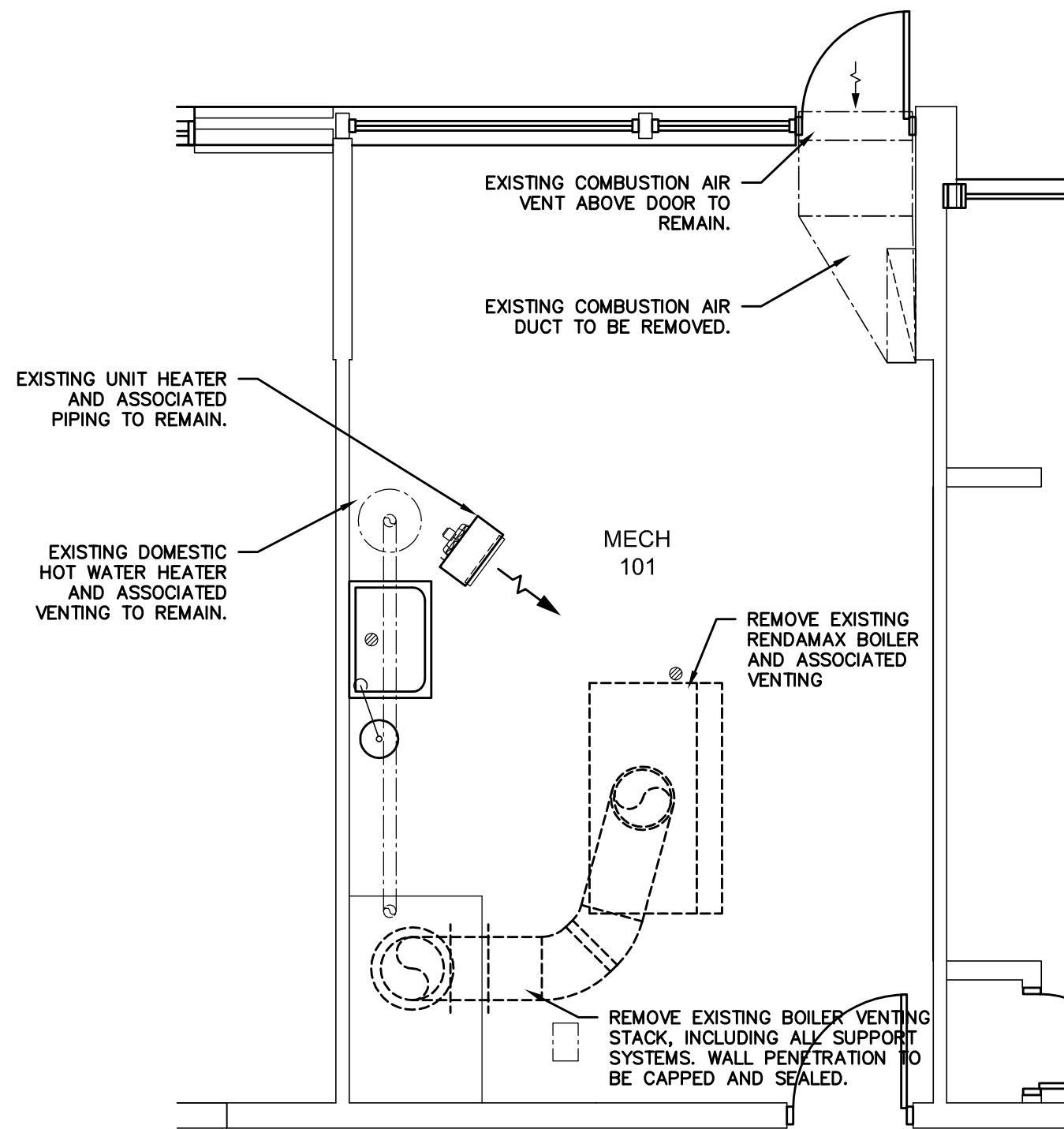
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Drawing Title:
MECHANICAL DRAWING LIST,
LEGENDS, NOTES AND
SCHEDULES

Drawing No.:

M-1

File: j:\Drawings\15-199 St.Elizabeth catholic school\3-Working Documents\M-1-5-HVAC.dwg
 April 18, 2016 - 09:47am Plotted by: stephenm



NOTES:

1. CONTRACTOR SHALL START DEMOLITION AND REMOVAL OF BOILER ROOM EQUIPMENT AFTER COMPLETE COORDINATION AND APPROVAL FROM THE BUILDINGS OWNER.
2. DISCONNECT AND MAKE SAFE ALL MECHANICAL AND ELECTRICAL SERVICES TO THE BOILER ROOM EQUIPMENT REQUIRED TO BE REMOVED.
3. REMOVE AND DISPOSE OFFSITE THE EXISTING HEATING BOILERS AND DEDICATED ACCESSORIES, PIPING, AND FLUE VENTING SYSTEM.
4. CONTRACTOR SHALL REPAIR THE WALLS AND FLOOR AFFECTED BY THIS CONTRACT TO MATCH EXISTING.
5. REMOVE/DISPOSE OF ALL EXISTING DEMO EQUIPMENT OFF-SITE.
6. DISCONNECT AND REMOVE ALL REDUNDANT AND ABANDONED BOILER CONTROLS.

1	ISSUED FOR TENDER	APRIL 18, 2016
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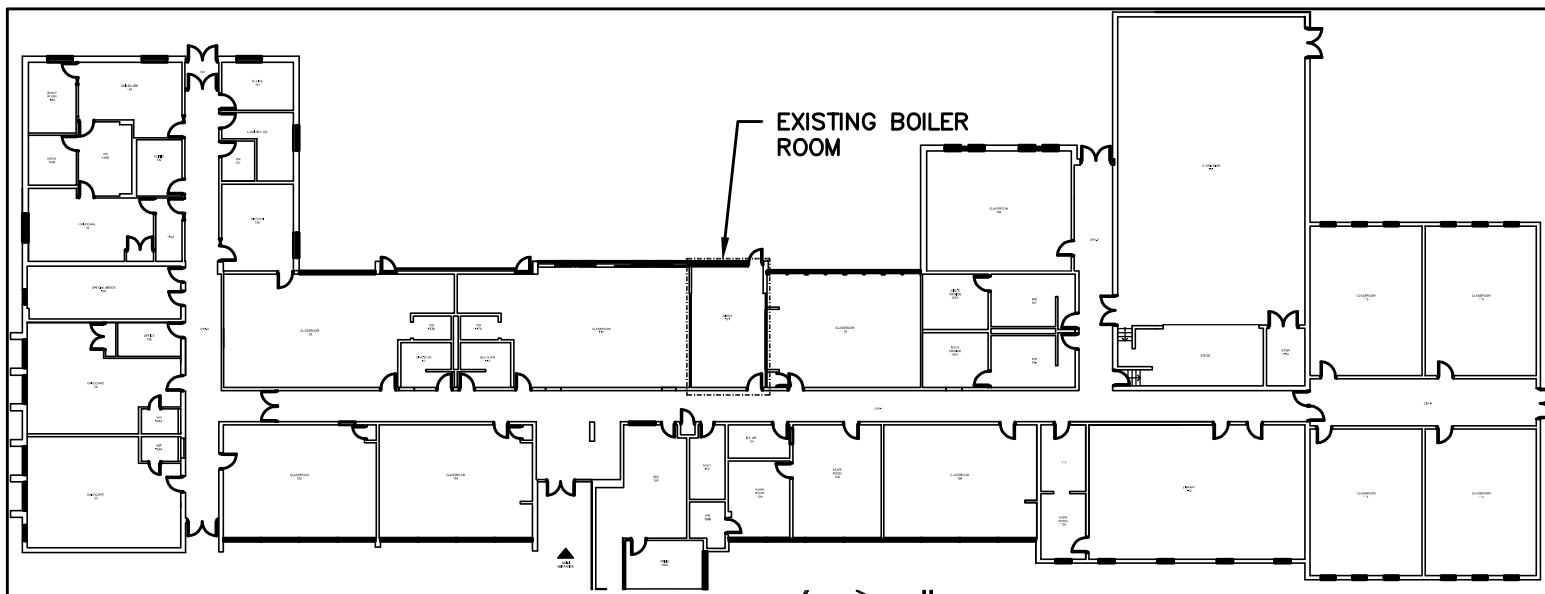
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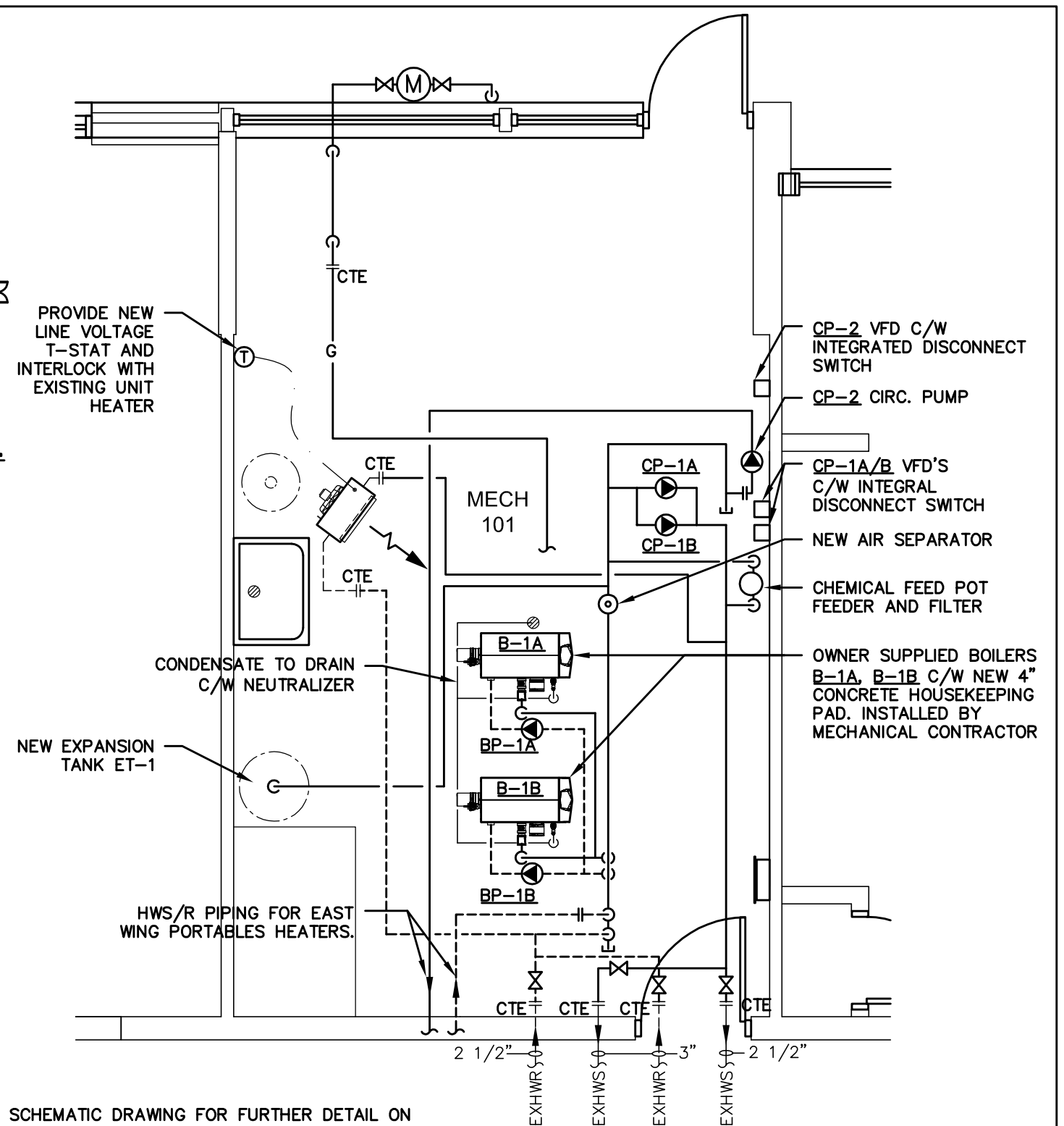
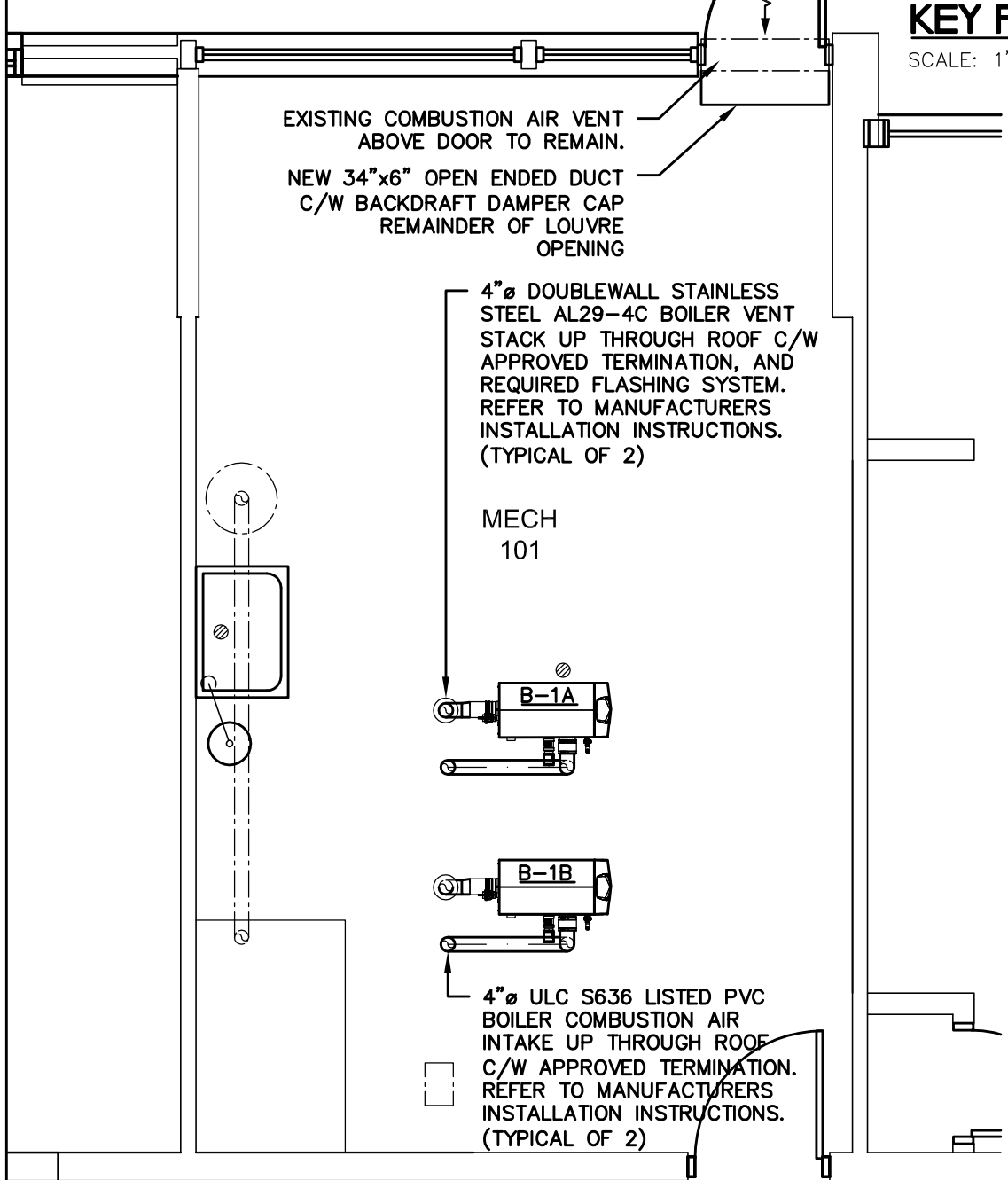
Project: SCCDSB - ST. ELIZABETH CATHOLIC SCHOOL - BOILER REPLACEMENT	Drawn By: ND	Checked By: SVM
Drawing Title: BOILER ROOM FLOOR PLAN - HVAC DEMOLITION	Date: FEB 12, 2016	Scale: 1/4" = 1'-0"
Drawing No.: M-2		

File: j:\Drawings\15-199 St.Elizabeth catholic school\3-Working Documents\M-1-5-HVAC.dwg
 April 18, 2016 - 09:47am Plotted by: stephenvm



KEY PLAN -MECHANICAL

SCALE: 1" = 40'



NOTES:

1. REFER TO SCHEMATIC DRAWING FOR FURTHER DETAIL ON PIPING AND ASSOCIATED VALVES AND ACCESSORIES.
2. BOILER SUPPLIED BY OWNER AND INSTALLED BY MECHANICAL CONTRACTOR.



VRM #15-199

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 7242 COLONEL TALBOT ROAD, LONDON, ONTARIO, N6L 1H8
 PHONE: (519)652-5047 • FAX: (519)652-5058 • www.vrmeng.com

Project:
 SCCDSB - ST. ELIZABETH CATHOLIC SCHOOL - BOILER REPLACEMENT

Drawing Title:
 BOILER ROOM FLOOR PLAN - HVAC NEW

Drawn By:
 ND

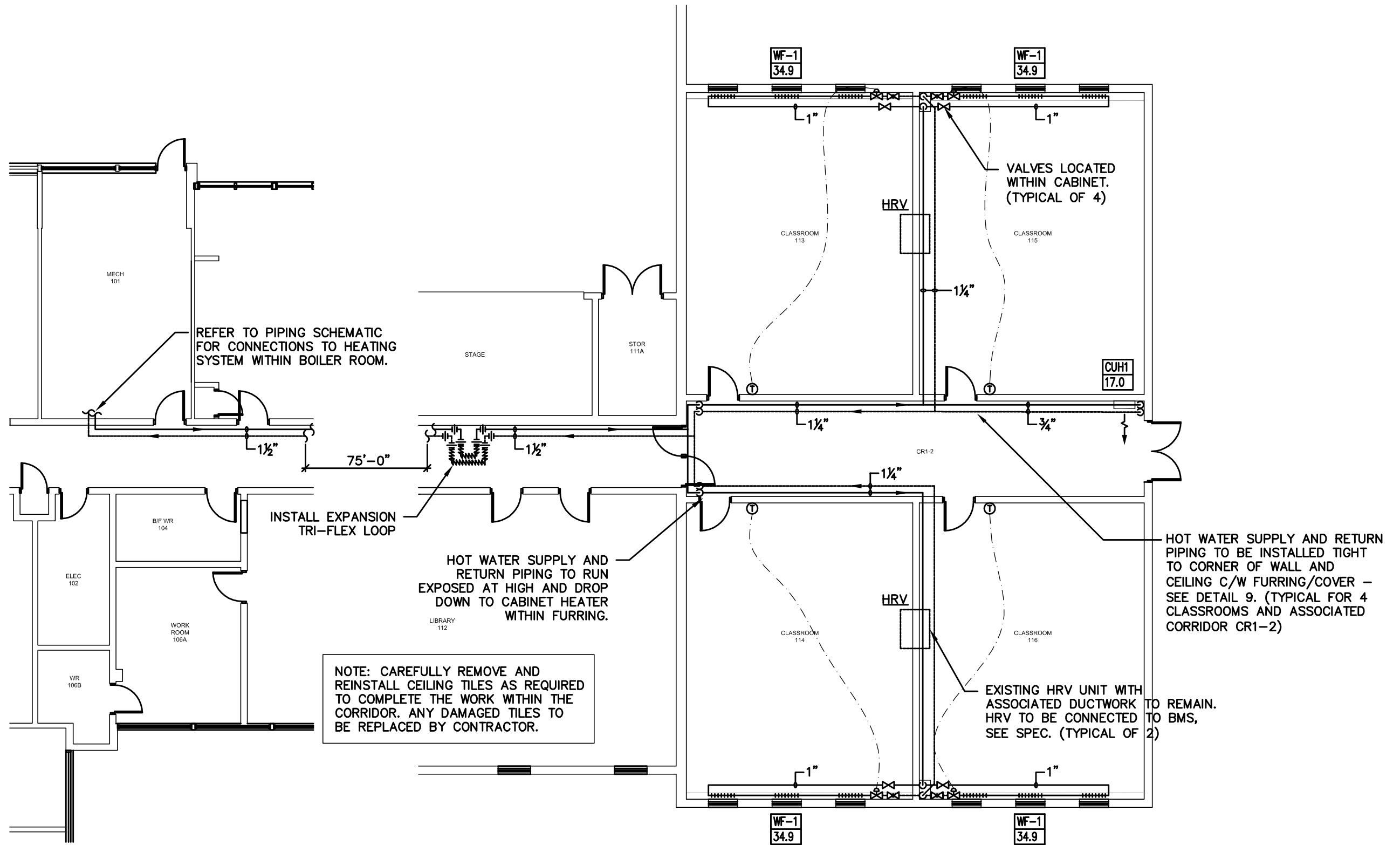
Checked By:
 SVM

Date:
 FEB 12, 2016

Scale:
 1/4"=1'-0"

Drawing No.:
M-3

File: j:\Drawings\15-199 St.Elizabeth catholic school\3-Working Documents\M-1-5-HVAC.dwg
 April 18, 2016 - 09:47am Plotted by: stephenvm



1	ISSUED FOR TENDER	APRIL 18, 2016
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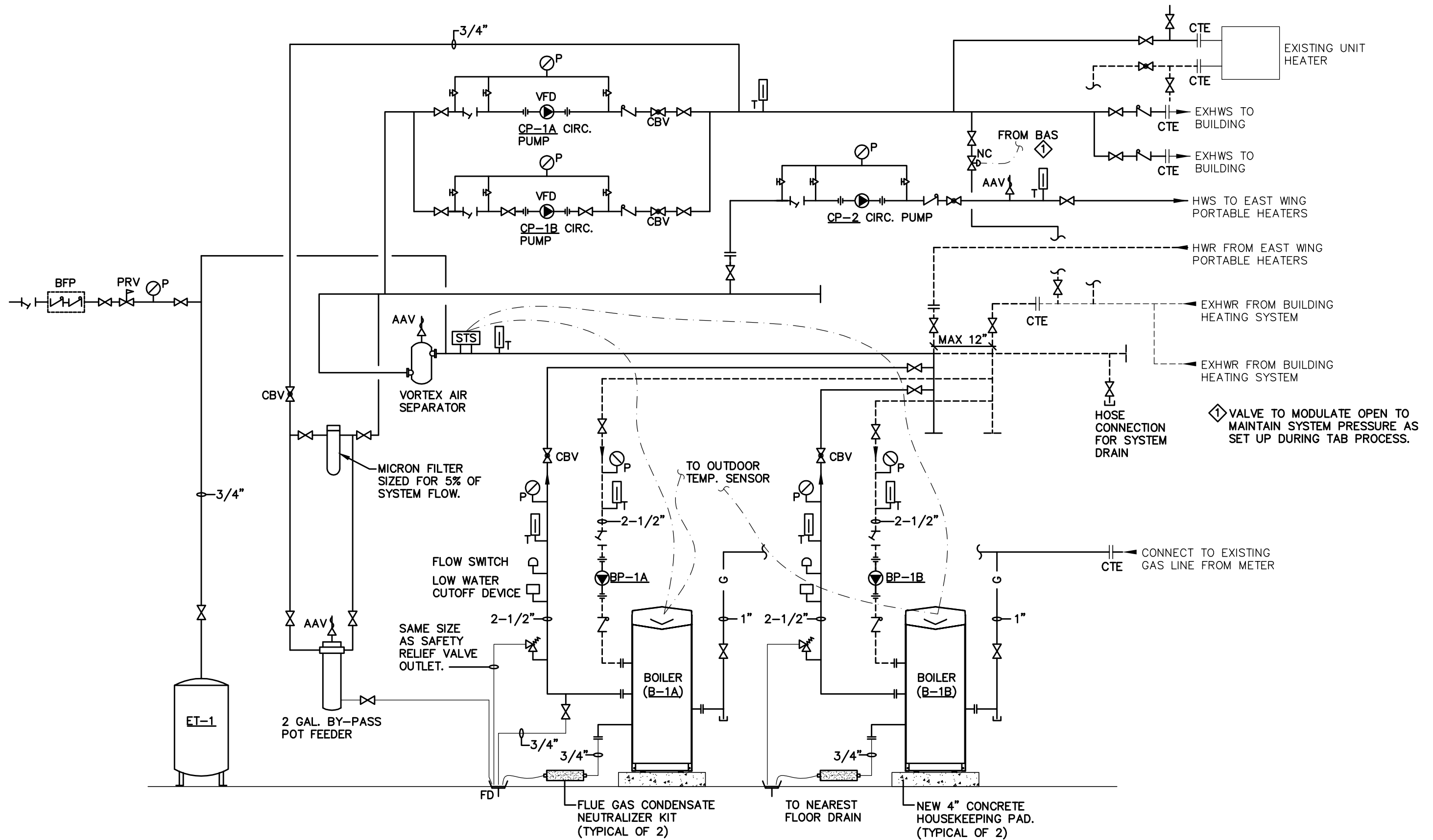

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Project: SCCDSB - ST. ELIZABETH CATHOLIC SCHOOL - BOILER REPLACEMENT	
Drawing Title: FLOOR PLAN - HVAC NEW	

Drawn By: ND	Checked By: SVM
Date: FEB 12, 2016	Scale: 3/32" = 1'-0"
Drawing No.: M-4	

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 April 18, 2016 - 09:47am Plotted by: stephenvm



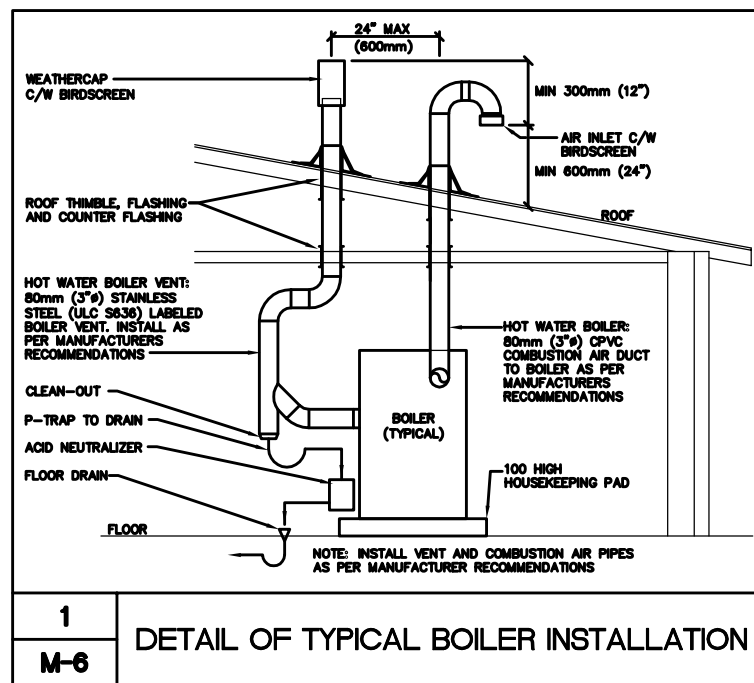
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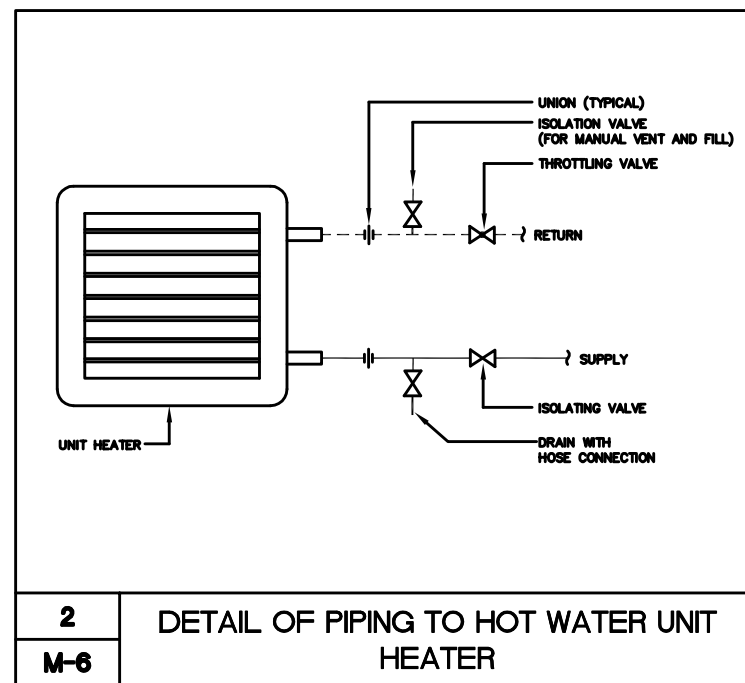
Project: SCCDSB - ST. ELIZABETH CATHOLIC SCHOOL - BOILER REPLACEMENT
Drawing Title: BOILER ROOM PIPING SCHEMATIC

Drawn By: ND	Checked By: SVM
Date: FEB 12, 2016	Scale: N.T.S.
Drawing No.: M-5	

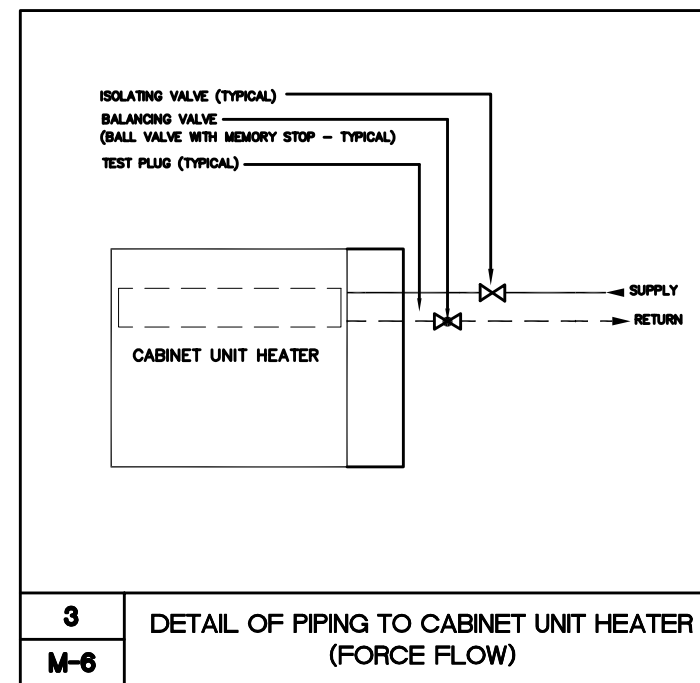
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April 18, 2016 - 09:54am Plotted by: stephenvm



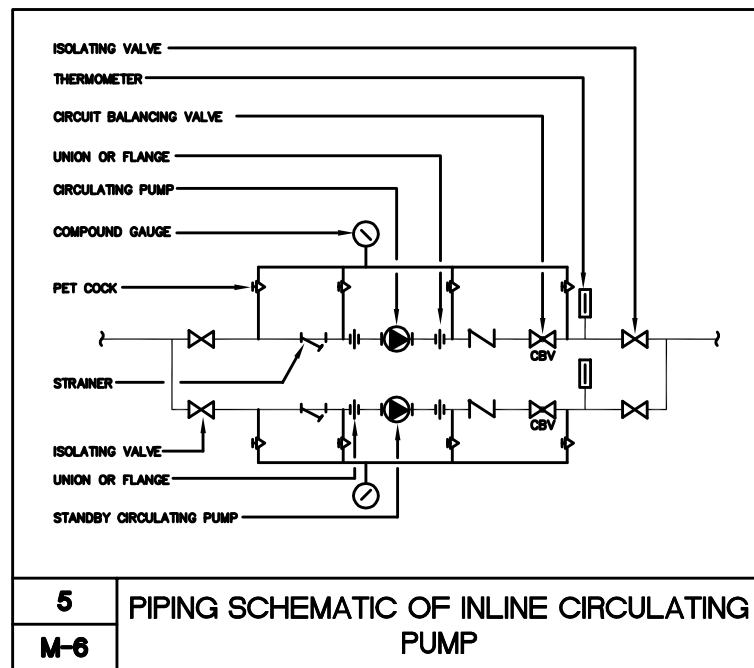
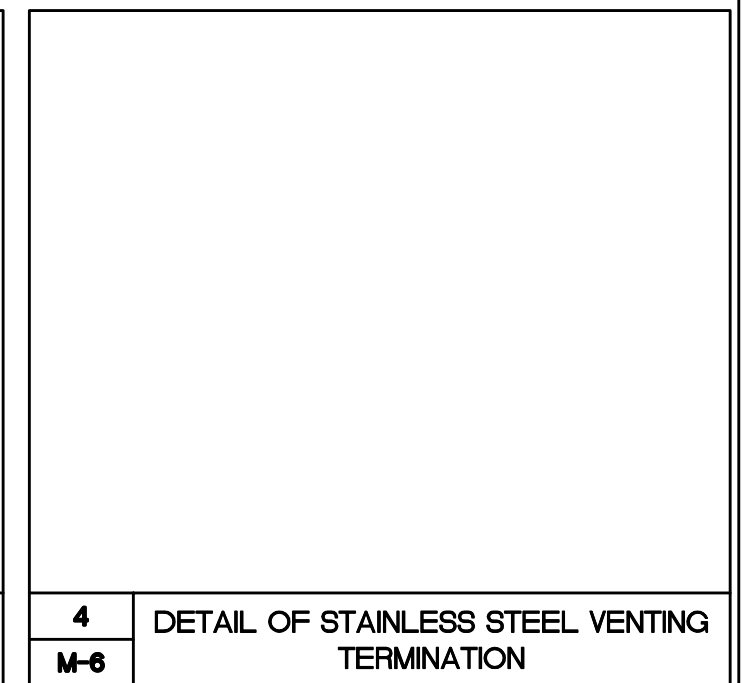
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M-6 DETAIL OF TYPICAL BOILER INSTALLATION



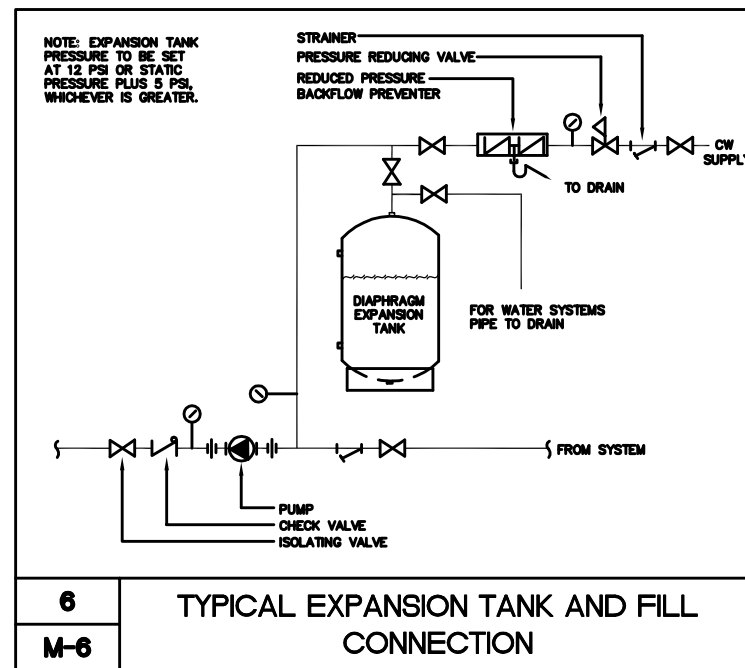
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M-6 DETAIL OF PIPING TO HOT WATER UNIT HEATER



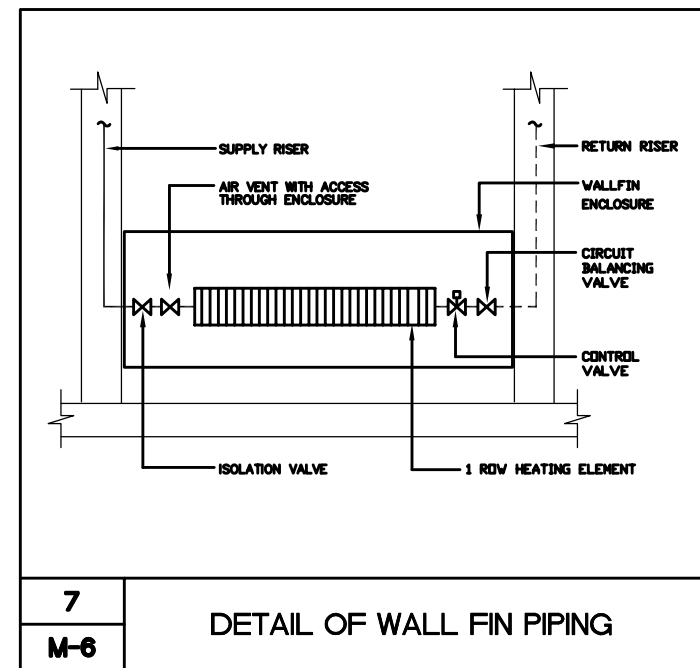
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M-6 DETAIL OF PIPING TO CABINET UNIT HEATER (FORCE FLOW)



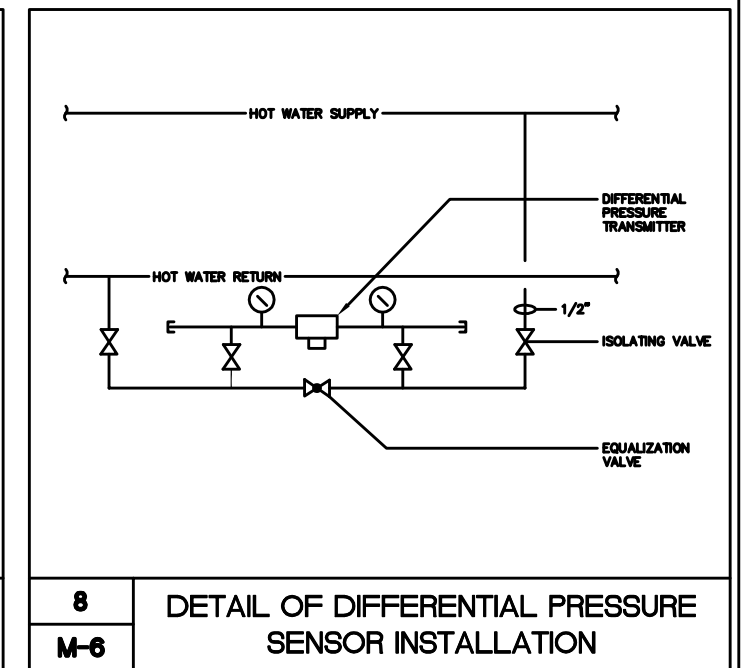
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M-6 PIPING SCHEMATIC OF INLINE CIRCULATING PUMP



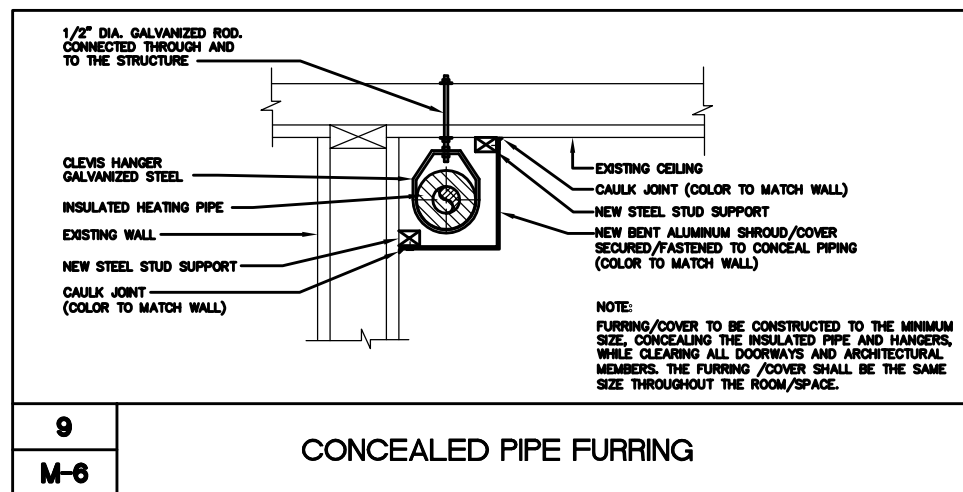
6
M-6 TYPICAL EXPANSION TANK AND FILL CONNECTION



7
M-6 DETAIL OF WALL FIN PIPING



8
M-6 DETAIL OF DIFFERENTIAL PRESSURE SENSOR INSTALLATION



9
M-6 CONCEALED PIPE FURRING

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Project:
SCCDSB - ST. ELIZABETH CATHOLIC SCHOOL - BOILER REPLACEMENT
Drawing Title:
MECHANICAL DETAILS

Drawn By: ND / SVM	Checked By: NV
Date: MAR. 11, 2016	Scale: N.T.S.
Drawing No.: M-6	

File: j:\Drawings\15-199 St.Elizabeth catholic school\3-Working Documents\M-1-5-HVAC.dwg
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CABINET UNIT HEATER	
DESCRIPTION	CUH1
TOTAL HEATING CAPACITY: (MBH)	17
AIRFLOW: (CFM)	245
FLUID FLOW: (USGPM)	0.93
FLUID STATIC PRESS.: (FT.H2O)	0.83
ENTERING AIR TEMP.: (°F)	20
ENTERING FLUID TEMP.: (°F)	170
LEAVING FLUID TEMP.: (°F)	150
NO. FANS:	1
MOTOR POWER: (HP)	1/25
MOTOR AMPS:	0.6
VOLTAGE: (V/PH/Hz)	120/1/60
MOTOR RPM:	1075
WEIGHT: (LBS)	75
ACCESSORIES:	
MODEL REFERENCE:	ENGINEERED AIR CUH-2 ARRANGEMENT 4 (FULLY EXPOSED WALL CABINET)
NOTES:	C/W DISCONNECT SWITCH. FAN SPEED CONTROL AND LINE VOLTAGE THERMOSTAT WITH LOCKABLE COVER

HOT WATER BOILER SCHEDULE (Owner Supplied)	
DESIGNATION	B-1, B-2
LOCATION:	MECH RM. 101
SERVICE:	HOT WATER HEATING
BOILER TYPE:	CONDENSING
MAX. OUTPUT (MBH):	451
THERMAL EFFICIENCY (GAS) %	93
FLUID:	WATER
FLUID FLOW (USGPM):	55
ENTERING FLUID TEMP (°F):	160
LEAVING FLUID TEMP (°F):	180
INPUT - NATURAL GAS (MBH):	500
TURNDOWN / # OF STAGES:	MODULATING BURNER WITH 5:1 TURNDOWN
ELECTRICAL - V/PH/Hz:	120/1/60
TOTAL AMPS	15.5
FLUE CONNECTION DIAMETER (IN):	4
ACCESSORIES:	NEUTRALIZER
NET WEIGHT (LBS):	310
MODEL REFERENCE:	LOCHINVAR KNIGHT XL KBN500

WALL FIN SCHEDULE	
DESCRIPTION	WF-1
APPLICATION:	WALL MOUNTED
DEPTH: IN (MM)	5" (125)
HEIGHT: IN (MM)	18" (450)
PANELS/ ROWS	1 Row
CAPACITY: MBH/FT (kW/M)	1.94 (1.86)
ENTERING FLUID TEMP.: °F (°C)	180 (82.2)
LEAVING FLUID TEMP.: °F (°C)	160 (71.1)
ACCESSORIES:	-
ENGINEERED AIR MODEL REFERENCE:	WF-2A
NOTES:	Enclosure to extend from wall to wall c/w access door for valve access

EXPANSION TANK SCHEDULE	
DESIGNATION	ET-1
LOCATION:	MECH. RM.
SERVICE:	HEATING SYSTEM
EXCHANGER TYPE TANK:	FULL ACCEPTANCE
FLUID TYPE:	WATER
TANK VOLUME: (GAL)	68.0
ACCEPTANCE VOLUME:(GAL)	34.0
MINIMUM PRESSURE: (PSI)	11
MAXIMUM PRESSURE: (PSI)	35
MINIMUM SUPPLY TEMP.:(°F)	40
MAXIMUM SUPPLY TEMP.:(°F)	190
DIAMETER:	24"
HEIGHT:	41"
MODEL REFERENCE:	AMTROL AX-120V

PUMP SCHEDULE			
DESCRIPTION	BP-1A & BP-1B (Owner Supplied)	CP-1A & CP-1B	CP-2
SERVICE:	BOILER CIRC. PUMP	BUILDING HEATING LOOP PUMP	PORTABLES HEATING LOOP
FLUID:	WATER	WATER	WATER
FLUID FLOW RATE: USGPM	46	90	20
HEAD: FT.HD	30	32	30
PUMP SPEED: (RPM)	1,750	1750	1750
MOTOR SIZE: HP	1	1.5 HP	0.75 HP
ELECTRICAL CHARACTERISTICS: (V/PH/Hz)	115/1/60	208/3/60	208/360
PUMP TYPE:	CLOSE COUPLED INLINE	CLOSE COUPLED INLINE	CLOSE COUPLED INLINE
CONTROLS:	CONSTANT, INTERCONNECTED WITH BOILER	VFD	VFD
MODEL		Bell & Gosset E-90	Bell&Gosset E-90
NOTES		C/W PREMIUM EFFICIENCY INVERTER DUTY MOTOR AND VFD	C/W PREMIUM EFFICIENCY INVERTER DUTY MOTOR AND VFD

1	ISSUED FOR TENDER	APRIL 18, 2016	 VRM #15-199 VANDERWESTEN RUTHERFORD MANTECON INC. CONSULTING STRUCTURAL/MECHANICAL/ELECTRICAL ENGINEERS LONDON • HAMILTON • WINDSOR • OTTAWA 7242 COLONEL TALBOT ROAD, LONDON, ONTARIO, N6L 1H8 PHONE: (519)652-5047 • FAX: (519)652-5058 • www.vrmeng.com	Project: SCCDSB – ST. ELIZABETH CATHOLIC SCHOOL – BOILER REPLACEMENT Drawing Title: MECHANICAL SCHEDULES	Drawn By: ND Date: FEB 12, 2016	Checked By: SVM Scale: N.T.S.
				Drawing No.: M-7		



APPENDIX B

INCENTIVE DOCUMENTATION REQUIREMENTS

For the purposes of realizing an Incentive from the IESO “Save on Energy” Incentive Program, the following list **some** of the requirements for the Consultants and Contractors. A full reference for the requirements is found at: <https://saveonenergy.ca/Business.aspx>

1. CONSULTANTS

a. Retrofit Lighting LED Measures

LED Exit Lights – (do not require Energy Star or DLC qualification)
LED Fixture Downlight Energy Star: http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=LTG DLC: http://www.designlights.org/
LED Light Bulb Energy Star: http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=LB DLC: http://www.designlights.org/
Integral LED Troffers DLC: http://www.designlights.org/
Energy Star Qualified LED lamps-Omnidirectional A shape Dry/Wet Location Energy Star: http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=LB
LED Exterior Lights DLC: http://www.designlights.org/

NOTE: Consultant to provide a screen shot of the Energy Star or DLC line item, whichever is applicable, at the time of Owner's review of drawings and specifications.

b. Unitary AC: Electric Resistance

Tons	BTU per hour	Minimum EER
≥ 3 to < 5.4 split system	≥ 36,000 to < 65,000	12.5
≥ 3 to < 5.4 single package with economizer	≥ 36,000 to < 65,000	12.0
≥ 5.4 to ≤ 7.5 split system	≥ 65,000 to ≤ 90,000	12.2
≥ 5.4 to ≤ 7.5 single package with economizer	≥ 65,000 to ≤ 90,000	12.2
> 7.5 to < 11.25	> 90,000 to < 135,000	12.2
≥ 11.25 to < 20	≥ 135,000 to < 240,000	12.2
≥ 20 to < 63.3	≥ 240,000 to < 760,000	10.8
≥ 63.3 or greater	≥ 760,000 or greater	10.4

c. Unitary AC: Non-Electric Resistance

Tons	BTU per hour	Minimum EER
≥ 3 to < 5.4 split system	≥ 36,000 to < 65,000	12.5
≥ 3 to < 5.4 single package with economizer	≥ 36,000 to < 65,000	12.0
≥ 5.4 to ≤ 7.5 split system	≥ 65,000 to ≤ 90,000	12.0
≥ 5.4 to ≤ 7.5 single package with economizer	≥ 65,000 to ≤ 90,000	12.0
> 7.5 to < 11.25	> 90,000 to < 135,000	12.0
≥ 11.25 to < 20	≥ 135,000 to < 240,000	12.0
≥ 20 to < 63.3	≥ 240,000 to < 760,000	10.6
≥ 63.3 or greater	≥ 760,000 or greater	10.2

NOTE: Schedules/Specifications/Drawings should be expressed in EER as opposed to SEER and are required to contain EER information in the Shop Drawings at the time of Owner's review of drawings and specifications.

2. CONTRACTORS

Information and action required of Contractors in order for the School Board to receive an Incentive.

2.1 At Award of Contract/Subcontract

1. Submit a quote (on letterhead) for the cost (labour, material & disposal) of incentive measures within **one (1) calendar week from the award of the accepted bid.** Itemize quantities of incentive items such as light fixtures, ballasts, RTU's in the Scope of Work specified for demolition.
2. Photographs before Demolition
Take (before) pictures of light fixtures to be demolished, (before) pictures of name plates of the RTU and other incentive items where applicable within one (1) calendar week from the award of the accepted bid.

2.2 At the Completion of the Incentible Portions of the Contract

1. Equipment Disposal and Decommissioning Documentation
Provide proof of disposal of old equipment as outlined below:
 - a. Lighting
Disposal Certificates / Documentation, Invoices with itemized listing of equipment types and quantities disposed.
 - b. Unitary AC
Written proof that other system's components have been sent to an Ontario Scrap Dealer or municipal landfill. (If applicable)
 - c. An **ODP tag** signed off by a certified technician for the removal of refrigerant in the old AC unit through a Refrigerant Management Canada Stewardship Program (RMC) wholesaler. (If applicable)
Signed Disposal Declaration Form (attached)



Sample Generic
Disposal Declaration.

- d. Disposal documentation submitted to the Board to be in a form satisfactory to the Local Distribution Company (LDC) on behalf of the IESO for the "Save on Energy " Program.
 - e. In the case of bulk disposal, e.g. lighting retrofit, a possible acceptable requirement is an itemized bulk disposal receipt and a statement written on Company letterhead certifying that the "xxx" number of fixtures has been disposed into the bulk disposal bin.
2. Photographs after Installation
Contractor to take photographs of installed incentive items and submit to the Board or Board's Designate.

Extracts from the "SaveONEnergy Retrofit Program" (A full guide is found on the "SaveONEnergy Retrofit Program" Website")

The saveONEnergy Retrofit Program participant agreement states:

"The Participant will take all necessary steps to have equipment that was removed or replaced as part of any Project disposed of or decommissioned in accordance with appropriate disposal or decommissioning processes, applicable laws, and in accordance with commercially reasonable environmental practices and shall evidence such activities by appropriate disposal certificates or similar documentation."