



INVITATION TO TENDER (ITT)

STRATHCONA GARDENS ENERGY EFFICIENCY UPGRADE PROJECT MECHANICAL CONTRACTOR SERVICES/STAGE 3 AHUS

ITT-01-20

ISSUE DATE

Tuesday, February 25, 2020

MANDATORY SITE VISIT

Monday, March 2, 2020

10:30 a.m. Pacific Time

Strathcona Gardens Recreation Complex

Main Reception

225 South Dogwood Street

Campbell River, BC V9W 8C8

DIRECT INQUIRIES TO

procurement@srd.ca

INQUIRIES AND ADDENDA - CLOSING DATE AND TIME

Thursday, March 12, 2020

2:00 p.m. Pacific Time

SUBMISSION CLOSING DATE AND TIME

Tuesday, March 17, 2020

2:00 p.m. Pacific Time

SUBMISSION LOCATION ONLY

Provide three printed copies to

Strathcona Regional District

990 Cedar Street

Campbell River, BC V9W 7Z8

Tenders will be opened in public shortly after closing

TABLE OF CONTENTS

A.	PROJECT SUMMARY	4
B.	BACKGROUND	4
C.	ADMINISTRATIVE REQUIREMENTS	5
1.0	DEFINITIONS.....	6
2.0	GENERAL TERMS AND CONDITIONS	6
3.0	EVALUATION.....	6
4.0	MANDATORY CONDITIONS	6
5.0	ALTERNATIVE SOLUTIONS.....	7
6.0	LATE TENDERS.....	7
7.0	CHANGES TO TENDERS.....	7
8.0	TENDERERS' EXPENSES.....	7
9.0	TENDER VALIDITY	7
10.0	FIRM COSTING	7
11.0	SUBCONTRACTORS.....	7
12.0	COMPLETENESS OF TENDER	8
13.0	CANCELLATION OF ITT	8
14.0	CONFLICT OF INTEREST/NO LOBBYING.....	8
15.0	FREEDOM OF INFORMATION	8
16.0	COLLECTION AND USE OF PERSONAL INFORMATION	8
17.0	LITIGATION HISTORY	9
18.0	LIABILITY FOR ERRORS	9
19.0	LIMITATION OF DAMAGES	9
20.0	NO IMPLIED APPROVALS	9
21.0	CONFIDENTIALITY AGREEMENT.....	9
22.0	LEGAL ENTITIES	10
23.0	RESERVATION OF RIGHTS	10
24.0	OWNERSHIP OF TENDERS	11
25.0	BRAND NAMES OR EQUIVALENT.....	11
26.0	COPYRIGHT.....	11
27.0	CONTRACT	11
28.0	EXECUTION OF CONTRACT	11
29.0	TRADE AGREEMENTS.....	11
D.	SUBMISSION OF TENDERS	12
30.0	PROPOSAL SUBMISSION.....	12
31.0	MANDATORY CRITERIA.....	12
32.0	ADDENDA.....	13
33.0	SIGNATURES	13
34.0	DEBRIEFING	13
E.	PROJECT DOCUMENTS	13
F.	PROJECT SCOPE	14
35.0	COMMON SCOPE	14
G.	SEPARATE PRICES	15
H.	PREFERRED SCHEDULE OF PROJECT MILESTONES	17

J.	DESIREABLE CRITERIA	18
K.	INTERVIEW AND/OR PRESENTATION	18
L.	REFERENCE CHECKS.....	18
M.	NEGOTIATIONS.....	19
N.	NEGOTIATION DELAY	19
O.	NOTIFICATION	19
P.	ADDENDA ACKNOWLEDGMENT	19
Q.	RESPONSE FORM.....	19
36.0	MANDATORY CRITERIA.....	20
37.0	DESIREABLE CRITERIA	21
38.0	RECENT PREVIOUS CONTRACTS	21
39.0	PRICES	22
40.0	SEPARATE PRICES	22
41.0	UNIT PRICING.....	22
	APPENDIX A: SIGNATURE AND RESPONSE FORM	23
	APPENDIX B: SCOPE OF WORK	24
	APPENDIX C: CONTRACT & INSURANCE POLICIES	25
C. 1	CONTRACT	25
C. 2	INSURANCE	25
	APPENDIX D: CONFIRMATION OF INTENTION.....	26
	APPENDIX E: ISSUED FOR TENDERING DRAWINGS AND SPECIFICATIONS.....	27

A. PROJECT SUMMARY

Strathcona Regional District (SRD) through this Invitation intends to contract with a qualified Mechanical Contractor to provide construction services for the *Energy Recovery Project Phase 3 AHUs* at Strathcona Gardens, located at 225 South Dogwood Street, Campbell River BC V9W 8C8.

The Contract will be issued in the form of the CCDC2 – 2008 Stipulated Price Contract for Services and Construction and may be further amended by negotiations with Supplementary Conditions.

The award of the Contract is subject to approval by the Strathcona Regional District's Board of Directors.

The Mechanical Contractor will be required to provide a Bid Bond (10% of the amount of the bid), Performance Bond (50% of the cost of work) and a Labour and Material Payment Bond (50% of the cost of the work) prior to the start of construction.

The Mechanical Contractor will be required to provide all insurance policies included in Appendix C – Contract and Insurance Policies.

The Mechanical Contractor will be required to complete the mandatory and desirable criteria included in section 6.2 response form.

The Mechanical Contractor will be required to complete, sign and submit not later than March 17, 2020 to SRD the Confirmation of Intention included in Appendix D.

Project activities are scheduled to begin immediately following the Mechanical Contractor selection process and the awarding of a contract.

The supply and installation of air handling units and associated work is to be completed not later than October 2020. The contractor is to provide a proposed schedule showing all project activities, milestones and final completion date.

B. BACKGROUND

Strathcona Gardens is the main multi-functional recreation complex serving users in the City of Campbell River, SRD Electoral Area D and the broader region. The facility has multiple ice surfaces, an aquatic centre, administration areas and multi-purpose spaces.

The SRD has been awarded \$4.6M through the Strategic Priorities Stream of the Federal Gas Tax Fund to undertake an Energy Efficiency Upgrade Project (EEUP) consisting of works that will increase energy efficiency and recovery at its Strathcona Gardens recreation facility. The EEUP has been phased and this Invitation to Tender (ITT) is for phase 3 to supply and install three Air Handling Units, one dehumidifier and all associated work included in the design.

The SRD is seeking a Mechanical Contractor to undertake the supply, installation and construction of four air handling units and associated work, all components of the Energy Efficiency Upgrade Project – Phase 3. Refer to the detailed scope under section 1.4 and design included in Appendix E.

General Information about Strathcona Gardens is available at:
<https://www.strathconagardens.com/>

C. ADMINISTRATIVE REQUIREMENTS

1.0 DEFINITIONS

Throughout this Invitation to Tender, the following definitions apply:

“Addenda”: means all additional information regarding this ITT including amendments to the ITT;

“BC Bid”: means the BC Bid website located at www.bcbid.ca;

“Closing Location”: includes the location or email address for receipt of submissions indicated in the Key Information Summary.

“Closing Time”: means the closing time and date for this ITT as set out in the Key Information Summary of this ITT.

“Contract”: means the written agreement resulting from the ITT executed by the SRD and the successful Tenderer.

“Contractor”: means the successful Tenderer to the ITT who enters into a Contract with the SRD.

“Engineering Services Coordinator/Engineering Service Manager”: means the person appointed by the Strathcona Regional District from time to time to represent the SRD as liaison between the SRD and the contractor;

“Department”: means the Department of the SRD issuing this ITT;

“Invitation to Tender” or “ITT”: means the solicitation described in this document as may be modified in writing from time to time by the SRD by Addenda; including any attached or referenced appendices, schedules or exhibits.

“Must” or “mandatory” means a requirement that must be met for a Tender to receive consideration.

“Preferred Tenderer”: means the Tenderer deemed by the SRD to have the highest ranked assessment of its response according to the process set out herein.

“Tenderer”: means a person or entity (excluding its parent, subsidiaries or other affiliates) with the legal capacity to contract, that submits a Tender in response to the ITT.

“Tender”: means a written response to the ITT that is submitted by a Tenderer.

“Response”: means the submission of an offer, bid, tender or proposal according to this request.

“Respondent” or “Tenderer”: means the company, individual or entity responding to this request.

“SRD”: means Strathcona Regional District and includes the Department issuing this request.

“SRD Contact”: means the individual named as the contact person for the SRD in the ITT.

“SRD Electronic Mail System”: means the electronic mail system of the Strathcona Regional District.

“Should”, “Could” “May” or “Desirable”: means a requirement having a significant degree of importance to the objectives of this Request.

“Supplier””: means the person or company selected to provide products and/or services under the terms of this contract. This extends to and includes any sub-contractors to the supplier.

“W.C.B.”: Workers Compensation Board of British Columbia, doing business as WorkSafe BC.

2.0 GENERAL TERMS AND CONDITIONS

Submitting a Tender indicates acceptance of all the terms and conditions set out in the ITT, including those that follow and that are included in all appendices and any addenda.

3.0 EVALUATION

Tenders will be assessed in accordance with the evaluation criteria. The SRD will be under no obligation to receive further information, whether written or oral, from any Tenderer. The SRD is under no obligation to perform any investigations or to otherwise verify any statements or representations made in a Tender.

Tenders from not-for-profit agencies will be evaluated against the same criteria as those received from any other Tenderers.

The SRD may consider and evaluate any Tenders from other jurisdictions on the same basis that the SRD purchasing authorities in those jurisdictions would treat a similar Tender from a British Columbia supplier.

EVALUATION TEAM

The evaluation team may consist of SRD employees, external consultants to the SRD and others as may be appointed to the evaluation team by the SRD. All persons on the evaluation committee shall be bound by the same standards of confidentiality and impartiality.

EVALUATION PROCESS

Evaluation of responses will be made in the same and subsequent order as stated in the subsections to this section.

4.0 MANDATORY CONDITIONS

The response must be contained in a sealed opaque package and must be received at the closing location not later than the closing time as noted in the summary of key information of this document.

A completed and signed form substantially similar in form and content to that in Appendix A is included with the response; and

The response must be in the English Language.

5.0 ALTERNATIVE SOLUTIONS

If more than one approach to deliver the services described in the ITT is offered, Tenderers should submit the alternative approach in a separate Tender.

6.0 LATE TENDERS

Tenders will be marked with their receipt time at the Closing Location. Only complete Tenders received and marked before the Closing Time will be considered to have been received on time. Tenders received late will be marked late and not considered or evaluated. In case of a dispute, the Tender receipt time as recorded by the SRD at the Closing Location will prevail whether accurate or not.

7.0 CHANGES TO TENDERS

By submitting a clear and detailed written notice, the Tenderer may amend or withdraw its Tender before the Closing Time. Unless the ITT otherwise provides, Tenderers should use a consistent submission method for submitting Tenders and any amendments or withdrawals. At Closing Time, all Tenders become irrevocable. The Tenderer will not change any part of its Tender after the Closing Time unless requested by the SRD for purposes of clarification.

8.0 TENDERERS' EXPENSES

Tenderers are solely responsible for their own expenses in participating in the ITT process, including costs in preparing a Tender and for subsequent finalizations with the SRD, if any. The SRD will not be liable for any claims, whether for costs, expenses, damages or losses incurred by the Tenderer in preparing its Tender, loss of anticipated profit in connection with any final Contract, or any other matter whatsoever.

9.0 TENDER VALIDITY

Tenders must remain open for acceptance for at least 90 days after the Closing Time.

10.0 FIRM COSTING

Costs will be firm for the entire Contract period unless the ITT specifically states otherwise.

11.0 SUBCONTRACTORS

Unless the ITT states otherwise, the SRD will accept Tenders where more than one organization or individual is proposed to deliver the services described in the ITT, so long as the Tender identifies the lead entity that will be the Tenderer and that will have sole responsibility to deliver the services under the Contract. The SRD will enter into a Contract with the Tenderer only. The evaluation of the Tenderer will include evaluation of the resources and experience of proposed sub-contractors.

All subcontractors, including affiliates of the Tenderer, should be clearly identified in the Tender.

A Tenderer may not subcontract to a firm or individual whose current or past corporate or other interests may, in the SRD's opinion, give rise to an actual or potential conflict of interest in connection with the services described in the ITT. This includes, but is not limited to, involvement by the firm or individual in the preparation of the ITT or a relationship with any employee, contractor or representative of the SRD involved in preparation of the ITT, participating on the evaluation

committee or in the administration of the Contract. If a Tenderer is in doubt as to whether a proposed subcontractor might be in a conflict of interest, the Tenderer should consult with the SRD Contact prior to submitting a Tender. By submitting a Tender, the Tenderer represents that it is not aware of any circumstances that would give rise to a conflict of interest that is actual or potential, in respect of the ITT.

Where applicable, the names of approved subcontractors listed in the Tender will be included in the Contract. No additional subcontractors will be added, nor other changes made to this list in the Contract without the written consent of the SRD.

12.0 COMPLETENESS OF TENDER

By submitting a Tender, the Tenderer warrants that, if the ITT is to design, create or provide a system or manage a program, all components required to run the system or manage the program have been identified in the Tender or will be provided by the Contractor at no additional charge.

13.0 CANCELLATION OF ITT

The ITT should not be construed as an agreement to purchase goods or services. The lowest priced or any Tender will not necessarily be accepted. The ITT does not commit the SRD in any way to award a Contract.

14.0 CONFLICT OF INTEREST/NO LOBBYING

A Tenderer may be disqualified if the Tenderer's current or past corporate or other interests, or those of a proposed subcontractor may, in the SRD's opinion, give rise to an actual or potential conflict of interest in connection with the services described in the ITT. This includes, but is not limited to, involvement by a Tenderer in the preparation of the ITT or a relationship with any employee, contractor or representative of the SRD involved in preparation of the ITT, participating on the evaluation committee or in the administration of the Contract. If a Tenderer is in doubt as to whether there might be a conflict of interest, the Tenderer should consult with the SRD Contact prior to submitting a Tender. By submitting a Tender, the Tenderer represents that it is not aware of any circumstances that would give rise to a conflict of interest that is actual or potential, in respect of the ITT.

A Tenderer must not attempt to influence the outcome of the ITT process by engaging in lobbying activities. Any attempt by the Tenderer to communicate for this purpose directly or indirectly with any employee, contractor or representative of the SRD, including members of the evaluation committee and any elected officials of the SRD, or with the media, may result in disqualification of the Tenderer.

15.0 FREEDOM OF INFORMATION

Tenders are subject to the provisions of the *Freedom of Information and Protection of Privacy Act* which provides that all information contained therein, with some exceptions, is subject to access by the public. Information that is confidential or proprietary in nature should be clearly noted as such. The Regional District cannot guarantee that any information contained within a proposal will remain confidential if a request for access is made.

16.0 COLLECTION AND USE OF PERSONAL INFORMATION

Tenderers are solely responsible for familiarizing themselves, and ensuring that they comply, with the laws applicable to the collection and dissemination of information, including resumes and other

personal information concerning employees and employees of any subcontractors. If the ITT requires Tenderers to provide the SRD with personal information of employees who have been included as resources in response to the ITT, Tenderers will ensure that they have obtained written consent from each of those employees before forwarding such personal information to the SRD. Such written consents should specify that the personal information may be forwarded to the SRD for the purposes of responding to the ITT and used by the SRD for the purposes set out in the ITT. The SRD may, at any time, request the original consents or copies of the original consents from Tenderers, and upon such request being made; Tenderers will immediately supply such originals or copies to the SRD.

17.0 LITIGATION HISTORY

The Strathcona Regional District reserves the right to refuse any tender submitted by any party either as tenderer or that includes an identified sub-contractor to a tenderer and including any officer or director of any party that has been or is currently in a legal dispute with the Strathcona Regional District.

In determining whether to reject a Tender under this clause, the SRD will consider whether the litigation is likely to affect the Tenderer's ability to work with the SRD, its consultants and representatives and whether the SRD's experience with the Tenderer indicates that the SRD is likely to incur increased costs in the administration of a Contract if it is awarded to the Tenderer.

18.0 LIABILITY FOR ERRORS

While the SRD has used considerable efforts to ensure information in the ITT is accurate, the information contained in the ITT is supplied solely as a guideline for Tenderers. The information is not guaranteed or warranted to be accurate by the SRD, nor is it necessarily comprehensive or exhaustive. Nothing in the ITT is intended to relieve Tenderers from forming their own opinions and conclusions with respect to the matters addressed in the ITT.

19.0 LIMITATION OF DAMAGES

By submitting a Tender, the Tenderer agrees that it will not claim damages, for whatever reason, relating to the Contract or in respect of the competitive process, in excess of an amount equivalent to the reasonable costs incurred by the Tenderer in preparing its Tender and the Tenderer, by submitting a Tender, waives any claim for loss of profits if no Contract is made with the Tenderer.

20.0 NO IMPLIED APPROVALS

Neither acceptance of a Tender nor execution of a Contract will constitute approval of any activity or development contemplated in any Tender that requires any approval, permit or license pursuant to any federal, provincial, regional district or municipal statute, regulation or by-law.

21.0 CONFIDENTIALITY AGREEMENT

The information provided by the SRD or its representatives to a Tenderer during or in connection with the ITT and any resulting contract is confidential and shall not be disclosed without the prior written approval of the SRD.

It is understood and agreed between the Tenderers and the SRD that the reciprocal obligations of confidentiality will remain in force and will continue to bind the parties, notwithstanding the completion, suspension or termination of this ITT process.

It is understood and agreed between the Tenderers and the SRD that any party that wishes to make a public announcement of any kind relating to the ITT process or its dealings with SRD in connection with this ITT must first seek the approval of the SRD by providing to the SRD, no less than seven (7) days prior to the public announcement, a final copy of any and all proposed press releases, advertising and sales promotion material.

22.0 LEGAL ENTITIES

The SRD reserves the right in its sole discretion to:

- disqualify a Tender if the SRD is not satisfied that the Tenderer is clearly identified;
- prior to entering into a Contract with a Tenderer, request that the Tenderer provide confirmation of the Tenderer's legal status (or in the case of a sole proprietorship, the Tenderer's legal name and identification) and certification in a form satisfactory to the SRD that the Tenderer has the power and capacity to enter into the Contract;
- not enter into a Contract with a Tenderer if the Tenderer cannot satisfy the SRD that it is the same legal entity that submitted the Tenderer's Tender; and
- require security screenings for Tenderers who are natural persons, subcontractors or key personnel before entering into a Contract and decline to enter into a Contract with a Tenderer or to approve subcontractor or key personnel that fail to pass the security screenings to the SRD's satisfaction.

23.0 RESERVATION OF RIGHTS

In addition to any other reservation of rights set out in the ITT, the SRD reserves the right, in its sole discretion:

- to modify the terms of the ITT at any time prior to the Closing Time, including the right to cancel the ITT at any time prior to entering into a Contract with a Tenderer;
- in accordance with the terms of the ITT, to accept the Tender or Tenders that it deems most advantageous to itself;
- to waive any non-material irregularity, defect or deficiency in a Tender;
- to request clarifications from a Tenderer with respect to its Tender, including clarifications as to provisions in its Tender that are conditional or that may be inconsistent with the terms and conditions of the ITT, without any obligation to make such a request to all Tenderers, and consider such clarifications in evaluating the Tender;
- to reject any Tender due to unsatisfactory references or unsatisfactory past performance under contracts with the SRD, or any material error, omission or misrepresentation in the Tender;
- at any time, to reject any or all Tenders; and
- at any time, to terminate the Tender process without award and to obtain the goods and services described in the ITT by other means, or to not proceed with the work covered by the Tender.

24.0 OWNERSHIP OF TENDERS

All Tenders and other records submitted to the SRD in relation to the ITT become the property of the SRD and are subject to the provisions of the Freedom of Information and Protection of Privacy Act. For more information on the application of the Act, go to <https://www.oipc.bc.ca/>.

25.0 BRAND NAMES OR EQUIVALENT

Unless otherwise stated, if, and wherever, the specifications state a brand name, a make, the name of manufacturer, a trade name or a vendor catalogue number, it is not intended to rule out the use of other equivalent materials or equipment.

If, however, products other than that brand or manufacturer specified are quoted in any ITT, the Tender must explicitly include the name of such products, its manufacturer, and trade name and any applicable vendor catalogue number, and the SRD may require that the Tenderer provide proof of equivalency. Evidence of quality in the form of samples may be requested.

26.0 COPYRIGHT

This document is subject to copyright and may be used, reproduced, modified and distributed only to the extent necessary for the Tenderer to prepare and submit a Tender.

27.0 CONTRACT

By submitting a Tender, the Tenderer agrees that should its Tender be successful the Tenderer will enter into a Contract with the SRD on substantially the same terms and conditions set out in Appendix C and such other terms and conditions to be finalized to the satisfaction of the SRD, if applicable.

Written notice to a Tenderer that it has been identified as the successful Tenderer and the subsequent full execution of a written Contract will constitute a Contract for the goods or services, and no Tenderer will acquire any legal or equitable rights or privileges relative to the goods or services until the occurrence of both such events.

28.0 EXECUTION OF CONTRACT

If a written Contract cannot be finalized with provisions satisfactory to the SRD within thirty (30) days of notification of the successful Tenderer, the SRD may, at its sole discretion at any time thereafter, terminate discussions with that Tenderer and either commence finalization of a Contract with the next qualified Tenderer or choose to terminate the ITT process and not enter into a Contract with any of the Tenderers.

29.0 TRADE AGREEMENTS

This ITT is covered by trade agreements, including the following:

- Canadian Free Trade Agreement; For more information visit to the following link: <https://www.cfta-alec.ca/>
- New West Partnership Trade Agreement; For more information visit to the following link: <http://www.newwestpartnershiptrade.ca/>

Contractors are encouraged to adopt best practices, including engaging in apprenticeship training and reporting on the use of registered apprentices and trainees. For more information visit the following link: <https://www2.gov.bc.ca/gov/content/industry/construction-industry/apprentices>

D. SUBMISSION OF TENDERS

Tenders must be submitted before Closing Time to the Closing Location as stated in the Summary of Key Information using the submission methods set out in this section of this ITT. Tenders must not be sent by fax, except in the circumstances set out below. The Tenderer is solely responsible for ensuring that, regardless of submission method selected, the SRD receives a complete Tender, including all attachments or enclosures, before the Closing Time. When both an electronic and printed copy submission is requested, the printed copy shall take precedence.

Tender shall be signed by a person authorized to sign on behalf of the Tenderer with the intent to bind the Tenderer to the ITT and to the statements and representations in the Tenderer's Tender. A scanned copy of the signed response form of this ITT is acceptable as is a cover letter identifying the Tenderer, identifying the ITT and including a signature of an authorized representative of the Tenderer that confirms the Tenderer's intent to be bound. For Tenders submitted via BC Bid attachment of the e-bidding key to an electronic Tender constitutes the signature

30.0 PROPOSAL SUBMISSION

Enclose three written copies and deliver to the closing location stated in the Summary of key information

31.0 MANDATORY CRITERIA

Responses will be first evaluated against the mandatory criteria. Responses not meeting these criteria will be rejected and excluded from any further consideration.

Tenders shall be submitted in duplicate complete with one digital copy in portable document format (.pdf file) on a CD, DVD or USB device. The signed and dated Tender Form provided herein must also be included. The deadline for receipt of proposals is 2:00 p.m. Pacific time on Thursday, March 17, 2020 at the following location:

Strathcona Regional District
990 Cedar Street
Campbell River, BC V9W 7Z8

Tenders must be submitted in a sealed package with the name and address of the proponent and the ITT title clearly marked on the outside.

SAMPLE LABEL

Name of Proponent Address of Proponent
CONFIDENTIAL – DO NOT OPEN
ITT-01-20 – Strathcona Gardens Energy Efficiency Upgrade Project Mechanical Contractor Services/Stage 3 AHUs
STRATHCONA REGIONAL DISTRICT 990 Cedar Street Campbell River, BC V9W 7Z8

Facsimile and electronic submissions will be disqualified.

Late Tenders will be disqualified.

Tenders that are unsealed, conditional, illegible, obscure, contain arithmetical errors, erasures, alterations or irregularities of any kind may, at the discretion of the Regional District, be disqualified.

The person(s) authorized to sign on behalf of the Tenderer and to bind the Tenderer to statements made in response to this ITT **must execute** the Submission Form. Unsigned Tenders will be disqualified.

Tenderers shall be solely responsible for the delivery of their Tenders in the manner and time prescribed. All submissions must be delivered according to the instructions provided herein and the Regional District will accept no responsibility for documents delivered to any other location.

32.0 ADDENDA

All Addenda will be posted on BC Bid. It is the sole responsibility of the Tenderer to check for Addenda on BC Bid. Tenderers are strongly encouraged to subscribe to BC Bid's email notification service to receive notices of Addenda.

33.0 SIGNATURES

If an individual is submitting a Tender, they shall print or type their name and address on the response form and sign the same in the spaces provided. Their signature shall be witnessed, and the witness shall give their address.

If a partnership is submitting a Tender, the name and address of the partnership shall be printed or typed on the response form and the names of all members of the partnership shall be printed or typed in the spaces provided. The response shall be signed by one or more of the partners in the following manner: for example, "Smith and Jones by John Jones a partner". The signature or signatures shall be witnessed, and the witness or witnesses shall give their address or addresses.

If a company is making the response, the name of the company and its place of business shall be printed or typed on the response form and the form shall be signed by the person or persons authorized to sign the response on behalf of the company, indicating the capacity in which they sign: for example, "John Doe Company Ltd. by John Smith, Secretary" or as the case may be.

Responses signed by an agent must be accompanied by proof of their agency.

34.0 DEBRIEFING

At the conclusion of the ITT process, the outcome will be posted on BC Bid and the SRD's website. Tenderers may request a debriefing meeting with the SRD.

E. PROJECT DOCUMENTS

The following documents will provide the design to the Energy Recovery Project that is the subject of this ITT. The referenced documents are posted along with this Invitation to Tender for the information of Tenderers.

Date	Report Title
January 29, 2020	Issued for Tendering - Mechanical Specifications (230 pages)
January 29, 2020	Issued for Tendering – Mechanical Drawings M1 to M8 (8 pages)
January 07, 2020	Issued for Tendering – Electrical Drawings E000 to E300 (5 pages)
January 10, 2020	Issued for Tendering – Structural Specs. and Details S01 & S02 (2 pages)
January 22, 2020	Issued for Tendering – Architectural Specifications and Details (9 pages)

F. PROJECT SCOPE

The general scope of work required of the Mechanical Contractor will be:

The current project consists generally of replacement of AHU-3, AHU-4, AHU-5 and the dehumidification unit serving arena 2 (herein referred to as DH-2):

35.0 COMMON SCOPE

- i. Drain down of existing heat pump loop pipes, including retention/storage of existing hydronic fluid contained within.
- ii. Testing of the existing PVC piping routed on the roof between the existing pool mechanical room and the existing refrigeration room to ensure it is still of sufficient integrity to re-use in the new low temperature heat pump loop.
- iii. Remediation or replacement of all duct and piping supports, except ductwork or piping that is included in a different Separate Price if that Separate Price is not accepted.
- iv. Installation of new parallel main circulation pumps, boiler loop injection pump, and refrigeration plant heat recovery pump
- v. Installation of piping and all required accessories to make a working system for the boiler injection loop to and from the boiler plant (including scanning and coring of floor in location shown and firestopping of penetrations).
- vi. Installation of new piping and remediation of existing piping in refrigeration plant room, including all required accessories to make a working system for the heat recovery loop, and to accommodate installation of new pump recovering heat from plant, as well as new tees and isolation valves as shown to set up for connection to new DH-2-2020.
- vii. Installation of tee fittings, isolation valves and caps for current or future connection to heat pump loop piping as shown on plans.
- viii. Completion of connection between existing original heat pump loop piping on roof and existing heat pump loop piping installed as part of Phase 2. Location is outside to east of existing refrigeration plant room.

- ix. Reintroduction of stored hydronic fluid, including chemical treatment thereof in order to match the existing fluid/chemical mix (including propylene glycol) and to match both the existing boiler hydronic fluid and the existing refrigeration low grade temperature loop hydronic fluid.
- x. Insulation of all new and existing heat pump piping and fittings, valves, etc., located outside the building.
- xi. Commissioning, controls and balancing, etc., of equipment and systems associated with Common Scope.
- xii. Permit application for demolition work and other required works except for Building Permit (by owner).
- xiii. Coordination of inspections and final approval by the City of Campbell River or other related authority.
- xiv. Close-out documents including as built drawings, operation and maintenance manuals, and warranties.
- xv. All included in the design (specifications and drawings) developed by AME Group and its subconsultants, Appendix E.

G. SEPARATE PRICES

Separate Price #1:

Described in Contract Documents, including, but not limited to, any and all work involved with unit or associated ductwork, piping, insulation, coil, pumps, enclosures, curbs, duct/pipe supports, roof work, commissioning, controls, balancing, structural, architectural, electrical, etc.

Separate Price #2:

Demolition of existing AHU-04 and installation of new AHU-04-2020 as described in Contract Documents, including, but not limited to, any and all work involved with unit or associated ductwork, piping, insulation, pumps, enclosures, curbs, duct/pipe supports, roof work, commissioning, controls, balancing, structural, architectural, electrical, etc.

Separate Price #3:

Demolition of existing AHU-05 and exhaust fans as noted and installation of new AHU-05-2020 as described in Contract Documents, including, but not limited to, any and all work involved with unit or associated ductwork, piping, insulation, coil, pumps, enclosures, curbs, duct/pipe supports, roof work, commissioning, controls, balancing, structural, architectural, electrical, etc.

Separate Price #4:

Demolition of existing DH-02 and installation of new DH-02-2020 as described in Contract Documents, including, but not limited to, any and all work involved with unit or associated ductwork, piping, insulation, coil, pumps, enclosures, curbs, duct/pipe supports, roof work, commissioning, controls, balancing, structural, architectural, electrical, etc.

Separate Price #5:

- i. Provide a Separate Price for cleaning of any outside air, supply air, return air, or exhaust air ductwork associated with AHU-3. Include in this Separate Price the cost to clean any duct accessories, coils, sensors, etc., associated with the ductwork systems.
- ii. Provide a Separate Price for cleaning of any outside air, supply air, return air, or exhaust air ductwork associated with AHU-4. Include in this Separate Price the cost to clean any duct accessories, coils, sensors, etc., associated with the ductwork systems.
- iii. Provide a Separate Price for cleaning of any outside air, supply air, return air, or exhaust air ductwork associated with AHU-5, EF-11 and EF-13. Include in this Separate Price the cost to clean any duct accessories, coils, sensors, etc., associated with the ductwork systems.
- iv. Provide a Separate Price for cleaning of any supply air or return air ductwork associated with DH-02. Include in this Separate Price the cost to clean any duct accessories, coils, sensors, etc., associated with the ductwork systems.

Separate Price #6:

Provide a Separate Price for removal and replacement of existing heat pump loop piping in full, matching existing routing. New piping to be painted or otherwise protected during installation from UV exposure according to the manufacturers recommendations/requirements until insulation is installed.

Separate Price #7:

- i. Provide a Separate Price for deletion of controls scope from this Contract. Separate Price to be divided according to other Separate Price scopes noted above – Common Scope, AHU-03, AHU-04, AHU-05 and DH-02.
- ii. The scope of Section 23 HVAC, and Section 25 Control is for building services within the project structure and 1m from the building.
- iii. Provide complete, fully tested, and operational systems to meet the requirements described herein and in complete accord with applicable codes and ordinances.
- iv. Contract documents and drawings of this Division are diagrammatic and approximately, to scale unless detailed otherwise. They establish scope, material, and installation quality but are not detailed installation instructions.
- v. Follow manufacturers' recommended installation instructions, details, and procedures for equipment, supplemented by requirements of the Contract Documents.
- vi. Install equipment generally in locations and routes indicated. Run piping and ductwork close to building structure, parallel to building lines, maximize headroom and maintain minimum interference with other services and free space. Remove and replace improperly installed equipment to satisfaction of the SRD at no extra cost.

- vii. For work within existing facilities, confirm locations and elevations of existing piping and equipment prior to commencement of new work.
- viii. Install equipment to provide service access, maintain service clearances and for ease of maintenance.
- ix. Connect to equipment specified in other Sections and to equipment supplied and installed by other Contractors or by the Owner. Uncrate equipment, move in place and install complete; start up and test.
- x. Install control valves, control dampers, thermal wells, and other devices on piping and ductwork, furnished by Division 25.

H. PREFERRED SCHEDULE OF PROJECT MILESTONES

ACTIVITY	COMPLETION
Contract Award by SRD Board	March 25, 2020
Contract issued to contractor	March 26, 2020
Submission of Shop Drawings for approval	Week of March 31, 2020
Ordering of equipment	Early April 2020
Mechanical Contractor Mobilizes/Construction starts	July 2020
Project completion	October 2020

I. RESPONSE EVALUATION

This section outlines the process and criteria for evaluation of responses to this request to select a preferred Tenderer or Tenderers if this request allows for the possibility of contracting with multiple suppliers.

TO COMPLETE, PLEASE USE TO RESPONSE FORM UNDER 6.2 (PAGES 21 & 22).

ITEM	EVALUATION CRITERIA	STATUS
1	Conflict of Interest	Pass/Fail
2	Consent of Surety	Pass/Fail
3	Commercial General Liability Insurance, for project requiring hot roofing work	Pass/Fail
4	Automobile Liability Insurance	Pass/Fail
5	Pollution Liability Insurance	Pass/Fail
6	Wrap Up Liability Insurance	Pass/Fail
7	Compliance with Workers' Compensation Legislation at the Place of the Project	Pass/Fail
8	Compliance with the ITT	Pass/Fail

J. DESIRABLE CRITERIA

Responses will be evaluated against the following desirable criteria.

TO COMPLETE, PLEASE USE TO RESPONSE FORM UNDER 6.2 (PAGE 22).

ITEM	EVALUATION CRITERIA	MAXIMUM POINTS
1	Project Manager	10
2	Site Superintendent/Foreman	10
3	Company's Track Record	10
4	Understanding of Project and services requested	10
5	Evaluation of Risks Inherent in the Project	5
6	Budget Management	5
7	Purchasing of equipment	5
8	Progress Payments	5
9	Project Scheduling	15
10	Cost ***	25

Total 100

*** The lowest cost Tender will be evaluated with the maximum number of points (25) available. All other proposals will receive a score based on the following formula: $(\text{Lowest Cost} \div \text{Tender Cost}) \times \text{Maximum Evaluation Score}$. The Regional District is seeking the best value for the construction budget and is not bound to accept the lowest price.

K. INTERVIEW AND/OR PRESENTATION

Selected Tenderers may be requested to attend an interview with the SRD's evaluation committee and/or make a presentation to the committee. This stage of the selection process may or may not be applicable as stated immediately below.

The SRD, at its sole discretion, may adjust their scores for the desirable criteria after clarification and/or verification of the written proposals. The highest scoring Tender ("Preferred Tender") will be selected by adding the scores from the desirable criteria evaluation and from the presentation. The Preferred Tender will then proceed to the next stage of the evaluation.

L. REFERENCE CHECKS

The references of the Preferred Tenderer may be contacted to validate any part of a Response. The SRD reserves the right to conduct such independent reference checks or verifications as are deemed necessary by it to clarify, test, or verify the information contained in the Response and confirm suitability of the Tenderer.

The SRD will not enter into a Contract with any Tenderer whose references, in the SRD's sole and reasonable opinion, are found to be unsatisfactory.

M. NEGOTIATIONS

The SRD reserves the right, at its sole discretion, to negotiate with the Preferred Tenderer. In no event will the SRD be required to offer any modified terms to any other Tenderer prior to entering into an agreement with the Preferred Tenderer and the SRD shall not incur any liability to any Tenderer as a result of such negotiation or modifications.

It is the intent of the SRD to ensure it has the flexibility it needs to arrive at a mutually acceptable Contract. It is not the intent of the SRD to allow for new or significantly altered Responses in any negotiations with the Preferred Tenderer.

Negotiations may include:

- Price adjustments.
- Minor changes to the requirements and responsibilities.
- Contract payment details
- Selected contract terms contained in the pro-forma contract as identified by the Tenderer for negotiation.

If a Contract cannot be negotiated with the Preferred Tenderer, the SRD will follow the process outlined immediately below.

N. NEGOTIATION DELAY

If a written Contract cannot be negotiated within thirty (30) days of notification of the Preferred Tenderer, the SRD may, at its sole discretion at any time thereafter, terminate negotiations with that Tenderer and either negotiate a Contract with the next best qualified Tenderer and so on or choose to terminate the Invitation to Tender process and not enter into a Contract with any of the Tenderers. Such cancellation does not preclude the SRD from entering into a contract with a Tenderer in respect of any aspect of the work contemplated by this Request.

O. NOTIFICATION

All Tenderers will be notified of the outcome of the evaluation and award process. Unsuccessful Tenderers may request a debriefing interview with the SRD.

P. ADDENDA ACKNOWLEDGMENT

Addenda No.	Date Issued

Q. RESPONSE FORM

The Proponents should attach additional materials that clearly reference the *desirable criteria* requested to be addressed.

36.0 MANDATORY CRITERIA

Item	Evaluation Criteria	Evaluation Rationale	Status
1	Conflict of Interest	Proponents determined, in the opinion of the SRD, to not have any conflict of interest, unfair advantage, or any relationship that has the potential for a conflict of interest to occur, will receive a PASS.	Pass/Fail
2	Consent of Surety	Proponents who can provide written evidence from their insurance provider of their ability to meet the SRD's requirements for a Bid Bond, Performance Bond and Labour & Material Payment Bond will receive a PASS.	Pass/Fail
3	Commercial General Liability Insurance, for project requiring hot roofing work	Proponents who can provide written evidence from their insurance provider of their ability to meet the Board's Commercial General Liability Insurance coverage will receive a PASS.	Pass/Fail
4	Automobile Liability Insurance	Proponents who can provide written evidence from their insurance provider of their ability to meet the Board's Automobile Liability Insurance coverage will receive a PASS.	Pass/Fail
5	Pollution Liability Insurance	Proponents who can provide written evidence from their insurance provider of their ability to meet the Board's Pollution Liability Insurance coverage will receive a PASS	Pass/Fail
6	Wrap Up Liability	Proponents who can provide written evidence from their insurance provider of their ability to meet the Board's Wrap Up Liability Insurance coverage will receive a PASS	Pass/Fail
7	Compliance with Workers' Compensation Legislation at the Place of the Project	Proponents who can provide written evidence of their valid Workers' Compensation Insurance coverage (WorkSafeBC Clearance Letter), will receive a PASS.	Pass/Fail
8	Compliance with the ITT	Proponents who are compliant with the ITT or who have exceptions or non-compliant items/sections determined, in the opinion of the SRD, acceptable for the performance of the Scope of Work, will receive a PASS.	Pass/Fail

37.0 DESIRABLE CRITERIA

Item	To be addressed.	Tenderers response
1	Proponent's named Project Manager and CV demonstrating experience relevant to the scope of work and performance, score higher.	
2	Proponent's named Site Superintendent and CV demonstrating experience relevant to the scope of work and performance, score higher.	
3	Proponents demonstrating better track record for completing projects on schedule and on budget, score higher. State successful projects.	
4.1	Proponents describing a better understanding of the project scope and objectives and demonstrating a skilled approach, score higher.	
4.2	Proponents describing a better understanding of the services and describing better assurance, score higher.	
5	Proponents describing better investigation and evaluation procedures, score higher.	
6	Proponents describing better reporting system and approach, score higher.	
7	Proponents describing better procedures, score higher.	
8	Proponents describing their understanding of progress payments under a GC CCDC2 contract, score higher.	
9	Proponents demonstrating ability to complete the project by the target date or sooner, score higher. Provide a proposed schedule with appropriate milestones, key tasks, durations and sequences that will result in project completion as requested.	
10	Lowest cost that account for all scope of work as defined in this ITT, score higher.	

38.0 RECENT PREVIOUS CONTRACTS

The Tenderers should complete the following table (or provide similar information in another format) referencing their work and individually the work of all sub-contractors proposed and enclose with your response. References for work similar to that specified herein are preferred.

The Tenderer ITT 01-20 Mechanical Contractor for Construction Services - Strathcona Gardens Energy Recovery Project authorizes the SRD to make such enquiries of references that it deems appropriate. Attach additional materials as may be applicable to your response that clearly reference this section.

Client/Owner	Contact Name and Contact Information	Description of the Work	Approx. Value	Completion Date

39.0 PRICES

Prices shall be given in Canadian Dollars with applicable taxes itemized and shown separately.

Tenderer: The table below is just an example, create your specific table with units, items, etc. as applicable to the request.

Item: Description of the component of the supply	Price Offered
PST	
GST	
Total	

40.0 SEPARATE PRICES

Please include separate prices. Also refer to section 1.5 for detailed scope of work.

Item: Description of the component of the supply	Price Offered
Separate price #1	
Separate price #2	
Separate price #3	
Separate price #4	
Separate price #5a	
Separate price #5b	
Separate price #5c	
Separate price #5d	
Separate price #6	
Separate price #7a	
Separate price #7b	
Separate price #7c	
Separate price #7d	
Separate price #7e	
Separate price #7f	
Separate price #7g	
Separate price #7h	
Separate price #7i	
Separate price #7j	

41.0 UNIT PRICING

Please provide unit pricing (i.e. hourly rates by position for any work that may not be included in the above lump sum proposed).

APPENDIX A: SIGNATURE AND RESPONSE FORM

Complete this section and enclose it with your response.

ITT Project Title: **Strathcona Gardens Energy Recovery Project – Phase 3 (AHUs)**

ITT Reference No: **01-20**

Legal Name of Tenderer: _____

Contact Person and Title: _____

Business Address: _____

Telephone: _____ E-Mail: _____

I/We, the undersigned duly authorized representative(s) of the contractor, having received and carefully reviewed all of the Tender documents, including the ITT and any issued addendums, and having full knowledge of the Site(s), and having fully informed ourselves as to the intent, difficulties, facilities and local conditions attendant to performing the Services, we have allowed for these conditions and submit this Tender in response to the ITT.

The undersigned further agrees, on behalf of the company named below, to supply the goods and services listed at the prices quoted and within the terms and conditions as identified in Invitation to Tender # 01-20. This Tender is valid and enforceable for at least Ninety (90) days following the closing date.

This Tenderer further warrants that this Tender is made without collusion with any other party except those expressly disclosed in this Tender and that the Tenderer has no conflict of interest.

The undersigned warrants that they have the authority to bind the company to this contract.

I/We confirm that this Tender is accurate and true to best of my/our knowledge.

I/We confirm that, if awarded a contract for the work, I/we will at all times be the “prime consultant/contractor” as provided by the Worker's Compensation Act (British Columbia) with respect to the Services. I/we further confirm that if I/we become aware that another consultant/contractor at the place(s) of the Services has been designated as the “prime consultant/contractor”, I/we will notify the SRD immediately, and I/we will indemnify and hold the SRD harmless against any claims, demands, losses, damages, costs, liabilities or expenses suffered by the SRD in connection with any failure to so notify the SRD.

This Tender is submitted this _____ day of _____, 2020

I/We have the authority to bind the Tenderer.

(Name of Tenderer)

(Name of Tenderer)

(Signature of Authorized Signatory)

(Signature of Authorized Signatory)

(Print Name and Position of Authorized Signatory)

(Print Name and Position of Authorized Signatory)

APPENDIX B: SCOPE OF WORK

The general scope of work required of the Mechanical Contractor will be:

The current project consists generally of replacement of AHU-3, AHU-4, AHU-5 and the dehumidification unit serving arena 2 (subsequently referred to as DH-2):

Common Scope:

- a) Drain down of existing heat pump loop pipes, including retention/storage of existing hydronic fluid contained within.
- b) Testing of the existing PVC piping routed on the roof between the existing pool mechanical room and the existing refrigeration room to ensure it is still of sufficient integrity to re-use in the new low temperature heat pump loop.
- c) Remediation or replacement of all duct and piping supports, except ductwork or piping that is included in a different Separate Price if that Separate Price is not accepted.
- d) Installation of new parallel main circulation pumps, boiler loop injection pump, and refrigeration plant heat recovery pump.
- e) Installation of piping and all required accessories to make a working system for the boiler injection loop to and from the boiler plant (including scanning and coring of floor in location shown and firestopping of penetrations).
- f) Installation of new, and remediation of existing, piping in refrigeration plant room, including all required accessories to make a working system for the heat recovery loop, and to accommodate installation of new pump recovering heat from plant, as well as new tees and isolation valves as shown to set up for connection to new DH-2-2020.
- g) Installation of tee fittings, isolation valves and caps for current or future connection to heat pump loop piping as shown on plans.
- h) Completion of connection between existing original heat pump loop piping on roof and existing heat pump loop piping installed as part of Phase 2. Location is outside to east of existing refrigeration plant room.
- i) Reintroduction of stored hydronic fluid, including chemical treatment thereof in order to match the existing fluid/chemical mix (including propylene glycol) to match both the existing boiler hydronic fluid and the existing refrigeration low grade temperature loop hydronic fluid.
- j) Insulation of all new and existing heat pump piping and fittings, valves, etc., located outside the building.
- k) Commissioning, controls and balancing, etc., of equipment and systems associated with Common Scope.
- l) Building Permit application for demolition work and other required works except for Building Permit (by owner).
- m) Coordination of inspections and final with approval by the City of Campbell River or other related authority.
- n) Close-out documents including as built drawings, operation and maintenance manuals, and warranties.
- o) All included in the design (specifications and drawings) developed by AME Group and its subconsultants, Appendix E..

APPENDIX C: CONTRACT & INSURANCE POLICIES

C. 1 CONTRACT

By submission of a Tender the Tenderer agrees that a contract entered into between the SRD and the selected Tenderer will be substantially the CCDC2 -2008 Stipulated Price Contract, client. Tenderers are to identify any contract terms that they could not agree to and the identification of any such terms shall be included in post-closing negotiations, if any.

C. 2 INSURANCE

At its' own expense and prior to the commencement of the term of the Contract, the Preferred Tenderer shall obtain and maintain or cause to be obtained and maintained in force during the term of the Contract, insurance acceptable to the SRD where the SRD is named as additional insured with limits not less than those shown for each respective item as follows:

Insurance	Independent or Trade Contractor
***Commercial General Liability (CGL)	\$2 million per occurrence
Automobile Liability	\$2 million per occurrence
Pollution Liability Insurance	\$2 million per occurrence
Wrap Up Liability	\$2 million per occurrence (one year after project completion)
Compliance with Workers' Compensation Legislation	WorkSafeBC Clearance Letter

*** If the *Project* requires hot roofing work, the *Construction Manager* or *Contractor* will provide, maintain and pay for a *Commercial General Liability Insurance in the amount of Two Million dollars (\$2,000,000)* inclusive per occurrence against bodily injury and property damage and will require the roofing *Subcontractor* to maintain a similar insurance policy. The *Owner* shall be added as an additional insured. Such insurance shall include, but not be limited to:

- Premises and Operations Liability;
- Products and Completed Operations;
- Owner's and Contractor's Protective Liability;
- Blanket Written Contractual Liability; SRD
- Contingent Employer's Liability.
- Personal Injury Liability;
- Non-Owned Automobile Liability;
- Cross Liability;
- Employees as Additional Insureds; and
- Broad Form Property Damage.

The Construction Manager shall, at its own expense, take special precautions to prevent fires occurring in or about the place of Work and shall observe, and comply with, all laws and regulations in force respecting fires and fire safety.

APPENDIX D: CONFIRMATION OF INTENTION

Invitation to Tender #01-20; Strathcona Gardens Energy Recovery Project Phase 3 AHUs

Please complete this form and e-mail immediately to SRD:

Attention: *Wolfgang Parada, Manager Engineering Services*

e-mail: ***procurement@srd.ca***

Failure to return this form may result in a termination of communication regarding this Request.

Company Name _____

Address _____

City _____ Postal Code: _____

Contact Person _____ Phone _____

E-Mail _____

I have received a copy of the above noted Invitation to Tender.

Yes. I will be responding to this Invitation to Tender.

A site visit is scheduled for: Date: ***Monday, March 2nd, 2020*** Time: ***10:30 AM, Pacific Time***

Commencing From: ***225 South Dogwood St. Campbell River, BC***

Attendance is: **Mandatory**

I authorize SRD to send further correspondence that it deems to be of an urgent nature by the following method:

Courier Collect Facsimile E-Mail

No, I will not be responding to the Request. I understand that if I do not submit a Tender, this will not affect our company's status as a potential Tenderer to SRD in the future.

Signature: _____ Title: _____

Date: _____

APPENDIX E: ISSUED FOR TENDERING DRAWINGS AND SPECIFICATIONS

Energy Retrofit Phase 2



01 EXISTING ROOF/SITE PLAN
M1 SCALE: NTS



PIPING			SYSTEM MONITORING		
DEMOLITION	EXISTING	NEW	DEMOLITION	EXISTING	NEW

LEGAL ADDRESS		GAS LOAD TABLE			
225 S DOGWOOD ST, CAMPBELL RIVER, BC V9W 8C8					
EQUIPMENT TAG	INPUT (EXISTING) (KW)	INPUT (EXISTING) (MBH)	INPUT (NEW) (KW)	INPUT (NEW) (MBH)	NOTES
ROOFTOP UNITS					
EXISTING AHU-1	252	860	252	860	EXISTING TO REMAIN
EXISTING AHU-2	205	700	205	700	EXISTING TO REMAIN
EXISTING AHU-3	103	350			EXISTING TO BE REPLACED
EXISTING AHU-4	59	202			EXISTING TO BE REPLACED
EXISTING AHU-5	103	350			EXISTING TO BE REPLACED
WATER HEATERS					
NEW DWH-01-2019	147	500	84	286	REPLACED IN ENERGY RETROFIT PHASE 1
NEW DWH-02-2019	NA	NA	84	286	REPLACED IN ENERGY RETROFIT PHASE 1
BOILERS					
NEW B-01-2019	308	1050	586	2000	REPLACED IN ENERGY RETROFIT PHASE 1
NEW B-02-2019	308	1050	586	2000	REPLACED IN ENERGY RETROFIT PHASE 1
NEW B-03-2019			586	2000	REPLACED IN ENERGY RETROFIT PHASE 1
DEHUMIDIFIER					
EXISTING DH-1	117	400	117	400	EXISTING TO REMAIN
EXISTING DH-2	117	400			DU REPLACEMENT - SEPARATE PRICE
UNIT HEATERS					
EXISTING UH-1 to UH-4	8	27.3	8	27.3	EXISTING TO REMAIN
TOTAL					
EXISTING LOAD	1726	5889			
NEW LOAD			2890	8559	
FUTURE LOAD ALLOWANCE					POOL AHUS

NOTES:
1. GAS DNSTREAM OF METER TO BE 34KPa (5PSI) BASED ON 17KPa (2.5PSI) PRESSURE DROP @ 200m. (CONTRACTOR TO VERIFY RUN)
2. "NEW LOAD" IS TOTAL CONNECTED LOAD OF EXISTING EQUIPMENT.
3. NEW AHUS TO HAVE HYDRONIC EQUIVALENT GAS LOADS OF REPLACED EXISTING

MECHANICAL DRAWING LIST		
DRAWINGS NO.	DESCRIPTION	SCALE
M1	COVER SHEET & ROOFSITE PLAN	N.T.S.
M2	MECHANICAL MOTORLIST AND SCHEDULES	N.T.S.
M3	ROOF PLAN - AHU DEMOLITION	1:100
M4	ROOF PLAN - ARENA DEHUMIDIFICATION DEMOLITION	1:100
M5	ROOF PLAN - AHU NEW	1:100
M6	ROOF PLAN - ARENA DEHUMIDIFICATION NEW	1:100
M7	SCHEMATIC & DETAILS - DEMO & NEW	N.T.S.
M8	DETAILS	N.T.S.

ELECTRICAL DRAWING LIST		
DRAWINGS NO.	DESCRIPTION	SCALE
E-000	COVER SHEET, DRAWING LIST & SYMBOL LEGEND	AS NOTED
E-001	ELECTRICAL FLOOR PLAN, SINGLE LINE DIAGRAM AND MECH SCHEDULE	AS NOTED
E-100	SITE PLAN	AS NOTED
E-200	ROOF PLAN - ELECTRICAL	AS NOTED
E-300	OUTLINE SPECIFICATION	AS NOTED

STRUCTURAL DRAWING LIST		
DRAWINGS NO.	DESCRIPTION	SCALE
S01	ROOF PLAN - AHU NEW	AS NOTED
S02	ROOF PLAN - AHU NEW	-

ARCHITECTURAL DRAWING LIST		
DRAWINGS NO.	DESCRIPTION	SCALE
ASK-01	AHU CURB DETAILS	AS NOTED

AIR HANDLING UNIT SCHEDULE

TAG	AHU-3	AHU-4	AHU-5
QUANTITY	1	1	1
LOCATION	ROOFTOP	ROOFTOP	ROOFTOP
SERVICE			
MANUFACTURER	TRANE	TRANE	ALDES
SYSTEM TYPE			
MODEL	OAGE144C5-C1BC	OAKE180DS	CH300DE
SUPPLY FAN			
TAG			
NORMAL VOLUME (CFM)	3000	5000	3000
MINIMUM OUTDOOR AIR (CFM)			
EXTERNAL STATIC (IN. WG)	1.27	2.60	1.20
TOTAL STATIC (IN. WG)	1.75	3.51	3.46
FAN TYPE			
FAN SPEED (RPM)	1242.0	1752.0	1528.0
ACTUAL FAN SPEED (RPM)			
MOTOR (HP)	3.8	5.0	5.0
BREAK HORSE POWER (HP)	1.7	3.9	2.7
VSD (VARIABLE SPD DRIVE)	YES	YES	VFD
POWER SUPPLY	575 / 3	575 / 3	575 / 3
RETURN FAN			
TAG			
VOLUME (CFM)	5000.0	3000.0	
EXTERNAL STATIC (IN. WG)	0.6	1.0	
TOTAL STATIC (IN. WG)	0.6	1.6	
FAN TYPE			
FAN SPEED (RPM)	1175.0	1030.0	
ACTUAL FAN SPEED (RPM)			
MOTOR (HP)	2.0	2.0	
BREAK HORSE POWER (HP)	1.1	1.5	
VSD (VARIABLE SPD DRIVE)	VFD		
POWER SUPPLY	575 / 3	575 / 3	
HEATING COIL			
CAPACITY (MBH)	172.30	244.2	177.0
AIR PRESSURE DROP (IN. WG)			
MAX AIR VELOCITY (FPM)			
EAT (DEG. F)	55.0	56.0	
LAT (DEG. F)	195.5	98.4	
EWI (DEG. F)	72.0	79.0	
LWT (DEG. F)	63.9	68.8	
COIL P. DROP (FT. WG)	8.1	11.5	
COIL FLOW (GPM)	36.4	45.0	
VALVE TYPE			
COOLING COIL			
SENSIBLE CAPACITY (MBH)	111	152.10	
TOTAL CAPACITY (MBH)	143	172.50	
AIR PRESSURE DROP (IN. WG)	0.23	0.880	
MAX AIR VELOCITY (FPM)	300	500.0	
EAT DB (DEG. F)	85	75.0	
EAT WB (DEG. F)	67	60.0	
LAT DB (DEG. F)	51	47.00	
LAT WB (DEG. F)	51	46.90	
EWI (DEG. F)	85	85.0	
LWT (DEG. F)	95	94.70	
COIL P. DROP (FT. WG)	8	10.80	
COIL FLOW (GPM)	36	45.0	
VALVE TYPE			
HEAT RECOVERY (AIR)			
SENSIBLE CAPACITY (MBH)			
EXHAUST LAT (DEG. F)			
SUPPLY LAT (DEG. F)			
RA EAT (DEG. F)			
QA EAT (DEG. F)			
BY-PASS			
PRE-HEAT COIL	REFER TO AHU-3 PH SCHEDULE		
FILTERS			
PRE-FILTER	MERV 8	MERV 8	MERV 8
MAIN FILTER	MERV 8	MERV 8	MERV 8
DIMENSIONS			
LXWXH (INCH)	155X82X72	187X90X84	142X71X71
REMARKS			
NOTES:	1. 100% ECONOMIZER CAPABILITY 2. ALL HOA AND VSD STARTER ARE TO BE FACTORY INSTALLED AND BE INSTALLED IN NEMA 4 RATED ENCLOSURES. 3. 100% OUTDOOR AIR WITH RETURN AIR RECIRCULATION TO PREVENT HEATING COIL FREEZING SIZED AT 30% OF UNIT AIRFLOW. 4. SINGLE POINT POWER CONNECTION TO UNIT (EXCEPT LIGHTING) 5. LIGHTING TO BE PROVIDED ON SEPARATE 120V CIRCUIT.		

MECHANICAL MOTORLIST

UNIT NUMBER	QTY	UNIT DESCRIPTION	UNIT LOCATION	STANDARD PWR (YES/NO)	GENCY POWER	ELECTRICAL LOAD				VOLT	PH	EQUIPMENT			STARTER			DISCONNECT			CONTROL			NOTES		
						MCA	FLA	KW	HP			S	I	C	S	I	C	S	I	C	S	I	C			
AHU-3-2020	1	AIR HANDLING UNIT	ROOFTOP	-		21.4	19.5			575	3	M	M	M	M	M	E	VFD	E	E	E	M	M	E	DDC	1,2
AHU-4-2020	1	POOL CHANGE ROOM AHU	ROOFTOP	-		29.8	27.4			575	3	M	M	M	M	M	E	VFD	E	E	E	M	M	E	DDC	1,2
AHU-5-2020	1	LOBBY/ADMIN AHU	ROOFTOP	-		12.5	10			575	3	M	M	M	M	M	E	VFD	E	E	E	M	M	E	DDC	1,2
AHU-5-2020	1	ARENA CHANGEROOMS	ROOFTOP	-																						
DH-2-2020	1	ARENA 2 DEHUMIDIFIER	ROOFTOP	-		55	50.5		15	575	3	M	M	M	M	M	E	VFD	E	E	E	M	M	E	DDC	1,2
P-01R-2020	1	DEHUMIDIFIER	ROOFTOP	-																						
P-02R-2020	1	PUMPS	ROOFTOP	-																						
P-02R-2020	1	CIRCULATION PUMP FOR AHU-3-2020	ROOFTOP	-					1	575	3	M	M	M	M	M	E	VFD	E	E	E	M	M	E	DDC	
P-02R-2020	1	CIRCULATION PUMP FOR AHU-4-2020	ROOFTOP	-					1.5	575	3	M	M	M	M	M	E	VFD	E	E	E	M	M	E	DDC	
P-03R-2020	1	CIRCULATION PUMP FOR AHU-5-2020	ROOFTOP	-					1.5	575	3	M	M	M	M	M	E	VFD	E	E	E	M	M	E	DDC	
P-201-2020	1	CIRCULATION PUMP FOR DH-2-2020	REFRIGERATION ROOM	-					3	575	3	M	M	M	M	M	E	VFD	E	E	E	M	M	E	DDC	
P-202-2020	1	ARENA HEAT REJECTION LOOP	REFRIGERATION ROOM	-					3	575	3	M	M	M	M	M	E	VFD	E	E	E	M	M	E	DDC	
P-203-2020	1	BOILER LOOP PUMP	POOL MECHANICAL ROOM	-					3	575	3	M	M	M	M	M	E	VFD	E	E	E	M	M	E	DDC	
P-13A-2020	2	MAIN HYDRONIC LOOP CIRCULATION PUMPS	POOL MECHANICAL ROOM	-					10	575	3	M	M	M	M	M	E	VFD	E	E	E	M	M	E	DDC	

SUPPLIER / INSTALL / WIRE CODES:
 MECH = MECHANICAL
 ELEC = ELECTRICAL
 G = GENERAL CONTRACTOR
 S = SUPPLIED BY
 I = INSTALLED BY
 C = CONNECTED BY

CONTROL DEVICE CODES:
 AQUA = PUMP CONTROLLED BY AQUASTAT
 BMS = BLDG MANAGEMENT SYSTEM
 ES = END SWITCH
 ET = LINE VOLTAGE TSTAT
 FA = FIRE ALARM
 FAP = FIRE ALARM PANEL
 FS = FLOW SWITCH
 GS = GAS SENSOR
 H = HUMIDITY SENSOR
 I = INTERLOCK, SEE NOTES
 LIGHT = WIRED TO LIGHT SWITCH
 LS = LEVEL SWITCH
 OS = OCCUPANT SENSOR
 PS = PRESSURE SWITCH
 R. STAT = REVERSE ACTING THERMOSTAT
 TC = TIME CLOCK
 MAG = MAGNETIC STARTER C/W AUX STATUS CONTACTS
 MRR = MOTOR RATED RELAY, 24 VAC COIL & MOTOR PROTECTION SWITCH
 PCS = PACKAGED CONTROL SYSTEM
 VFD = VARIABLE FREQUENCY DRIVE
 RVSS = REDUCED VOLTAGE STARTER
 WS = WALL SWITCH
 CP = CONTROL PANEL

EMERGENCY POWER CODES:
 VP = VITAL POWER
 DVP = DELAYED VITAL POWER
 CP = CONDITIONAL POWER
 NP = NORMAL POWER

**ELECTRICAL LOAD CODES:
 BHP = BREAK HORSEPOWER
 FLA = UNIT FULL LOAD AMPS
 HP = UNIT OR MOTOR HORSE POWER
 PH = POWER PHASE
 MCA = MINIMUM CIRCUIT AMPS
 VOLT = REQUIRED SUPPLY VOLTAGE**

GENERAL NOTES:
 A. ALL FIRE ALARM DEVICES WIRED BY ELECTRICAL
 B. CONTROL PANELS ARE SHIPPED LOSS & REQUIRE FIELD WIRING
 C. PCS EQUIPMENT REQUIRES SINGLE SOURCE POWER CONNECTION, UNLESS NOTED OTHERWISE.
 D. CP, VFD EQUIPMENT REQUIRES POWER WIRING TO AND FROM CONTROL PANEL TO CONTROLLED EQUIPMENT

MISCELLANEOUS CODES:
 FFCP = FIRE FIGHTERS CONTROL PANEL
 FRAC = FRACTIONAL HORSEPOWER
 INT = INTEGRAL PART OF UNIT

NOTES:
 1. SINGLE POINT POWER CONNECTION
 2. CONNECT TO EXISTING DDC CONTROLS AND ALL EXISTING SENSORS IN SYSTEM

PUMP SCHEDULE

EQUIPMENT TAG	QTY	DESCRIPTION	LOCATION	TYPE	MANUFACTURER	MODEL	FLOW (EA) (GPM)	LIQUID TEMP. (DEG. F)	HEAD (EA) (FT)	MOTOR (HP)	MOTOR (RPM)	AT DESIGN (RPM)	POWER (V/PH/Hz)	NOTES
P-01R-2020	1	CIRCULATION PUMP FOR AHU-3-2020	ROOFTOP	CLOSE COUPLED VERTICAL IN-LINE	ARMSTRONG	4380	37	95.0	20.0	1.0	1760	1760	575/3/60	2,3
P-02R-2020	1	CIRCULATION PUMP FOR AHU-4-2020	ROOFTOP	CLOSE COUPLED VERTICAL IN-LINE	ARMSTRONG	4380	45	95.0	25.0	1.5	3250	3250	575/3/60	2,3
P-03R-2020	1	CIRCULATION PUMP FOR AHU-5-2020	ROOFTOP	CLOSE COUPLED VERTICAL IN-LINE	ARMSTRONG	4380	89	95.0	15.0	1.5	3635	3635	575/3/60	2,3
P-201-2020	1	CIRCULATION FOR DH-2-2020	REFRIGERATION ROOM	CLOSE COUPLED VERTICAL IN-LINE	ARMSTRONG	4380	157	95.0	40.0	3.0	1981	1981	575/3/60	2,3
P-202-2020	1	MAIN HYDRONIC LOOP CIRCULATORS	REFRIGERATION ROOM	CLOSE COUPLED VERTICAL IN-LINE	ARMSTRONG	4300	400	95.0	20.0	3.0	1118	1118	575/3/60	2,3
P-203-2020	1	BOILER LOOP PUMP	POOL FILTER ROOM	CLOSE COUPLED VERTICAL IN-LINE	ARMSTRONG	4300	200	95.0	25.0	3.0	2642	2642	575/3/60	2,3
P-13A-2020	1	MAIN HYDRONIC LOOP CIRCULATORS	POOL FILTER ROOM	CLOSE COUPLED VERTICAL IN-LINE	ARMSTRONG	4300	275	95.0	75.0	10.0	3323	3323	575/3/60	1,2,3
P-13B-2020	1	MAIN HYDRONIC LOOP CIRCULATORS	POOL FILTER ROOM	CLOSE COUPLED VERTICAL IN-LINE	ARMSTRONG	4300	275	95.0	75.0	10.0	3323	3323	575/3/60	1,2,3

NOTES:
 1. 2 @ 50% CAPACITY, PARALLEL CONFIGURATION
 2. CONTROLLED VIA A VFD (VARIABLE FREQUENCY DRIVE)
 3. HIGH EFFICIENCY MOTOR, SEE MOTORLIST FOR STARTER / VFD / CONTROLS

AIR HANDLING UNIT

TAG	AHU-3PH
QUANTITY	1
LOCATION	ROOF
MANUFACTURER	TRANE
MODEL	CSA008
PRE-HEAT COIL	
CAPACITY (MBH)	120
AIR PRESSURE DROP (IN. WG)	0.151
MAX AIR VELOCITY (FPM)	376.0
EAT (DEG. F)	18.0
LAT (DEG. F)	55.0
EWI (DEG. F)	79.0
LWT (DEG. F)	72.0
COIL P. DROP (FT. WG)	4.0
COIL FLOW (GPM)	36.4
FILTERS	
MAIN FILTER	MERV 8
DIMENSIONS	
LXWXH (INCH)	64 9X50.5X43.6
REMARKS	

- NOTES:
 1. 100% ECONOMIZER CAPABILITY
 2. ALL HOA AND VSD STARTER ARE TO BE FACTORY INSTALLED AND BE INSTALLED IN NEMA 4 RATED ENCLOSURES.
 3. 100% OUTDOOR AIR WITH RETURN AIR RECIRCULATION TO PREVENT HEATING COIL FREEZING SIZED AT 30% OF UNIT AIRFLOW.
 4. SINGLE POINT POWER (EXCEPT LIGHTING) CONNECTION TO UNIT
 5. LIGHTING TO BE PROVIDED ON SEPARATE 120V CIRCUIT.

ARENA 2 DEHUMIDIFIER

TAG	DH-2-2020
QUANTITY	1
LOCATION	ROOFTOP
SERVICE	
MANUFACTURER	MUNTERS
SYSTEM TYPE	
MODEL	FREE DRY HCU68010
SUPPLY FAN	
TAG	
NORMAL VOLUME (CFM)	0-8,000
MINIMUM OUTDOOR AIR (CFM)	0-8,000
EXTERNAL STATIC (IN. WG)	1.00
TOTAL STATIC (IN. WG)	
FAN TYPE	
FAN SPEED (RPM)	1375.0
ACTUAL FAN SPEED (RPM)	
MOTOR (HP)	15.0
BREAK HORSE POWER (HP)	
VSD (VARIABLE SPD DRIVE)	YES
POWER SUPPLY	575/3/60
REACTIVATION FAN	
TAG	
VOLUME (CFM)	VARIABLE TO 8,000
EXTERNAL STATIC (IN. WG)	
TOTAL STATIC (IN. WG)	
MOTOR (HP)	10.0
REACTIVATION HEATER	
CONDENSER CIRCUIT A (MBH)	150.00
PRE-COOL DX COIL	
REFRIGERANT TYPE	R-410A
AIRFLOW (CFM)	8000.0
TOTAL CAPACITY (NOMINAL TONS)	10.0
COIL CIRCUITS	1.0
LWT (DEG. F)	-
COIL P. DROP (FT. WG)	-
COIL FLOW (GPM)	-
DESICCANT ROTOR	
DIMENSIONS (DIAMETER IN x DEPTH MM)	60 x 200
AIRFLOW (CFM)	8,000
FILTERS	
SUPPLY AIRSTREAM	2" 30% PLEATED
REACTIVATION AIRSTREAM	2" 30% PLEATED
ELECTRICAL	
SYSTEM VOLTAGE (V/PH)	460/3/60
CONTROL CIRCUIT VOLTAGE	120V
SUPPLY BLOWER MOTOR AMPS	16.0
REACTIVATION FAN MOTOR AMPS	12.4
COMPRESSOR A AMPS	17.3
CONTROL TRANSFORMER AMPS	2.2
UNIT FLA	50.5
UNIT MCA	55.0
UNIT MOP	70.0
DIMENSIONS	
LXWXH (INCH)	233.75x 95.875 x 87.25
REMARKS	2.5
NOTES:	

1. 100% ECONOMIZER CAPABILITY
 2. ALL HOA AND VSD STARTER ARE TO BE FACTORY INSTALLED AND BE INSTALLED IN NEMA 4 RATED ENCLOSURES.
 3. SINGLE POINT POWER CONNECTION TO UNIT (EXCEPT LIGHTING)
 4. LIGHTING TO BE PROVIDED ON SEPARATE 120V CIRCUIT



REV.	DATE	DESCRIPTION
1	2020.01.27	ISSUED FOR TENDER

CONSULTANT:
 SEAL:
 PROJECT TITLE:
**STRATHCONA
 GARDENS RECREATION
 COMPLEX - ENERGY
 RETROFIT PHASE 2**
 PROJECT ADDRESS:
 225 S DOGWOOD STREET
 CAMPBELL RIVER, BC
 V9W 6C8
 DRAWN BY: YB
 CHECKED BY: CT, CB
 SCALE: AS NOTED
 DATE: 01/29/2020
 DRAWING TITLE:
**MECHANICAL
 MOTORLIST AND
 SCHEDULES**
 PROJECT NO. 009a-086-19 DRAWING NO. M2



DEMO EXISTING AHU-4, & ROOF CURB

CONFIRM ON-SITE EXTENT OF REMOVING EXISTING DUCTWORK TO COORDINATE WITH INSTALLATION OF NEW AHU, ONLY REMOVE AS NECESSARY

5 EXISTING AHU-4 - DEMO
M3 SCALE: NTS



DISCONNECT GAS & REMOVE BRANCH BACK TO THE MAIN & CAP OFF.

DISCONNECT ELECT & SAFELY STOW FOR RECONNECTION TO NEW. REFER TO ELECT FOR DETAILS.

DEMOLISH AHU-4, AND APPROX SFT OF S/A DUCTWORK

4 EXISTING AHU-4 - DEMO
M3 SCALE: NTS



DEMOLISH S/A DUCT TO ROOF & PROVIDE PROTECTION FROM ELEMENTS UNTIL NEW AHU IS READY TO CONNECT.

DISCONNECT ELECTRICAL REFER TO ELECTRICAL FOR DETAILS.

3 EXISTING AHU-3 - DEMO
M3 SCALE: NTS



DISCONNECT GAS & REMOVE BRANCH BACK TO THE MAIN & CAP OFF.

DEMOLISH EXISTING ROOF CURB

DEMOLISH EXISTING DUCTWORK TO ROOF PENETRATION. PROVIDE PROTECTION FROM ELEMENTS UNTIL NEW AHU IS READY TO CONNECT.

2 EXISTING AHU-3 - DEMO
M3 SCALE: NTS

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consulting mechanical engineers

1200-1000-1000 1200-1000-1000 1200-1000-1000
720 JOHNSON ST. VANCOUVER, BC V6C 3M4

1100-888 W HAVESIDE ST. VANCOUVER, BC V6C 3M4

748-1122 484-1987 3W CALGARY, AB T2B 1K6

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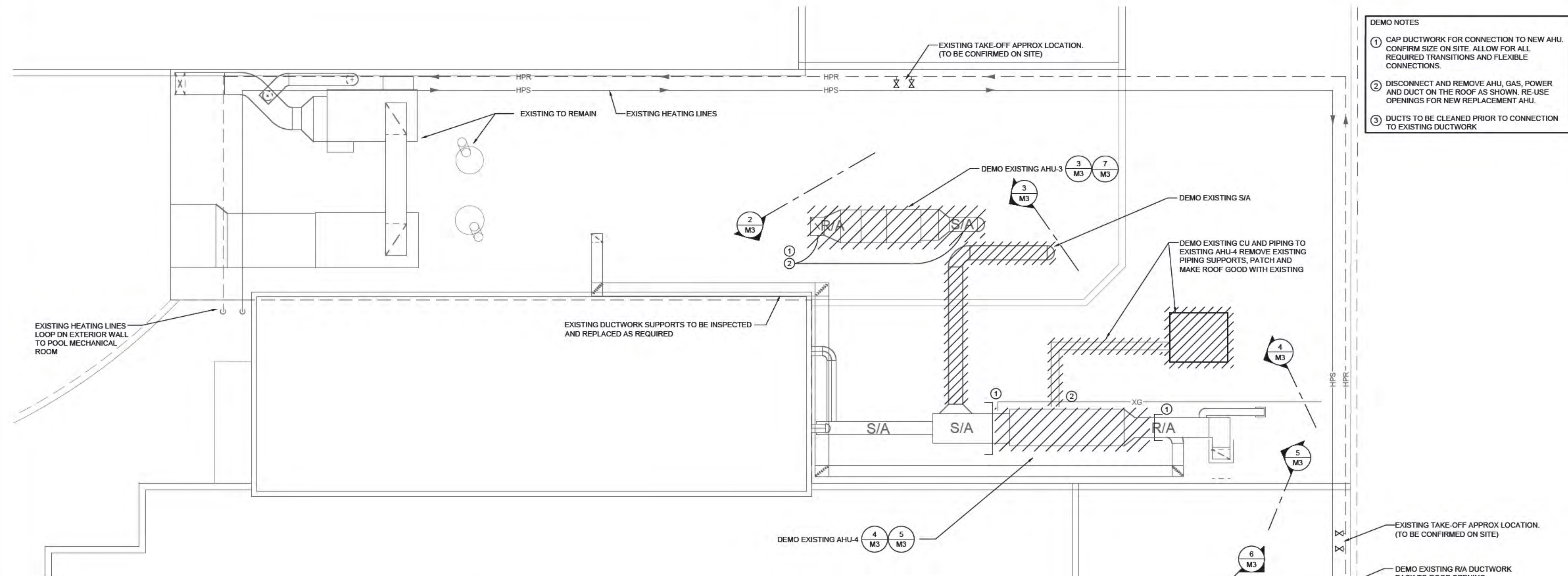


NEW AHU-5 TO CONNECT TO EXISTING R/A

DEMO AHU-5, CONFIRM ROOF CURB / HOUSEKEEPING PAD SIZE FOR FUTURE USE. IF NOT SUITABLE FOR FUTURE, TO BE DEMOLISHED.

DEMO AND CAP OFF DUCTS AND GAS PIPING. NEW AHU-5 TO CONNECT TO EXISTING S/A. DEMOLISH EXISTING DUCTWORK ONLY ENOUGH FOR RECONNECTION TO NEW AHU AND NEW COIL. CONFIRM ON-SITE AND WITH NEW AHU SELECTION.

6 EXISTING AHU-5 - DEMO
M3 SCALE: NTS



DEMO NOTES

- CAP DUCTWORK FOR CONNECTION TO NEW AHU. CONFIRM SIZE ON SITE. ALLOW FOR ALL REQUIRED TRANSITIONS AND FLEXIBLE CONNECTIONS.
- DISCONNECT AND REMOVE AHU, GAS, POWER AND DUCT ON THE ROOF AS SHOWN. RE-USE OPENINGS FOR NEW REPLACEMENT AHU.
- DUCTS TO BE CLEANED PRIOR TO CONNECTION TO EXISTING DUCTWORK



DEMO EXISTING CHANGE ROOM E/A FAN EF-11 AND COVER UP OPENING UNTIL NEW AHU-5 IS READY TO CONNECT.

7 EXISTING EF-11 - DEMO
M3 SCALE: NTS



DEMO EXISTING WASHROOM E/A FAN EF-13 AND COVER UP OPENING UNTIL NEW AHU-5 IS READY TO CONNECT.

8 EXISTING EF-13 - DEMO
M3 SCALE: NTS



CUT BACK EXISTING HEAT PUMP LOOP FROM POOL & CAP OFF TYP. OF 4

RETAIN VALVES & PASS OVER TO OWNER TYP. OF 4

DEMOLISH EXISTING HYDROVIC LOOP

NEW PARALLEL PUMPS TO BE LOCATED APPROXIMATELY HERE, REFER TO NEW LAYOUT FOR DETAILS

9 P-13 - DEMO
M3 SCALE: NTS

1 ROOF PLAN - AHU DEMOLITION
M3 SCALE: 1:100

CONSULTANT:

SEAL:

PROJECT TITLE:
STRATHCONA GARDENS RECREATION COMPLEX - ENERGY RETROFIT PHASE 2

PROJECT ADDRESS:
225 S DOGWOOD STREET
CAMPELL RIVER, BC
V9W 6C8

DRAWN BY: YB
CHECKED BY: CT, CB
SCALE: AS NOTED
DATE: 01/29/2020

DRAWING TITLE:
ROOF PLAN - AHU DEMOLITION

PROJECT NO. 009a-086-19
DRAWING NO. M3

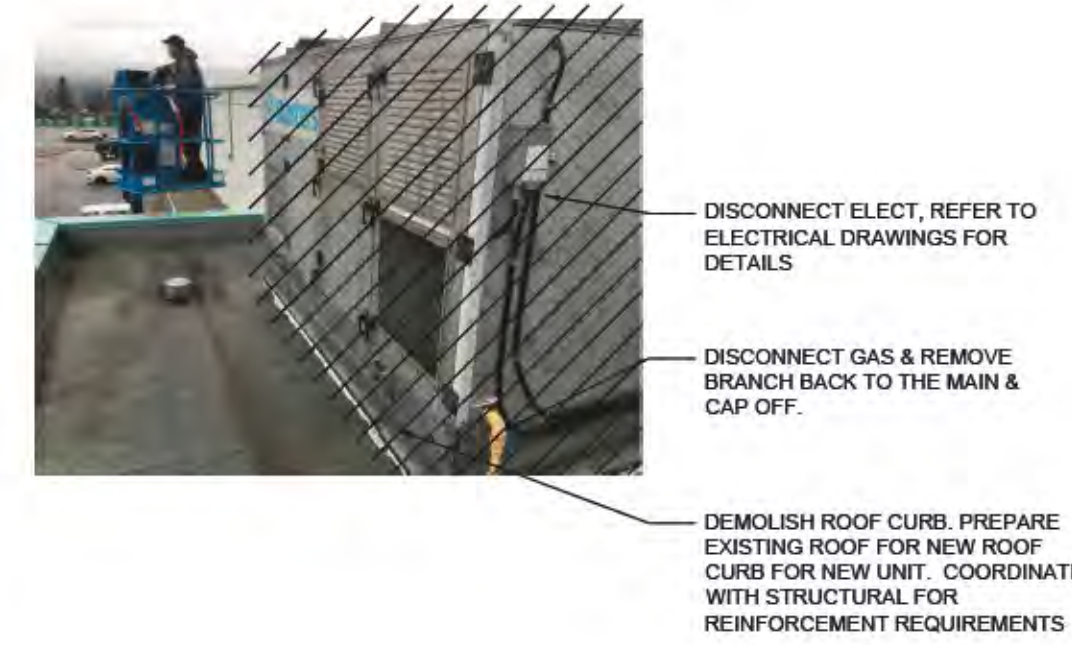
PROJECT NORTH



4 EXISTING HYDRONIC LOOP DEMO
M4 SCALE: NTS



4 EXISTING DH-2 - DEMO
M4 SCALE: NTS



3 EXISTING DH-2 - DEMO
M4 SCALE: NTS



2 EXISTING DH-2 - DEMO
M4 SCALE: NTS

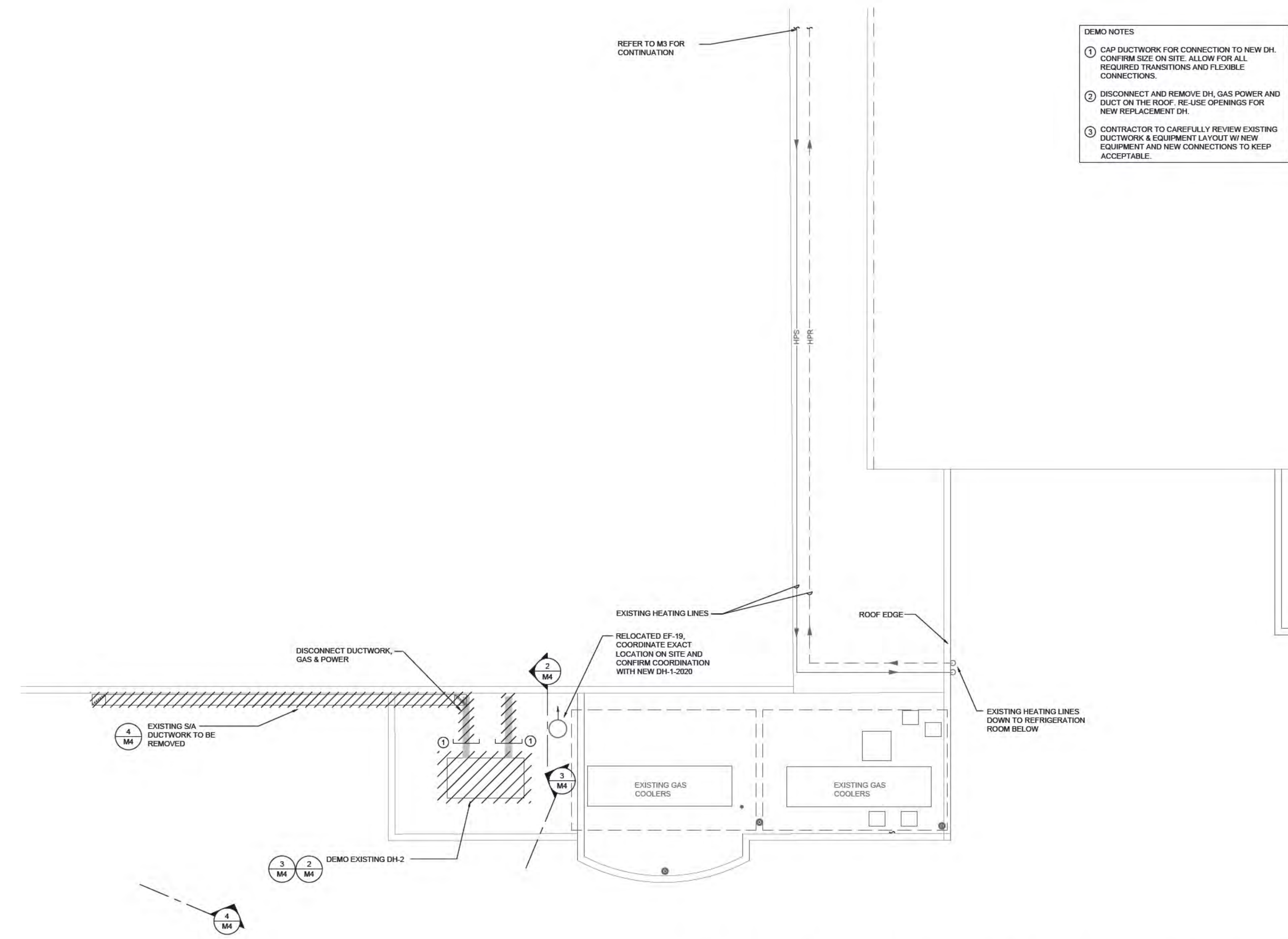
AME Group
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1.	2020.01.27	ISSUED FOR TENDER



1 ROOF PLAN - ARENA DEHUMIDIFICATION DEMOLITION
M4 SCALE: 1:100

CONSULTANT:

SEAL:

PROJECT TITLE:
STRATHCONA GARDENS RECREATION COMPLEX - ENERGY RETROFIT PHASE 2

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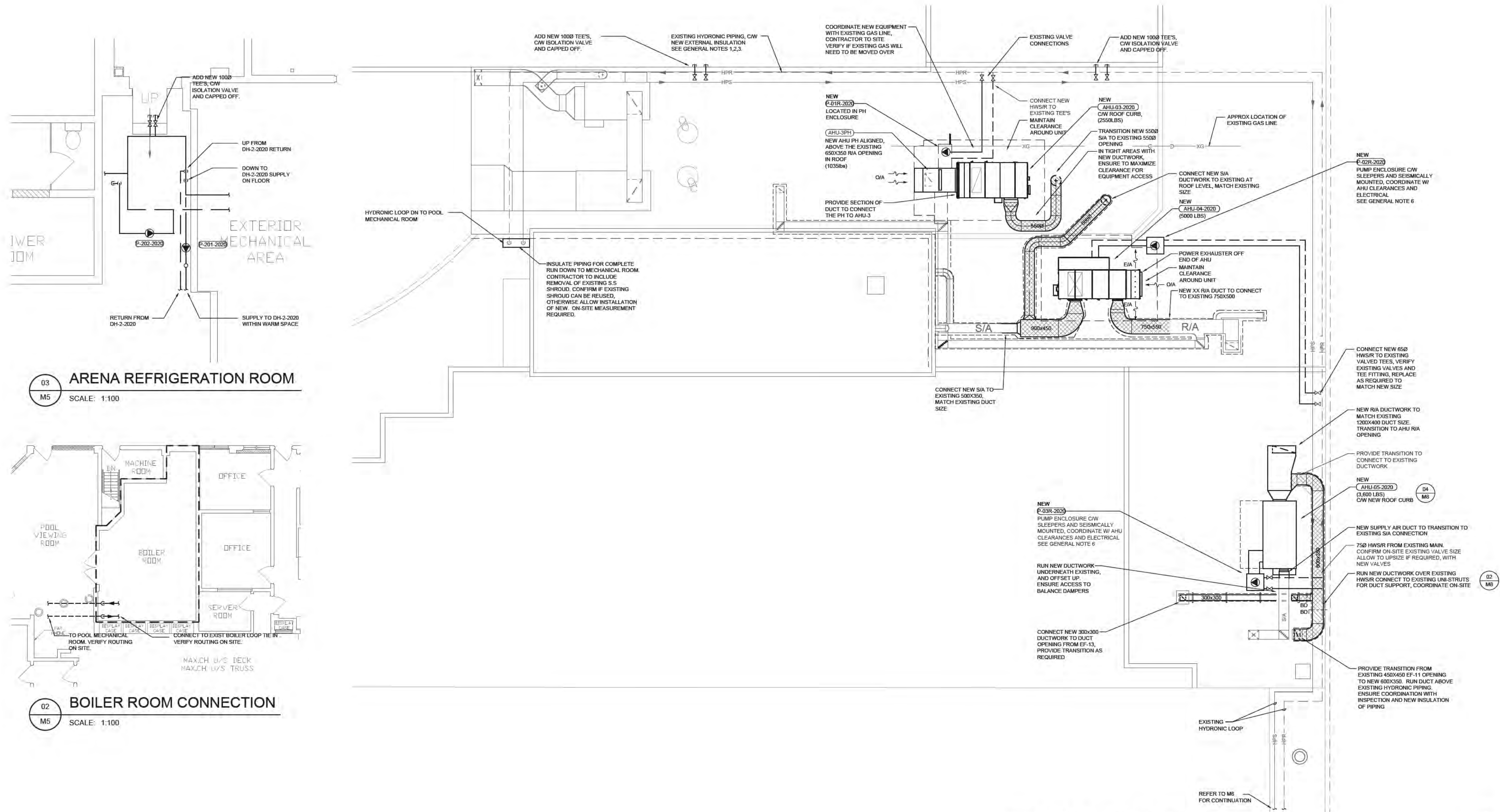
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PROJECT NO.	DRAWING NO.
009a-086-19	M4

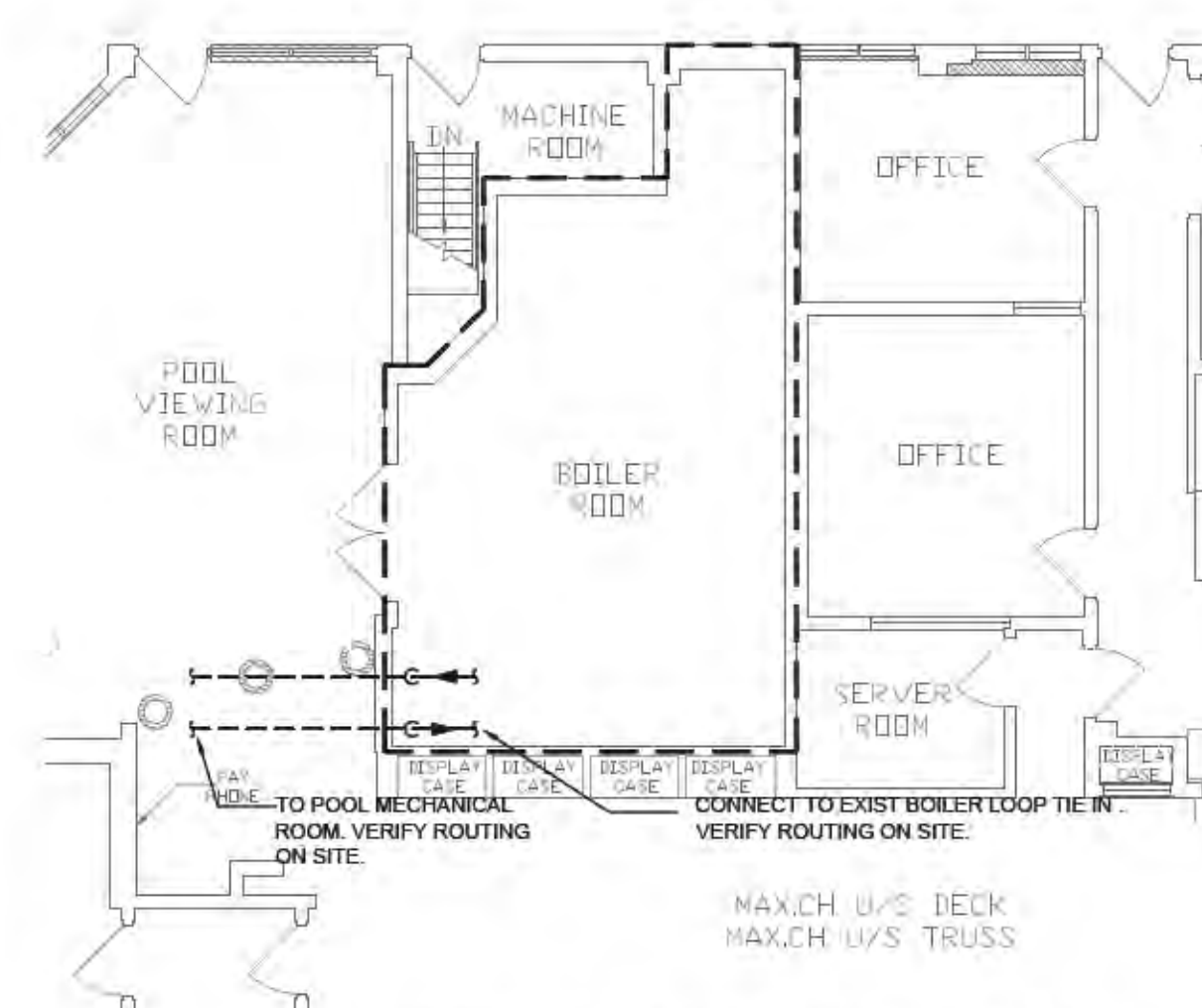
PROJECT NORTH

REV.	DATE	DESCRIPTION
1	2020.01.27	ISSUED FOR TENDER

- GENERAL NOTES**
- CONTRACTOR TO DRAIN EXISTING HYDRONIC SYSTEM OF GLYCOL TEST CONCENTRATION, AND CONFIRM CAPABILITY WITH NEW EQUIPMENT. ALLOW FOR RECHARGING WITH NEW GLYCOL SHOULD EXISTING NOT BE COMPATIBLE.
 - CONTRACTOR TO INSPECT EXISTING HYDRONIC LOOP TO BE USED IN THIS PHASE, AND TEST TO ENSURE IN GOOD CONDITION. PRIOR TO CHARGING THE SYSTEM AND ALLOW REPLACEMENT OF PART OR IN WHOLE IF DEEMED NECESSARY.
 - ALL EXISTING HYDRONIC PIPING TO BE INSULATED THROUGHOUT COMPLETE RUN, CONTRACTOR TO ALLOW REMOVAL AND REINSTALLATION OF BRACKETS AND SUPPORTS AS REQUIRED TO PROPERLY INSULATE PIPING.
 - PROVIDE NEW EXTERNAL INSULATION ON ALL EXISTING AND NEW DUCTWORK, CW ALUMINUM CLADDING.
 - ALL NEW DUCT CONNECTIONS TO THE NEW UNITS (AHU'S & DH), TO CW FLEXIBLE DUCT CONNECTIONS SUITABLE FOR DESIGN CONDITIONS.
 - PROVIDE 900X900X1200 HIGH WEATHERPOOF PUMP BOXES FOR P-03R-2020 & P-03R-2020. BOXES TO BE SEALED WEATHER TIGHT DOUBLE WALL. ALLOW CLEARANCE FOR ELECTRICAL & PLUMBING CONNECTIONS INSIDE. SEAL PIPING PENETRATIONS.
 - PROVIDE INSULATED SEALED ACCESS HATCHES FOR ALL BALANCE DAMPERS. REFER TO PLAN FOR LOCATIONS.
 - CONTRACTOR TO PROVIDE A TOTAL COST PER EACH DUCT SUPPORT FOR REPLACEMENT OF EXISTING IDENTIFIED DURING SITE WALKTHROUGH & TENDER PERIOD. ANY SUPPORTS REQUIRING REPLACEMENT NOT PREVIOUSLY IDENTIFIED SHALL BE REPLACED ON A COST PER SUPPORT AS PER TENDER BID.
 - ALL NEW DUCTWORK AND PIPING TO HAVE SUPPORTS, REFER TO DETAIL.
 - ALL EXISTING DUCTWORK ASSOCIATED WITH THE ENTIRE RUN.
 - CONFIRM SIZE OF ALL CURRENT DUCT OPENINGS IN ROOF ON SITE.



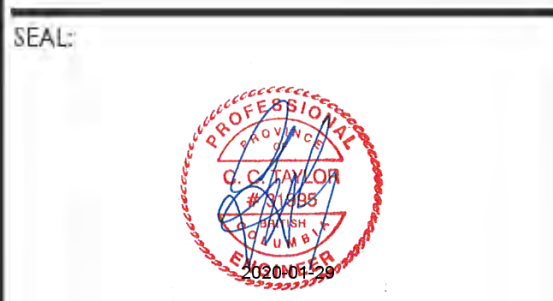
03 ARENA REFRIGERATION ROOM
M5 SCALE: 1:100



02 BOILER ROOM CONNECTION
M5 SCALE: 1:100

01 ROOF PLAN - AHU NEW
M5 SCALE: 1:100

CONSULTANT:



PROJECT TITLE:
STRATHCONA GARDENS RECREATION COMPLEX - ENERGY RETROFIT PHASE 2

PROJECT ADDRESS:
225 S DOGWOOD STREET
CAMPBELL RIVER, BC
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DRAWN BY: YB.BS
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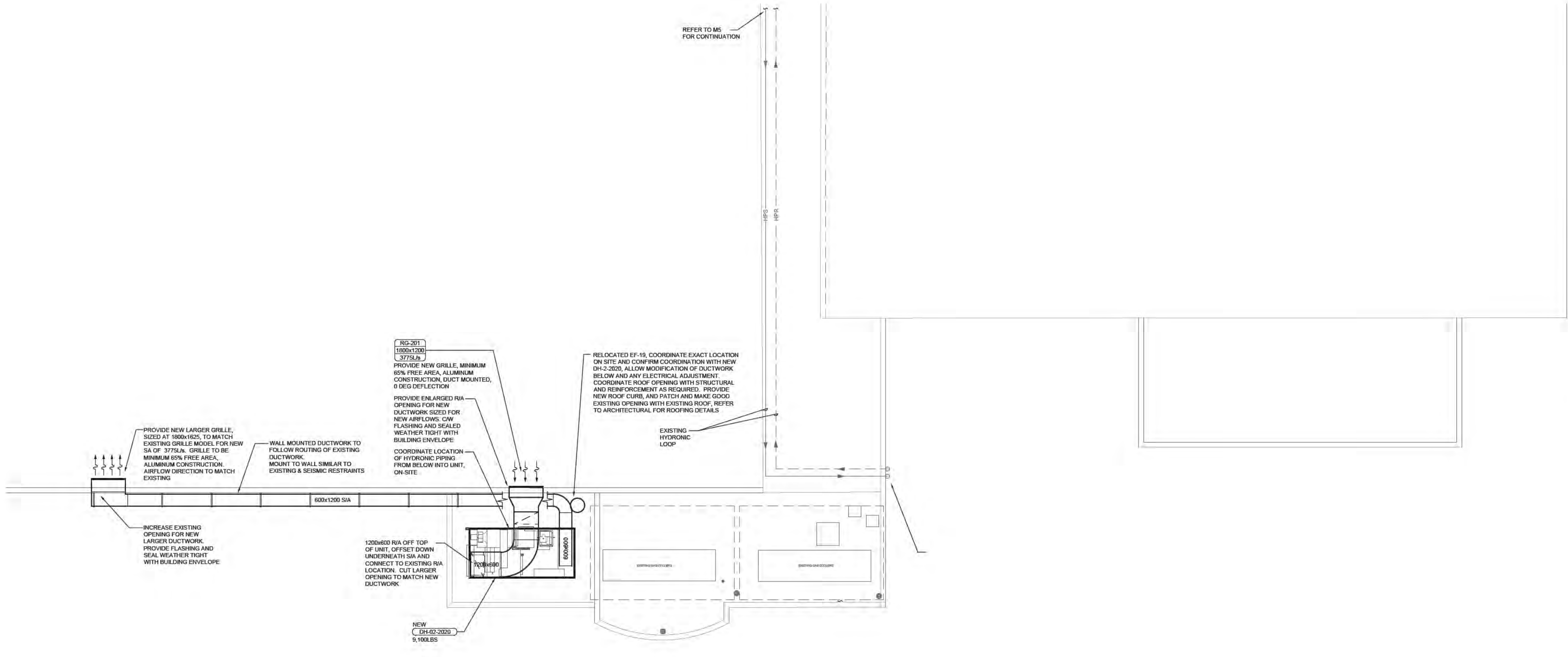
DRAWING TITLE:
ROOF PLAN - AHU NEW

PROJECT NO. 009a-086-19
DRAWING NO. M5



REV.	DATE	DESCRIPTION
1	2020.01.27	ISSUED FOR TENDER

- GENERAL NOTES**
- 1 CONTRACTOR TO DRAIN EXISTING HYDRONIC SYSTEM OF GLYCOL, TEST CONCENTRATION, AND CONFIRM CAPABILITY WITH NEW EQUIPMENT. ALLOW FOR RECHARGING WITH NEW GLYCOL SHOULD EXISTING NOT BE COMPATIBLE.
 - 2 CONTRACTOR TO INSPECT EXISTING HYDRONIC LOOP TO BE USED IN THIS PHASE, AND TEST TO ENSURE IN GOOD CONDITION, PRIOR TO CHARGING THE SYSTEM AND ALLOW REPLACEMENT OF PART OR IN WHOLE IF DEEMED NECESSARY.
 - 3 ALL EXISTING HYDRONIC PIPING TO BE INSULATED THROUGHOUT COMPLETE RUN, CONTRACTOR TO ALLOW REMOVAL AND REINSTALLATION OF BRACKETS AND SUPPORTS AS REQUIRED TO PROPERLY INSULATE PIPING.
 - 4 PROVIDE NEW EXTERNAL INSULATION ON ALL EXISTING AND NEW DUCTWORK, CW ALUMINUM CLADDING.
 - 5 ALL NEW DUCT CONNECTIONS TO THE NEW UNITS (AHU'S & DH), TO CW FLEXIBLE DUCT CONNECTIONS SUITABLE FOR DESIGN CONDITIONS.
 - 6 PROVIDE 900X900X1200 HIGH WEATHERPROOF PUMP BOXES FOR P-02R-2020 & P-03R-2020. BOXES TO BE SEALED WEATHER TIGHT DOUBLE WALL. ALLOW CLEARANCE FOR ELECTRICAL & PLUMBING CONNECTIONS INSIDE. SEAL PIPING PENETRATIONS.
 - 7 PROVIDE INSULATED SEALED ACCESS HATCHES FOR ALL BALANCE DAMPERS, REFER TO PLAN FOR LOCATIONS.
 - 8 CONTRACTOR TO PROVIDE A TOTAL COST PER EACH DUCT SUPPORT FOR REPLACEMENT OF EXISTING IDENTIFIED DURING SITE WALKTHROUGH & TENDER PERIOD. ANY SUPPORTS REQUIRING REPLACEMENT NOT PREVIOUSLY IDENTIFIED SHALL BE REPLACED ON A COST PER SUPPORT AS PER TENDER BID.
 - 9 ALL NEW DUCTWORK AND PIPING TO HAVE SUPPORTS, REFER TO DETAIL.
 - 10 ALL EXISTING DUCTWORK ASSOCIATED WITH THE WORK IN THIS PHASE TO BE CLEANED FOR ITS ENTIRE RUN.
 - 11 CONFIRM SIZE OF ALL CURRENT DUCT OPENINGS IN ROOF ON SITE.



CONSULTANT:

SEAL:



PROJECT TITLE:
STRATHCONA GARDENS RECREATION COMPLEX - ENERGY RETROFIT PHASE 2

PROJECT ADDRESS:
225 S DOGWOOD STREET
CAMPBELL RIVER, BC
V9W 6C8

DRAWN BY	YB
CHECKED BY	CT, CB
SCALE	AS NOTED
DATE	01/29/2020

DRAWING TITLE:
ROOF PLAN - ARENA DEHUMIDIFICATION NEW

PROJECT NO.	DRAWING NO.
009-086-19	M6

01 ROOF PLAN - ARENA DEHUMIDIFICATION NEW
M6 SCALE: 1:100



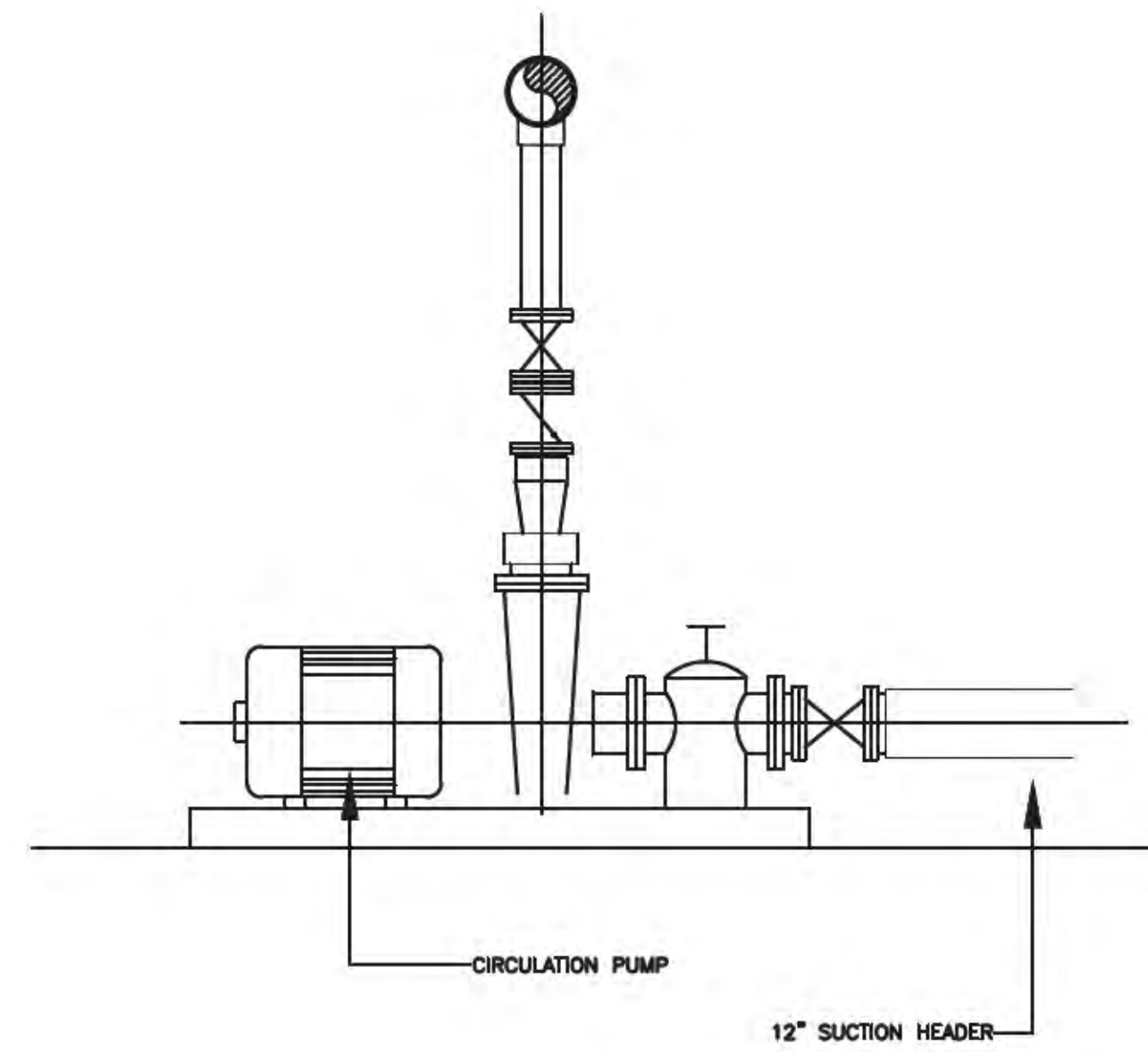
REV.	DATE	DESCRIPTION
1.	2020.01.27	ISSUED FOR TENDER



NEW PUMP TO BE LOCATED APPROX HERE. REFER TO NEW LAYOUT FOR DETAILS.



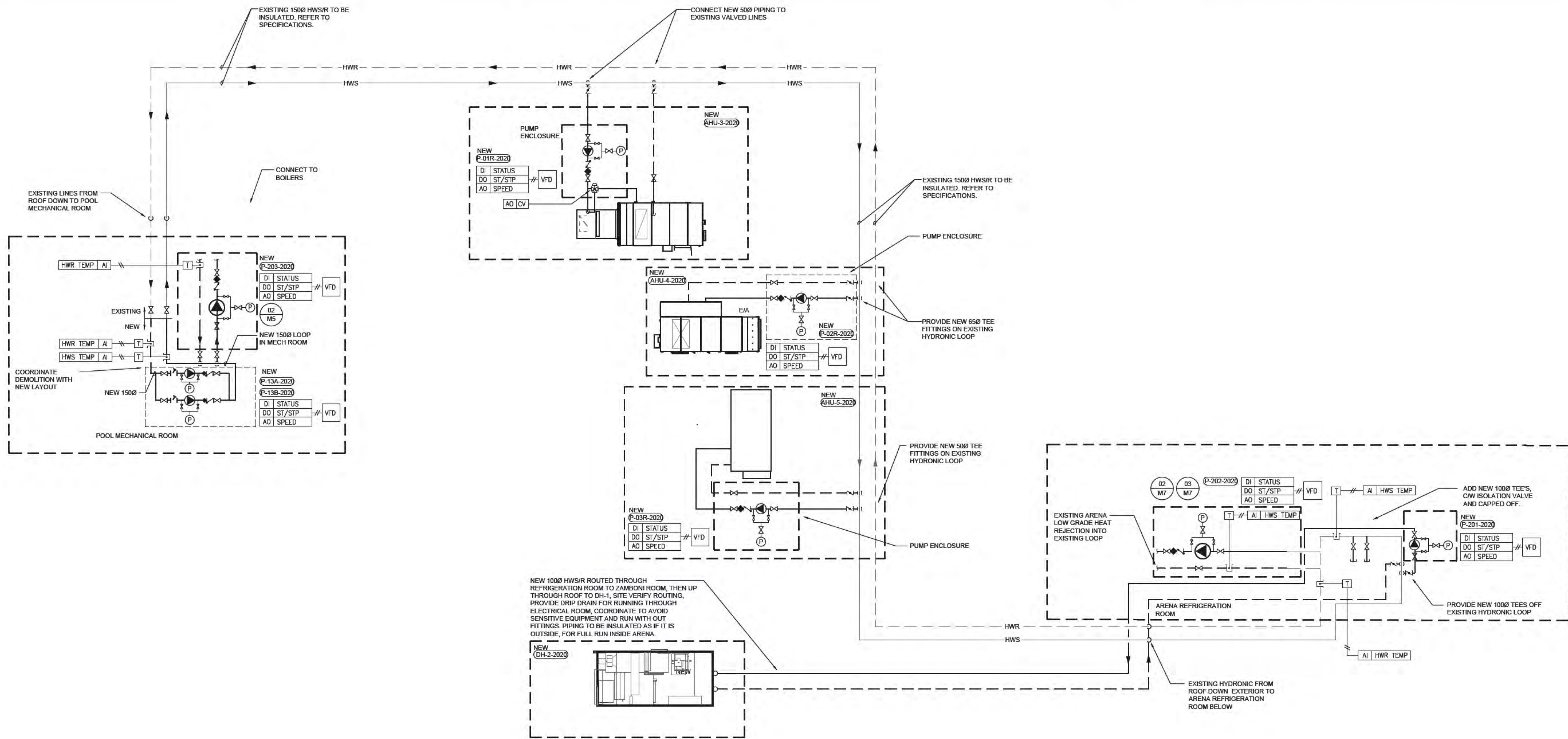
NEW PUMP TO BE LOCATED APPROX HERE. REFER TO NEW LAYOUT FOR DETAILS.



02 CIRCULATION PUMP/COIL DETAIL
SCALE: NTS

04 P-202-2020 LOCATION
SCALE: NTS

03 P-201-2020 LOCATION
SCALE: NTS



01 SCHEMATIC - HYDRONIC NEW
SCALE: NTS

CONSULTANT:

SEAL:



PROJECT TITLE:
STRATHCONA GARDENS RECREATION COMPLEX - ENERGY RETROFIT PHASE 2

PROJECT ADDRESS:
225 S DOGWOOD STREET
CAMPBELL RIVER, BC
V9W 6C8

DRAWN BY: YB, BS
CHECKED BY: CT, CB
SCALE: AS NOTED
DATE: 01/29/2020

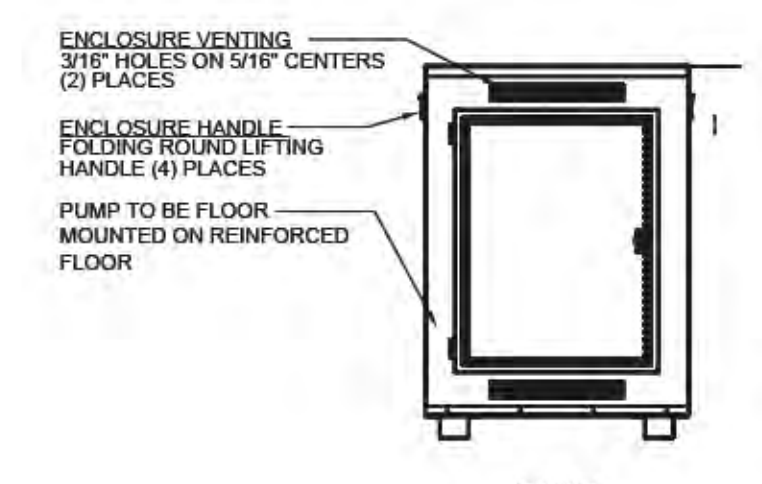
DRAWING TITLE:
SCHEMATICS & HYDRONIC - NEW

PROJECT NO.: 009a-086-19
DRAWING NO.: M7

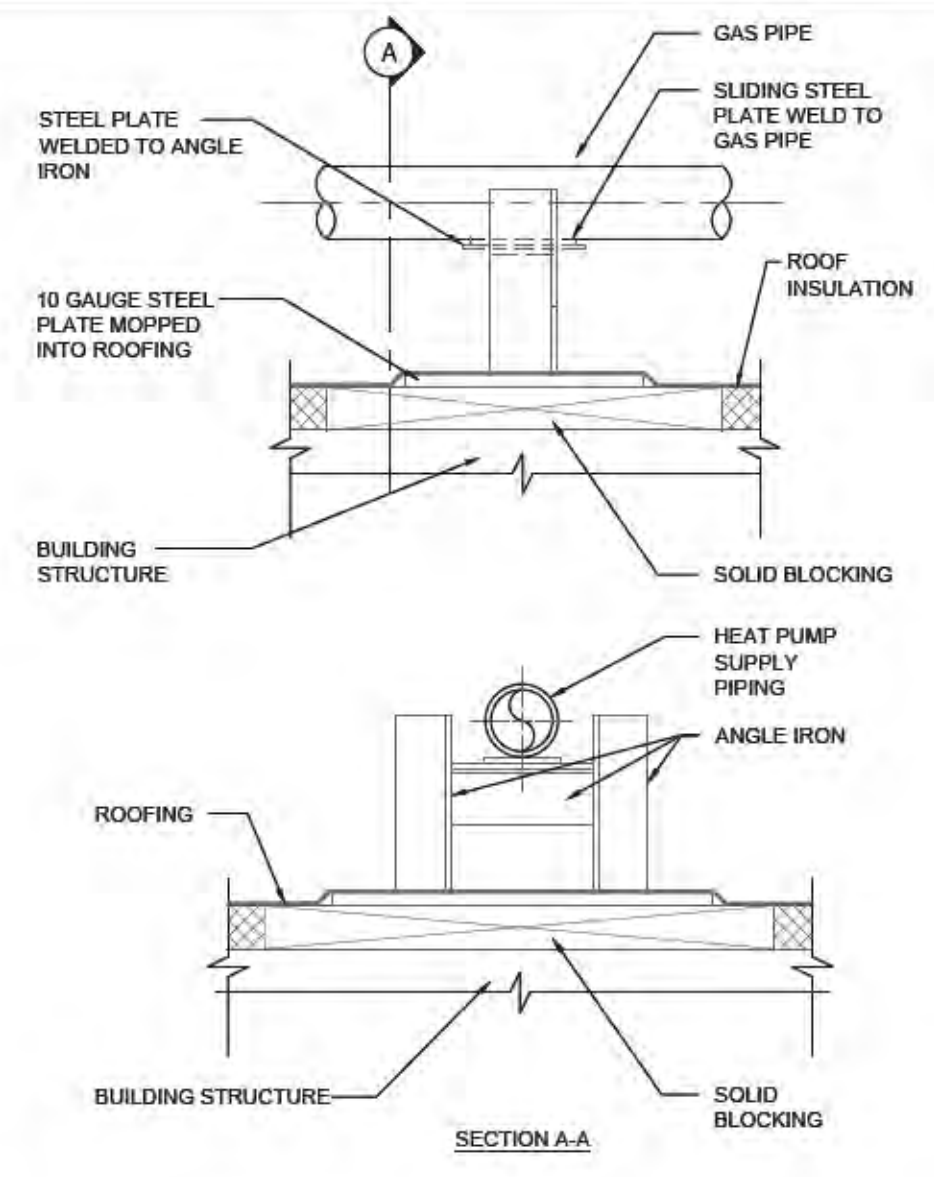
REV.	DATE	DESCRIPTION
1	2020.01.27	ISSUED FOR TENDER

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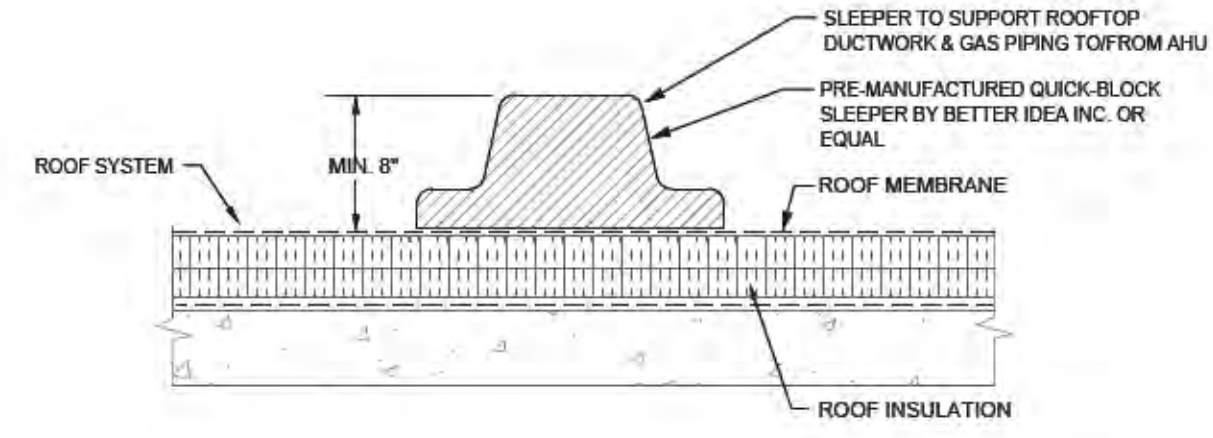
- ENCLOSURE CONSTRUCTION:
16GA GALV-N
- MOUNTING FEET: 12GA GALV-H FORMED HAT
- FINISH: POWDER COAT
- COLOR: TBD
- WEIGHT: 21 LBS



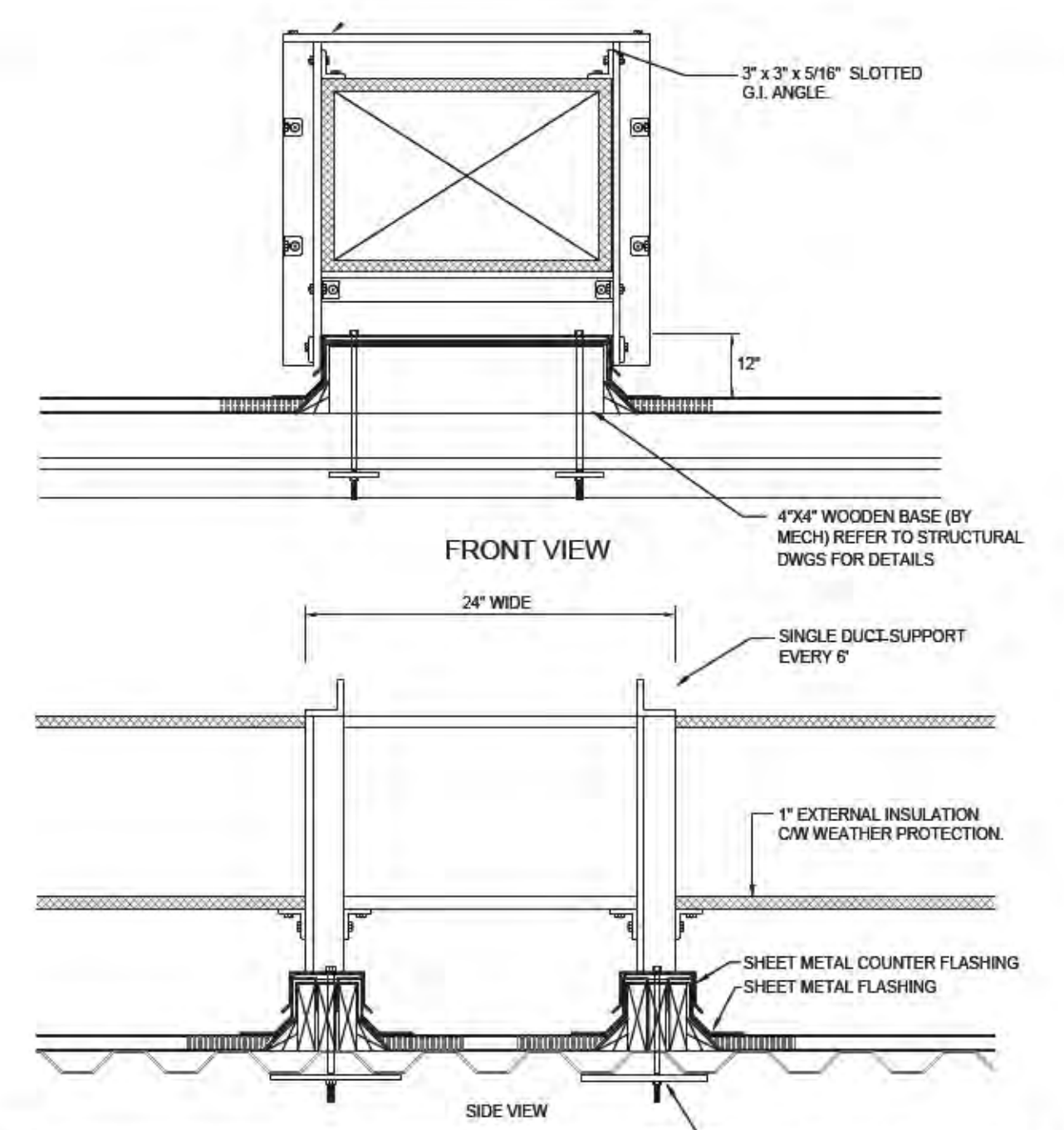
6 PUMP ENCLOSURE DETAIL
M8 NTS



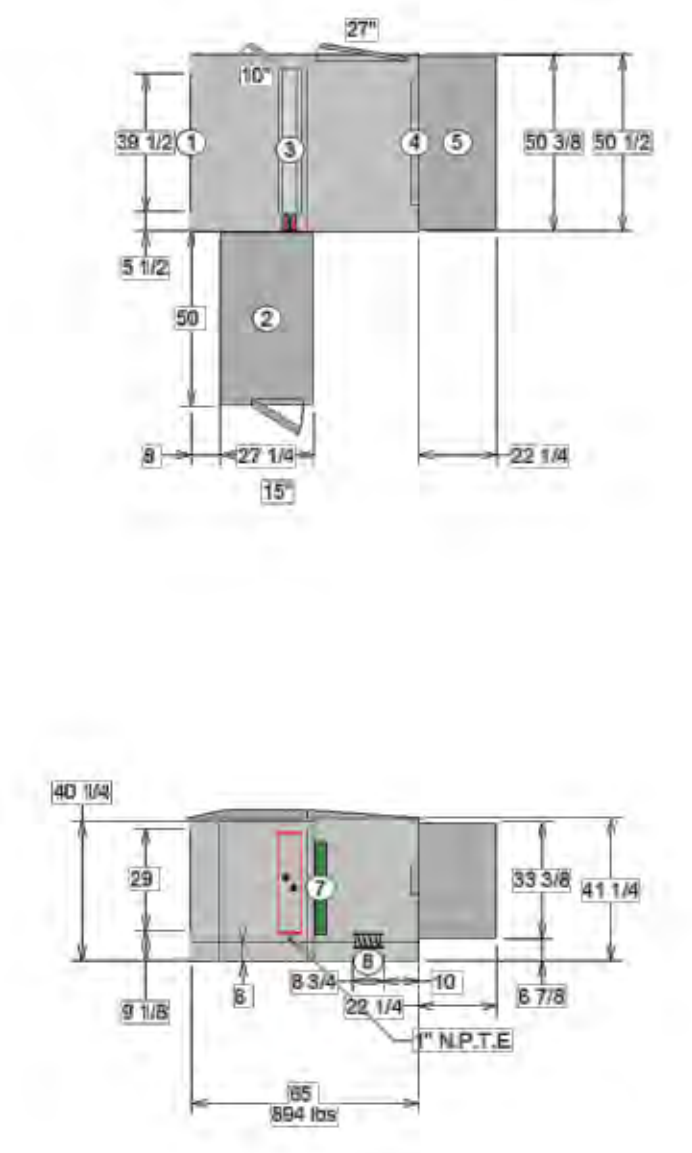
3 ROOFTOP PIPE SUPPORT
M8 NTS



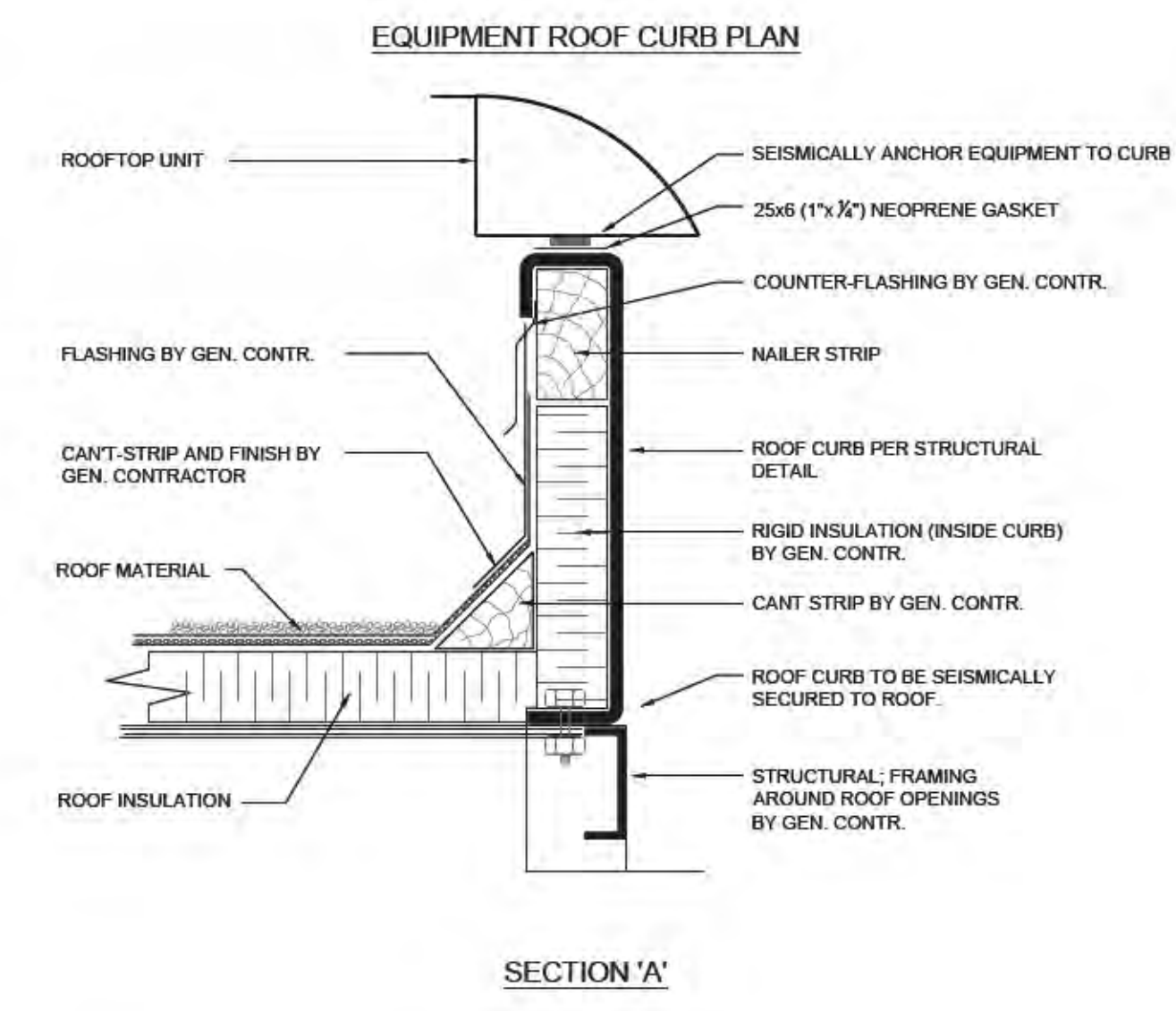
5 SLEEPER DETAIL
M8 NTS



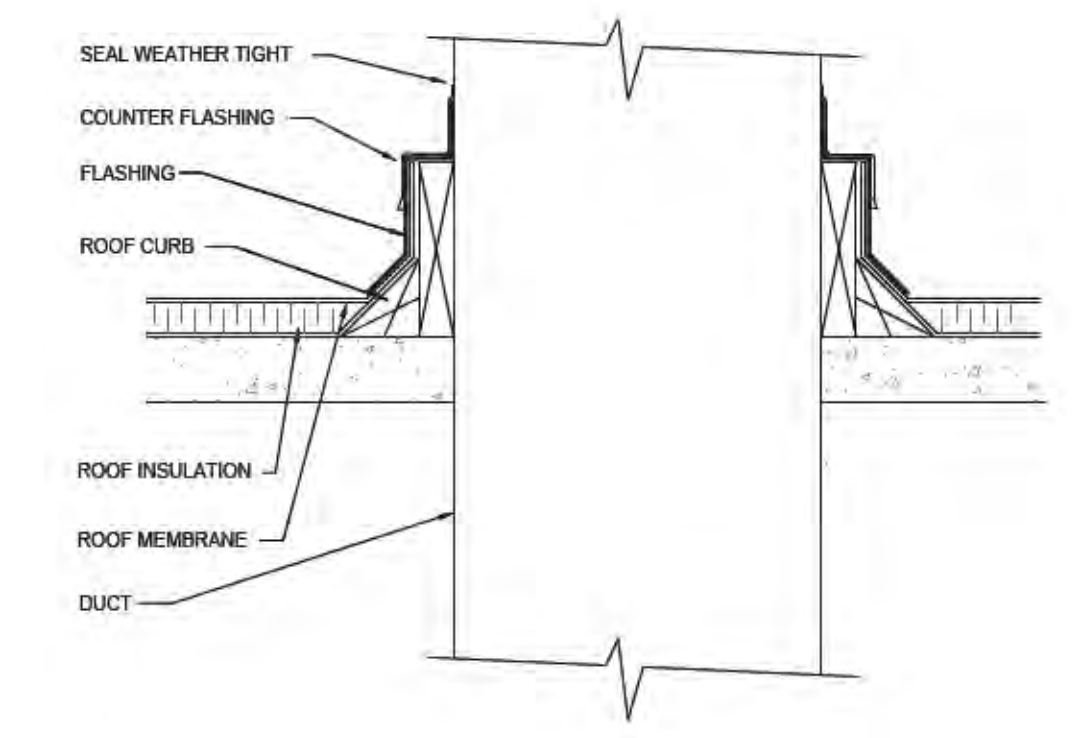
2 DUCT SUPPORT DETAIL
M8 NTS



7 AHU-3 PH DETAIL
M8 NTS



4 ROOF CURB DETAIL
M8 NTS



1 DUCT PENETRATION THROUGH ROOF DETAIL
M8 NTS

CONSULTANT:

SEAL:



PROJECT TITLE:
STRATHCONA GARDENS RECREATION COMPLEX - ENERGY RETROFIT PHASE 2

PROJECT ADDRESS:
225 S DOGWOOD STREET
CAMPBELL RIVER, BC
V9W 8C8

DRAWN BY: YB, BS
CHECKED BY: CT, CB
SCALE: AS NOTED
DATE: 01/29/2020

DRAWING TITLE:
DETAILS

PROJECT NO. 009a-086-19 DRAWING NO. M8

STRATHCONA GARDENS RECREATION COMPLEX

ENERGY RETROFIT - PHASE 2

225 S DOGWOOD STREET CAMPBALL RIVER, BC

ABBREVIATIONS

A	AMPS	N	NEW
AD	ACCESS DOOR	NC	NORMALLY CLOSED
AFCI	ARC FAULT CIRCUIT INTERRUPTER	NIC	NOT IN CONTRACT
AFF	ABOVE FINISHED FLOOR	NL	NIGHT LIGHT
BBH	BASEBOARD HEATER	NO	NORMALLY OPEN
BU	BATTERY UNIT	OC	OVER COUNTER
C	CONDUIT	R	RELOCATE
CL	CEILING MOUNTED	RC	REUSE EXISTING CIRCUIT
D	DEDICATED	RIC	ROUGH IN AND CONNECT
DHWT	DOMESTIC HOT WATER TANK	RO	ROUGH IN ONLY
E	EXISTING	RR	REMOVE AND REINSTALL
EF	EXHAUST FAN	SC	SEPARATE CIRCUIT
EM	EMERGENCY CIRCUIT	TYP	TYPICAL
ER	EXISTING TO BE REMOVED	UC	UNDER CABINET MOUNTED
GFCI	GROUND FAULT CIRCUIT INTERRUPTER	UPS	UNINTERRUPTIBLE POWER SUPPLY
GND	GROUND	V	VOLTS
IG	ISOLATED GROUND	W	WATTS
JB	JUNCTION BOX	WAP	WIRELESS ACCESS POINT
KW	KILOWATTS	WF	WALL FEED
LV	LOW VOLTAGE	WP	WEATHERPROOF

NOTE: NOT ALL SYMBOLS APPLY. CONTRACTOR TO REFER TO FLOOR PLANS.

DRAWING LIST

Drawing Number	Drawing Title
E-000	COVER SHEET, DRAWING LIST & SYMBOL LEGEND
E-001	ELECTRICAL FLOOR PLAN, SINGLE LINE DIAGRAM AND MECH SCHEDULE
E-100	SITE FLOOR PLAN
E-200	ROOF PLAN - ELECTRICAL
E-300	OUTLINE SPECIFICATION

SINGLE LINE DIAGRAM LEGEND

	ISOLATION TRANSFORMER - DELTA-WYE UNLESS OTHERWISE NOTED.
	MOLDED CASE CIRCUIT BREAKER
	LOW VOLTAGE, DRAW-OUT CIRCUIT BREAKER, TRIP PLUG AND FRAME SIZE AS SHOWN
	FUSIBLE LOAD BREAK ISOLATION SWITCH, VOLTAGE, FUSE AND FRAME SIZE AS SHOWN.
	INTEGRAL SWITCH AND FUSE UNIT, FUSE AND FRAME SIZE AS SHOWN
	LOAD BREAK ISOLATION SWITCH, VOLTAGE AND FRAME SIZE AS SHOWN.
	AUTOMATIC TRANSFER SWITCH WITH BY-PASS
	AUTOMATIC TRANSFER SWITCH WITHOUT BY-PASS
	METERING SOCKET
	CURRENT TRANSFORMER

NOTE: NOT ALL SYMBOLS APPLY. CONTRACTOR TO REFER TO FLOOR PLANS.

POWER AND SYSTEMS LEGEND

	WALL MOUNTED DUPLEX RECEPTACLE 120 VOLT, 15 AMP, CSA 5-15R OR AS NOTED
	WALL MOUNTED DUPLEX RECEPTACLE 120 VOLT, 20 AMP, CSA 5-20R
	WALL MOUNTED RECEPTACLES 2 DUPLEX CSA 5-15R
	WALL MOUNTED SIMPLEX RECEPTACLE 250 VOLT, 30 AMP, CSA 14-30R
	WALL MOUNTED OVER COUNTER GFCI DUPLEX RECEPTACLE 120 VOLT, 15 AMP, CSA 5-15R
	WALL MOUNTED OVER COUNTER GFCI DUPLEX RECEPTACLE 120 VOLT, 20 AMP, CSA 5-20R
	ONE BACKBOX C/W ONE MINIMUM 1-1/4" CONDUIT OR AS SPECIFIED ON DETAILS, STUBBED INTO CEILING SPACE C/W TWO CONNECTORS WITH NYLON BUSHINGS AND PULL STRINGS FOR COMMUNICATIONS USE. ONE CONDUIT PER BOX.
	ONE BACKBOX C/W MINIMUM 1-1/4" CONDUIT OR AS SPECIFIED ON DETAILS, STUBBED INTO CEILING SPACE OR TO AUDIO VISUAL DEVICE C/W TWO CONNECTORS WITH NYLON BUSHINGS AND PULL STRINGS FOR USE BY AUDIO VISUAL CONTRACTOR. REFER TO AUDIO VISUAL DRAWINGS FOR COMPLETE REQUIREMENTS INCLUDING BACKBOX SIZE/TYPE, EXACT CONDUIT SIZE, ROUTING AND TERMINATION POINTS, ETC.
	ONE BACKBOX C/W ONE MINIMUM 1" CONDUIT STUBBED INTO CEILING SPACE C/W TWO CONNECTORS WITH NYLON BUSHINGS AND PULL STRINGS FOR CABLE TV USE. ONE CONDUIT PER BOX.
	FEED POINT FOR COMMUNICATIONS CABLING. LETTER DENOTES FEED LOCATION: W= WALL, F= FLOOR, P= PAC POLE, WM = WIREMOLD
	CEILING MOUNTED DUPLEX RECEPTACLE 120 VOLT, 15 AMP, CSA 5-15R
	FLOOR OR CEILING MOUNTED (AS SHOWN) COMBINATION COMMUNICATION / DUPLEX RECEPTACLE 120 VOLT, 15 AMP, CSA 5-15R, REFER TO CORRESPONDING DETAIL.
	FLOOR POKE THROUGH COMBINATION COMMUNICATION / DUPLEX RECEPTACLE 120 VOLT, 15 AMP, CSA 5-15R, REFER TO CORRESPONDING DETAIL.
	SURFACE MOUNTED SINGLE TUB PANEL. RATING AS NOTED ON SINGLE LINE/PANEL SCHEDULE.
	FLUSH MOUNTED SINGLE TUB PANEL. RATING AS NOTED ON SINGLE LINE/PANEL SCHEDULE.
	DIRECT CONNECTION TO EQUIPMENT AS NOTED
	DISCONNECT SWITCH
	TRANSFORMER
	CONNECTION TO MOTOR
	GROUNDING BUS BAR
	RACEWAY RECEPTACLE, TYPE AS SPECIFIED C/W QUANTITY OF DEVICES INDICATED

NOTE: NOT ALL SYMBOLS APPLY. CONTRACTOR TO REFER TO FLOOR PLANS.

REV.	DATE	DESCRIPTION
1	JAN.10.2020	ISSUED FOR TENDER REVIEW
2	JAN.22.2020	ISSUED FOR TENDER

SEAL:

CONSULTANT:

Smith + Andersen
300 - 6400 Roberts Street Burnaby British Columbia V5G 4G9
604 294 8414 f 604 294 6405 smithandanderson.com

PROJECT TITLE:
STRATHCONA GARDENS RECREATION COMPLEX - ENERGY RETROFIT PHASE 2

PROJECT ADDRESS:
225 S DOGWOOD STREET
CAMPBELL RIVER, BC
V9W 8C8

DRAWN BY	KG
CHECKED BY	RB
SCALE	N.T.S.
DATE	01/07/2020

DRAWING TITLE:
**COVER SHEET
DRAWING LIST &
SYMBOL LEGEND**

PROJECT NO.	DRAWING NO.
18625.002.E	E-000

MECHANICAL EQUIPMENT SCHEDULE

PROJECT NAME: STRATHCONA GARDENS RECREATION COMPLEX
PROJECT #: 18625.002.001

Smith + Andersen
300 - 6400 Roberts Street
Burnaby, BC, V5G 4C9

REF. TAG	DESCRIPTION	LOAD	VOLT	Ø	CCT. NO.	BKR. SIZE	FEEDER	NOTE
AHU-3-2020	POOL CHANGE ROOM AHU	21.4MCA	600	3	EXISTING MCCA 4	3P-25A	3#10	2,3,4,5,6
AHU-4-2020	LOBBY/ADMIN AHU	25.1MCA	600	3	EXISTING MCCA 6	3P-30A	3#10	2,3,4,5,6
AHU-5-2020	ARENA CHANGE ROOMS	9.5MCA	600	3	EXISTING MCCA 8	3P-15A	3#12	3,4,5,6
DH-2	DE-HUMIDIFICATION SYSTEM ARENA 2	42.7MCA	600	3	EE.2,4,6	3P-50A	3#6	3,4,5,6
P-01R-2020	CIRCULATION PUMP FOR AHU-3-2020	1HP	600	3	EE.1,3,5	3P-15A	3#12	3,4,5,6
P-02R-2020	CIRCULATION PUMP FOR AHU-4-2020	1.5HP	600	3	EE.7,9,11	3P-15A	3#12	3,4,5,6
P-03R-2020	CIRCULATION PUMP FOR AHU-5-2020	1.5HP	600	3	EE.13,15,17	3P-15A	3#12	3,4,5,6
P-201-2020	CIRCULATION PUMP FOR DH-2-2020	3HP	600	3	EE.19,21,23	3P-15A	3#12	3,4,5,6
P-202-2020	ARENA HEAT REJECTION LOOP	3HP	600	3	EE.25,27,29	3P-15A	3#12	3,4,5,6
P-203-2020	BOILER ROOM PUMP	3HP	600	3	FILTER RM. PNL	3P-15A	3#12	1,3,4,5,6
P-13A-2020	MAIN HYDROLIC LOOP CIRCULATION PUMP	10HP	600	3	FILTER RM. PNL	3P-25A	3#10	1,3,4,5,6
P-13B-2020	MAIN HYDROLIC LOOP CIRCULATION PUMP	10HP	600	3	FILTER RM. PNL	3P-25A	3#10	1,3,4,5,6

GENERAL NOTES:

- ELECTRICAL CONTRACTOR TO MAKE ALL FINAL CONNECTIONS FOR CONTROL DEVICES AND ANY OWNER SUPPLIED EQUIPMENT.
- PROVIDE MOTOR STARTERS WHERE REQUIRED. COORDINATE WITH MECHANICAL. MAKE ALL FINAL CONNECTIONS.
- VFD'S WILL BE PROVIDED BY MECHANICAL CONTRACTOR. MAKE ALL FINAL CONNECTIONS.
- IT IS THE RESPONSIBILITY OF THE ELECTRICAL CONTRACTOR TO PERFORM SITE MEASUREMENTS OF ALL CONDUCTOR/FEEDER RUNS AND SIZE APPROPRIATELY PER CANADIAN ELECTRICAL CODE. ANY REQUIRED MODIFICATIONS TO FIRST BE CONFIRMED WITH ENGINEER AND INCLUDED IN AS-BUILT DRAWINGS.

SCHEDULE NOTES:

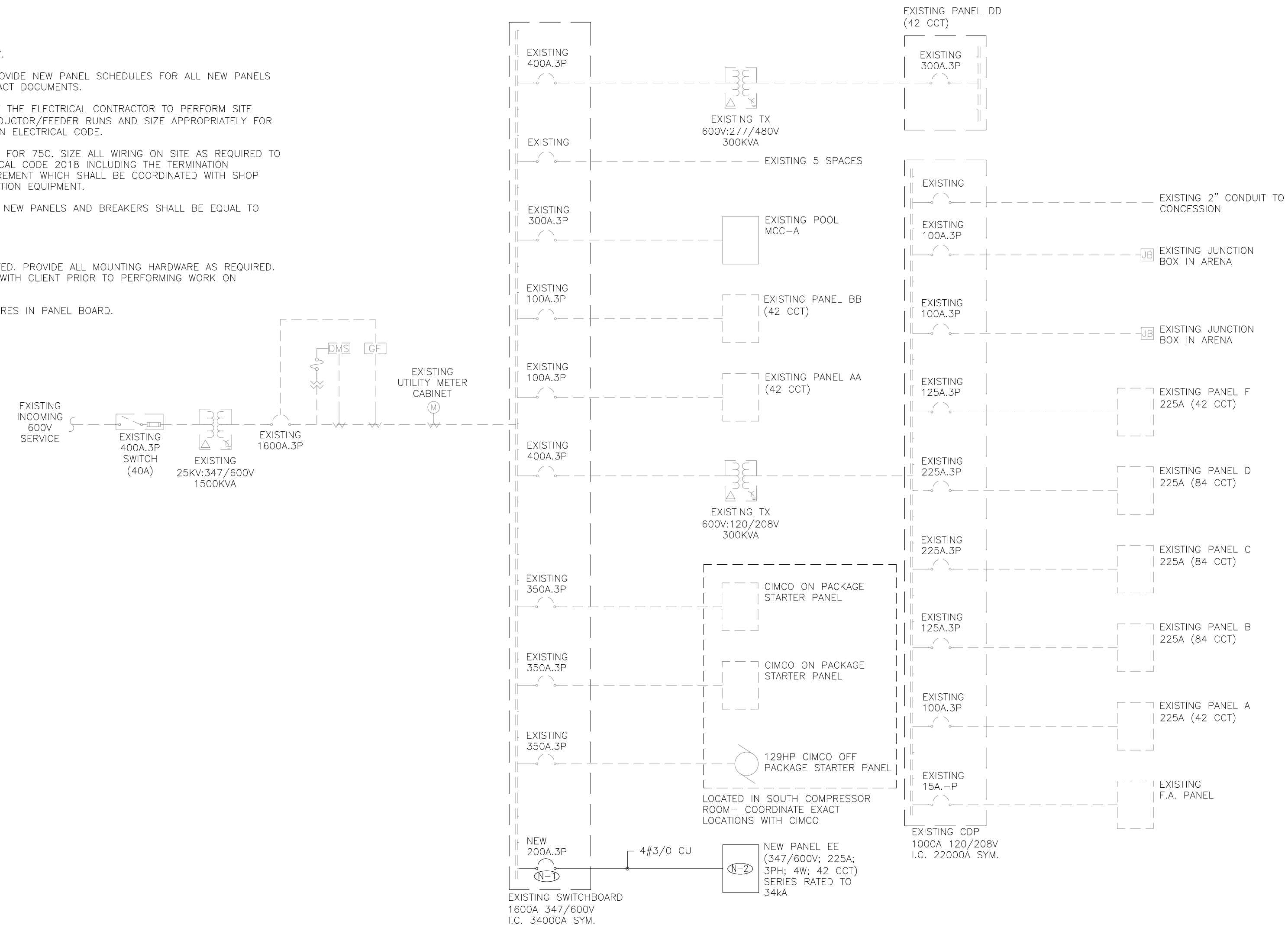
- PROVIDE CIRCUIT FROM EXISTING FILTER ROOM PANEL.
- PROVIDE NEW BREAKER C/W ALL MOUNTING HARDWARE AS REQUIRED TO ACCOMMODATE INSTALLATION OF NEW BREAKER.
- CONNECT TO EXISTING DDC SYSTEM. COORDINATE WITH CONTROLS CONTRACTOR.
- DISCONNECT SUPPLIED AND INSTALLED BY ELECTRICAL (DIV.16).
- CONTROLS BY MECHANICAL (DIV.15).
- VFD SUPPLIED AND INSTALLED BY DIV.15, WREDED BY ELECTRICAL (DIV.16).

GENERAL NOTES:

- RISER IS DIAGRAMMATIC ONLY.
- THIS CONTRACTOR SHALL PROVIDE NEW PANEL SCHEDULES FOR ALL NEW PANELS AS SHOWN IN THESE CONTRACT DOCUMENTS.
- IT IS THE RESPONSIBILITY OF THE ELECTRICAL CONTRACTOR TO PERFORM SITE MEASUREMENTS OF ALL CONDUCTOR/FEEDER RUNS AND SIZE APPROPRIATELY FOR VOLTAGE DROP PER CANADIAN ELECTRICAL CODE.
- ALL CONDUCTORS ARE SIZED FOR 75C. SIZE ALL WIRING ON SITE AS REQUIRED TO MEET THE CANADIAN ELECTRICAL CODE 2018 INCLUDING THE TERMINATION TEMPERATURE RATING REQUIREMENT WHICH SHALL BE COORDINATED WITH SHOP DRAWINGS FOR THE DISTRIBUTION EQUIPMENT.
- FAULT CURRENT RATING FOR NEW PANELS AND BREAKERS SHALL BE EQUAL TO DISTRIBUTION BOARD RATING.

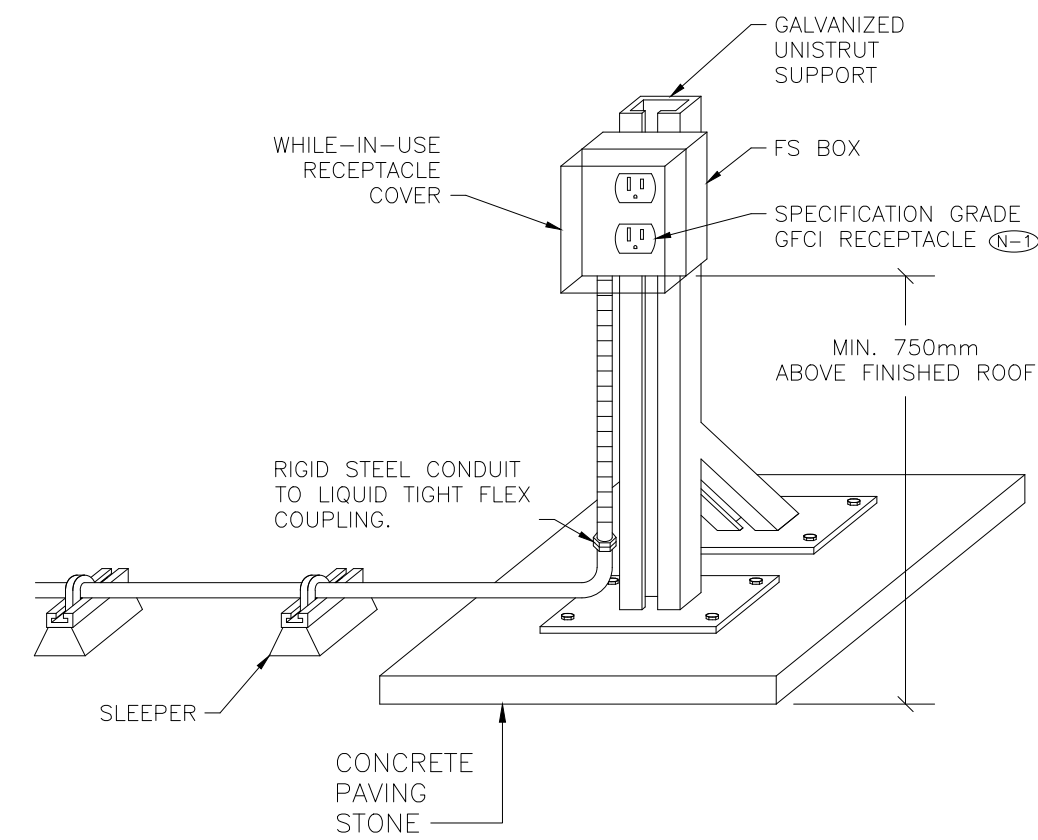
REFERENCE NOTES:

- (N-1) PROVIDE BREAKER INDICATED. PROVIDE ALL MOUNTING HARDWARE AS REQUIRED. COORDINATE SHUT DOWN WITH CLIENT PRIOR TO PERFORMING WORK ON SWITCHBOARD.
- (N-2) PROVIDE SIX 1P-15A SPARES IN PANEL BOARD.



1 MECHANICAL EQUIPMENT SCHEDULE
E-001

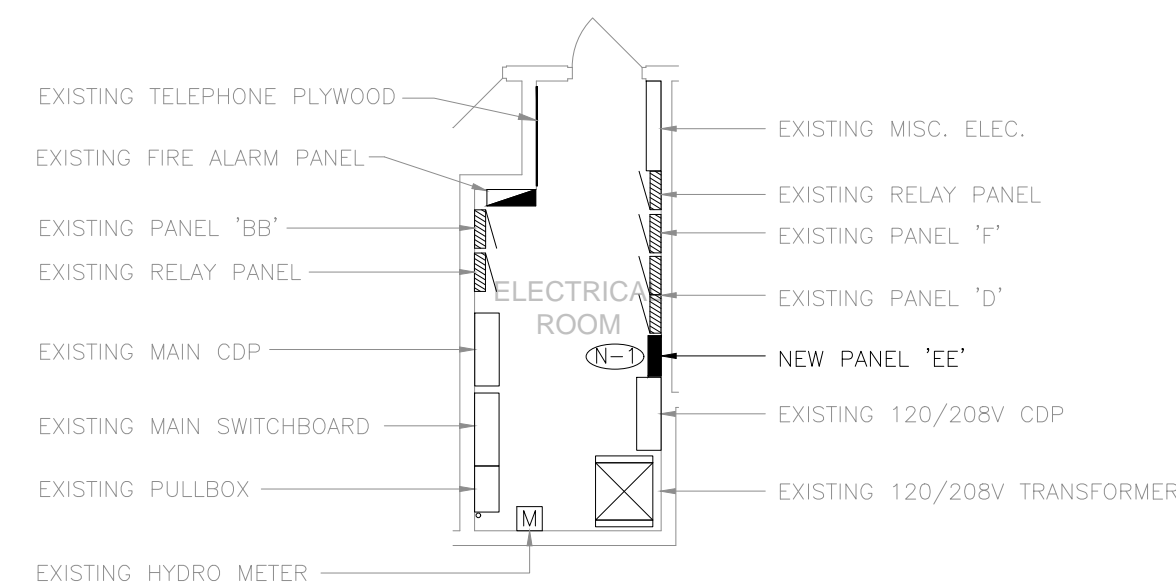
2 SINGLE LINE DIAGRAM
N.T.S.



REFERENCE NOTES:

- (N-2) PROVIDE RECEPTACLE C/W WEATHERPROOF WHILE-IN-USE COVER. RECEPTACLE TO BE MOUNTED ON INDEPENDENTLY SUPPORTED UNISTRUT STANDOFF AS SHOWN ABOVE. PROVIDE LIQUID TIGHT FLEXIBLE CONDUIT WHEN CONDUIT RUN IS OUTDOORS. ALTERNATIVELY, PROVIDE METAL OR HEAVY DUTY UV-RATED WEATHERPROOF PLASTIC POST SIMILAR TO ARLINGTON: GARD-N-POST.

3 MAINTENANCE RECEPTACLE DETAIL
N.T.S.



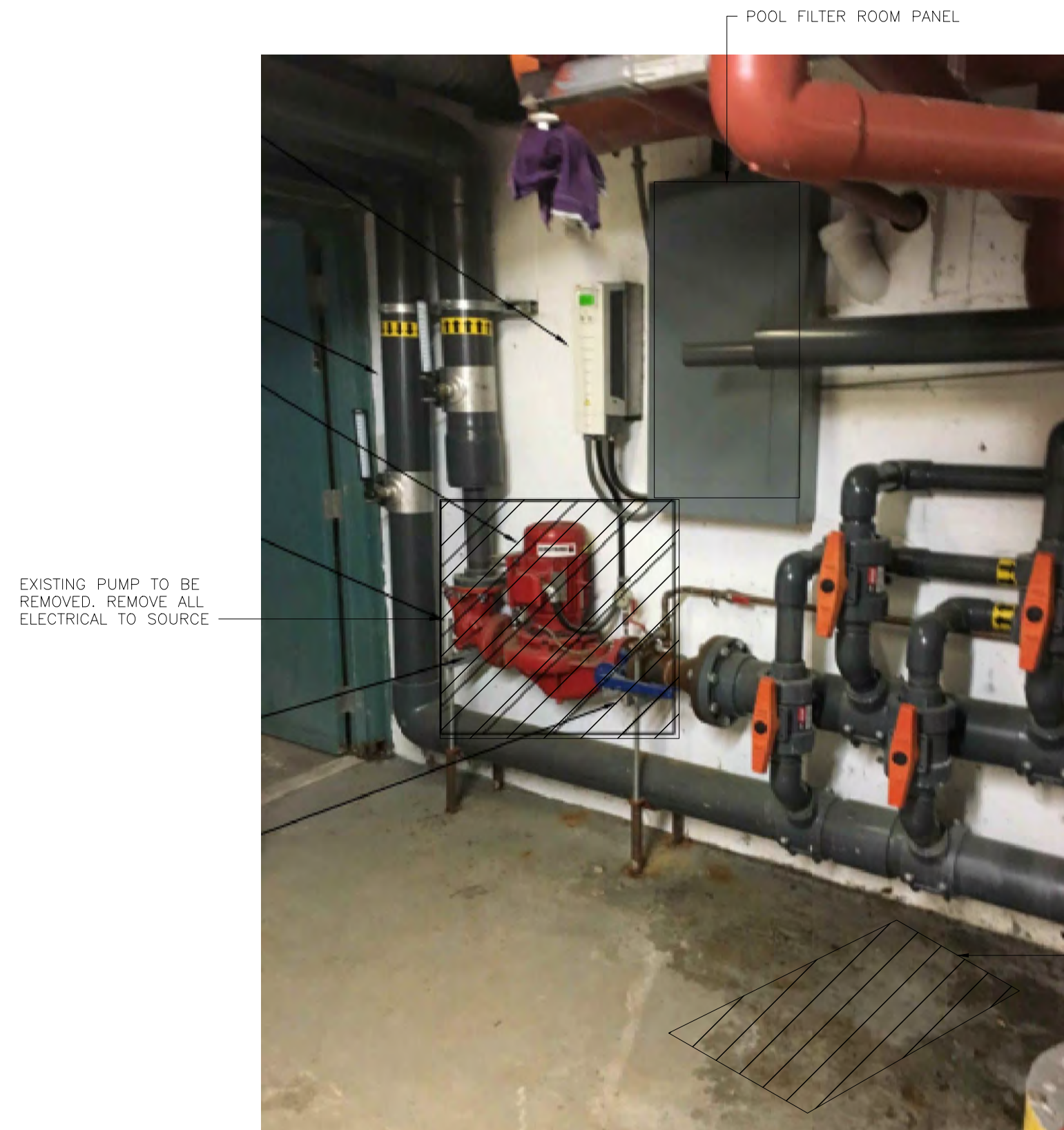
GENERAL NOTES:

- EXACT LOCATION OF PANEL EE SHALL BE DETERMINED ON SITE TO ENSURE PANELBOARD HAS ADEQUATE CLEARANCES PER CSA C22.1 2018. ELECTRICAL CONTRACTOR TO CONFIRM LOCATION ON SITE PRIOR TO TENDER CLOSE. ALLOW FOR ANY MODIFICATIONS/RELOCATION OF EXISTING ELECTRICAL EQUIPMENT AND/OR CONDUIT ETC. TO FACILITATE INSTALLATION OF NEW PANELBOARD.

REFERENCE NOTES:

- (N-2) RELOCATE ALL CONFLICTING ELECTRICAL INCLUDING BUT NOT LIMITED TO EXISTING CONDUIT AND SWITCH BETWEEN 120/208V CDP AND PANEL D TO ACCOMMODATE INSTALLATION OF NEW PANEL EE. MAKE ALL SYSTEMS GOOD.

4 EXISTING ELECTRICAL ROOM PLAN
1:100



EXISTING PUMP TO BE REMOVED. REMOVE ALL ELECTRICAL TO SOURCE

PROVIDE SEPARATE PRICE #1 IN BID FOR DEMOLITION OF EXISTING PUMP AND INSTALLATION OF NEW PUMPS IN BOILER ROOM

APPROX. LOCATION OF NEW PUMPS (P-13A/B-2020 AND P-203-2020). CONNECT NEW PUMPS TO POOL FILTER ROOM PANEL. PROVIDE NEW BREAKER AND WIRES TO SUIT. REFER TO MECHANICAL EQUIPMENT SCHEDULE FOR DETAILS. CONFIRM FINAL LOCATION WITH MECHANICAL CONTRACTOR PRIOR TO ROUGH-IN.

ELECTRICAL CONTRACTOR TO VERIFY FILTER ROOM PANEL'S UPSTREAM BREAKER IN ADJACENT MCC-A DURING TENDER WALK THROUGH AND ADVISE ENGINEER OF BREAKER SIZE PRIOR TO BID CLOSE. PROVIDE SEPARATE PRICE IN BID TO RE-FEED PANEL WITH A 200A BREAKER AND 4#300MCM CU FEEDERS IF REQUIRED TO PROVIDE CAPACITY FOR NEW PUMPS.

5 POOL FILTER ROOM PUMP P-13
N.T.S.

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SEAL:

CONSULTANT:



Smith + Andersen

300 - 6400 Roberts Street Burnaby British Columbia V5G 4C9
604 294 8414 f 604 294 6405 smithandandersen.com

PROJECT TITLE:

STRATHCONA
GARDENS RECREATION
COMPLEX - ENERGY
RETROFIT PHASE 2

PROJECT ADDRESS:

225 S DOGWOOD STREET
CAMPBELL RIVER, BC
V9W 8C8

DRAWN BY

KG

CHECKED BY

RB

SCALE

AS NOTED

DATE

01/07/2020

DRAWING TITLE:

ELECTRICAL FLOOR
PLAN, SINGLE LINE &
MECH SCHEDULE

PROJECT NO.

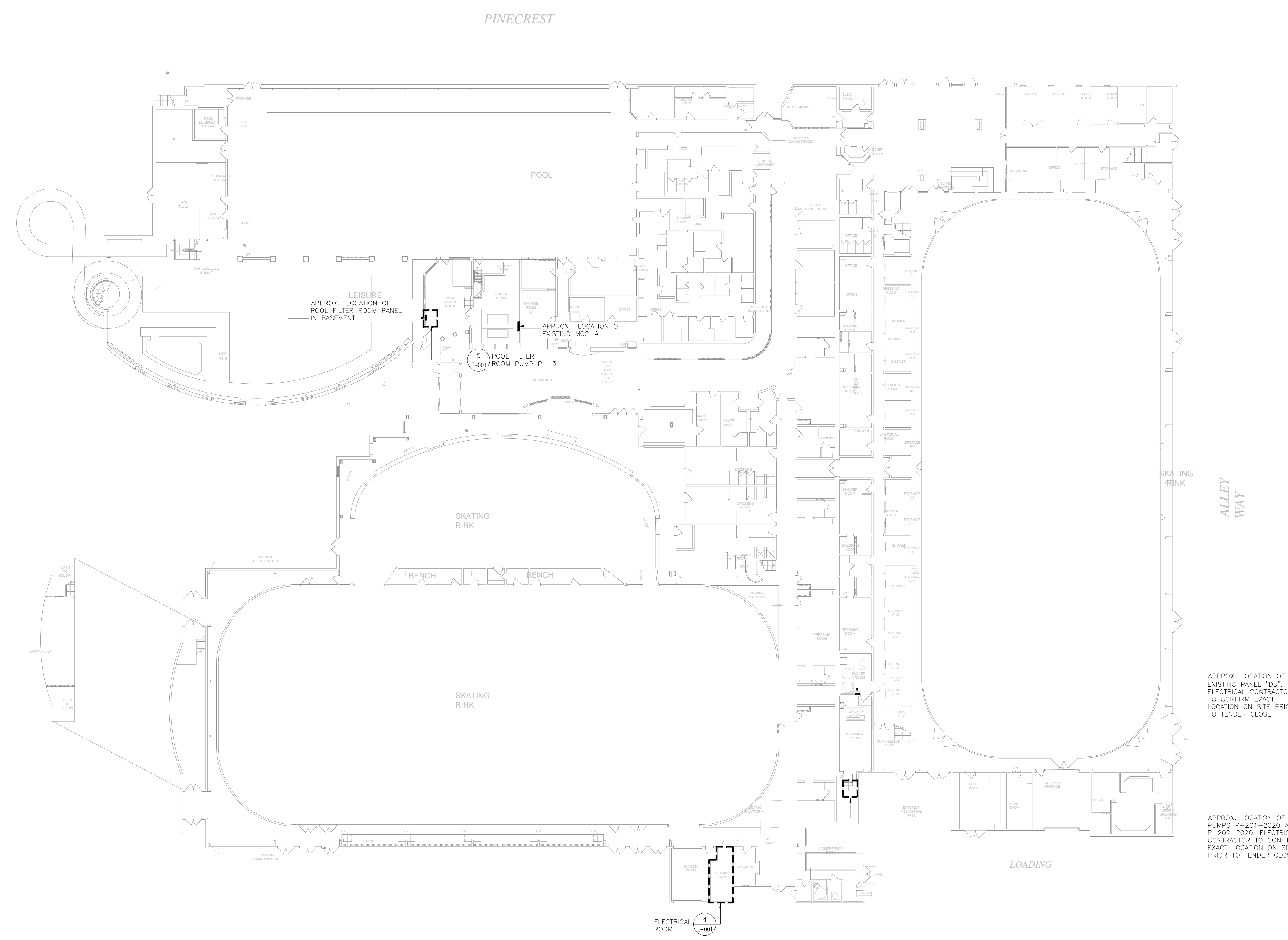
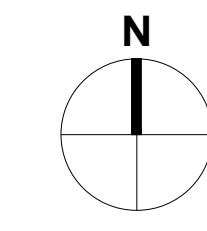
18625.002.E

DRAWING NO.

E-001

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PROJECT TITLE:
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COMPLEX - ENERGY
RETROFIT PHASE 2

PROJECT ADDRESS:
225 S DOGWOOD STREET
CAMPBELL RIVER, BC
V9W 8C8

DRAWN BY: KG
CHECKED BY: RB
SCALE: AS NOTED
DATE: 01/07/2020

DRAWING TITLE:
SITE FLOOR PLAN

PROJECT NO.: 18625.002.E
DRAWING NO.: E-100

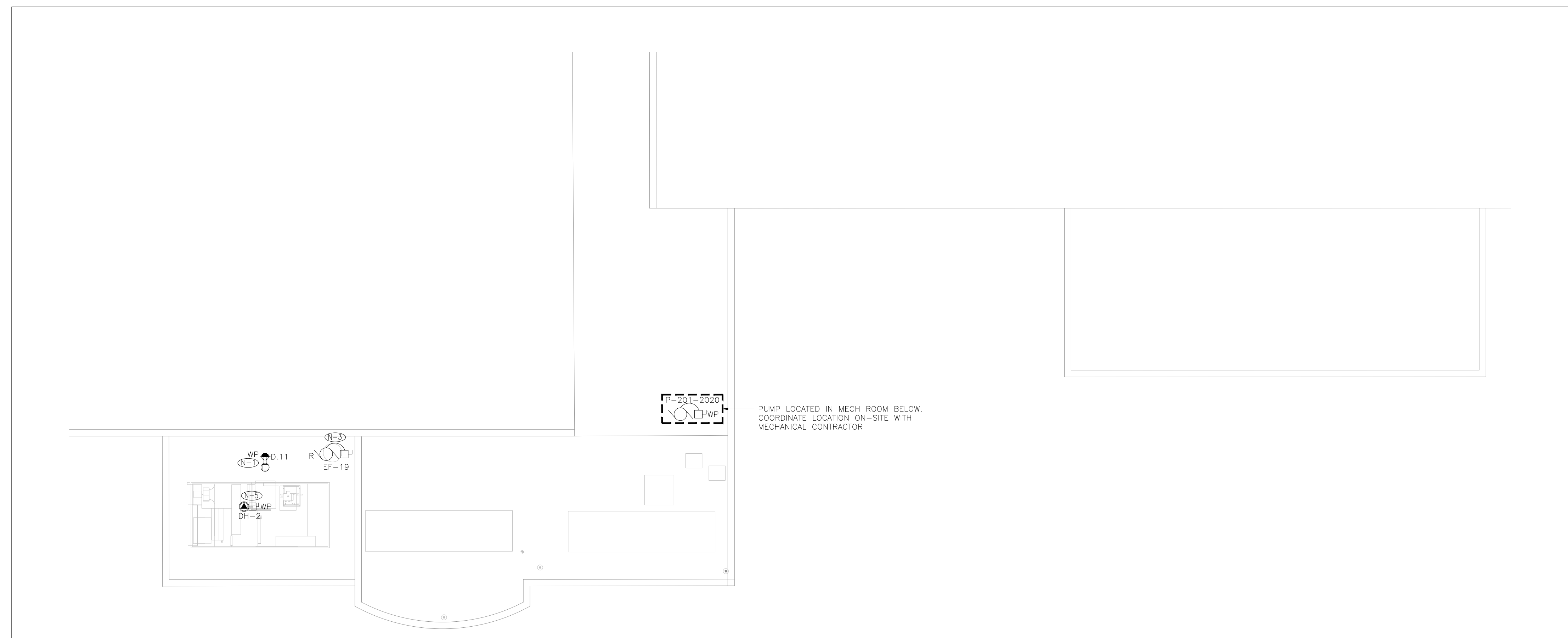
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1
E-200 ROOF PLAN - AHU-3 / AHU-4 / AHU-5 ELECTRICAL
1:100



1
E-200 ROOF PLAN - DH-2 ELECTRICAL
1:100

- GENERAL NOTES:**
- COORDINATE EXACT LOCATION OF ALL NEW EQUIPMENT WITH MECHANICAL PRIOR TO ROUGH-IN.
 - CONFIRM ALL PROPER LABELING OF MECHANICAL EQUIPMENT PRIOR TO INSTALL OF LAMACOID LABELS WITH MECHANICAL.
 - THE COMPLETE EXTENT OF DEMOLITION IS NOT SHOWN. REFER TO THE MECHANICAL DRAWINGS TO DETERMINE THE COMPLETE EXTENT OF DEMOLITION. ALLOW FOR ALL COSTS.
 - ALL EQUIPMENT SHOWN ON THIS DRAWING DENOTED AS EXISTING TO BE REMOVED ARE TO BE REMOVED BACK TO SOURCE AS PART OF THIS SCOPE OF WORK UNLESS NOTED OTHERWISE.
 - THE ELECTRICAL CONTRACTOR IS TO MAKE GOOD ALL PENETRATIONS FROM ELECTRICAL EQUIPMENT AND DEVICES DISCONNECTED, RELOCATED AND OR REMOVED IN THIS PROJECT.
 - ALL EXISTING ELECTRICAL DEVICES, EQUIPMENT AND LIGHTING WITHIN AREAS DEEMED NOT IN SCOPE SHALL REMAIN LIVE AND OPERATIONAL. ELECTRICAL CONTRACTOR TO ENSURE SERVICES TO ALL AREAS ARE ISOLATED AND PROTECTED DURING THE COURSE OF DEMOLITION AND CONSTRUCTION. REWIRE ALL SERVICES AS REQUIRED TO ENSURE CONTINUITY OF EXISTING TO REMAIN SERVICES.
 - VISIT THE SITE AND EXAMINE EXISTING CONDITIONS AND ALL TENDERING DOCUMENTS, DRAWINGS AND SPECIFICATIONS. MAKE ALL NECESSARY ALLOWANCES IN TENDER PRICE FOR REMOVAL, RELOCATION, REROUTING, RECONNECTION OF EXISTING ELECTRICAL EQUIPMENT AND WIRING AS NECESSARY FOR THE EXECUTION AND COMPLETION OF THIS PROJECT. NO ALLOWANCES WILL BE MADE AT A LATER DATE FOR ANY EXPENSE INCURRED BY THIS TRADE THROUGH FAILURE TO MAKE THIS EXAMINATION.
 - OBSOLETE CONDUITS AND CABLES SHALL BE DISCONNECTED FROM THEIR SOURCE OF SUPPLY, CUT BACK TO SOURCE, AND BE REMOVED.
 - ALL EXISTING SERVICES INCLUDING ALL POWER THAT WILL BE AFFECTED BY THE RENOVATION AND REQUIRED TO MAINTAIN SERVICE TO SYSTEMS AS NOTED SHALL BE REROUTED AND/OR RELOCATED TO ACCOMMODATE ALTERATIONS.
 - ALL INFORMATION SHOWN IS BASED UPON AS-BUILT DRAWINGS. THIS CONTRACTOR SHALL VERIFY EXTENT OF WORK REQUIRED DURING SITE VISIT.
 - PROVIDE ROOF JACKS FOR ALL ROOFTOP EQUIPMENT AS REQUIRED. AFTER CONDUCTORS ARE DRAWN THROUGH ROOF JACK, SEAL INSIDE CONDUIT WITH DUCT-SEAL PUTTY, COORDINATE PENETRATIONS WITH GENERAL CONTRACTOR.
 - EXISTING CONDUITS, WIRING AND BREAKERS TO BE REUSED WHEREVER POSSIBLE. ELECTRICAL CONTRACTOR SHALL MEGGER EXISTING WIRING AND CONFIRM ACCEPTANCE PRIOR TO REUSING EXISTING CIRCUITS. PROVIDE REPORT OF FINDING TO ENGINEER FOR REVIEW.
 - ER DENOTES EXISTING TO BE REMOVED TO SOURCE. EXISTING CONDUIT AND WIRING TO BE REMOVED TO SOURCE. PANEL SCHEDULE(S) TO BE UPDATED TO SUIT.

- REFERENCE NOTE:**
- (N-D) PROVIDE 20A GFI WEATHERPROOF RECEPTACLE ON POST AS PER DETAIL 3/E-001. COORDINATE EXACT LOCATION ON SITE. PROVIDE 1P-20A BREAKER AND PROVIDE UPDATED TYPE-WRITTEN PANEL SCHEDULE TO SUIT.
 - (M-D) EXISTING MECHANICAL EQUIPMENT TO BE REMOVED AND REPLACED WITH NEW. ELECTRICAL CONTRACTOR TO EVALUATE CONDITION OF EXISTING FEEDERS AND WIRE SIZE. RE-USE IF POSSIBLE AND EXTEND TO SUIT NEW EQUIPMENT LOCATION. MAKE GOOD ALL SYSTEMS. PROVIDE SEPARATE PRICE IN BID FOR PROVISION OF NEW FEEDER.
 - (E-D) ALLOW FOR RELOCATION OF EXHAUST FAN EF-19 TO FACILITATE INSTALLATION OF NEW DEHUMIDIFICATION UNIT DH-2. EXTEND CONDUIT AND WIRING FOR EF-19 TO SUIT. MAKE GOOD ALL SYSTEMS. COORDINATE EXACT LOCATION ON SITE.
 - (P-D) PUMP INSTALLED IN FIELD BUILT WEATHER PROOF ENCLOSURE. COORDINATE FINAL LOCATION AND SIZE OF ENCLOSURE WITH MECHANICAL TO ENSURE SUFFICIENT SPACE FOR ALL ELECTRICAL COMPONENTS INCLUDING DISCONNECT SWITCH WITHIN ENCLOSURE. PRIOR TO ROUGH-IN.
 - (E-S) EXISTING MECHANICAL UNIT TO BE REMOVED AND REPLACED WITH NEW. REMOVE EXISTING CABLE TO SOURCE. PROVIDE NEW CABLE AND BREAKER AND CONNECT TO MCC OR PANEL AS INDICATED ON MECHANICAL EQUIPMENT SCHEDULE ON DRAWING E-001.

PROVIDE SEPARATE PRICE #2 IN BID FOR ALL WORK ASSOCIATED WITH DEMOLITION OF EXISTING AHU-3 AND INSTALLATION OF NEW AHU-3, PUMP AND ROOF TOP RECEPTACLE. OVERALL SCOPE AS INDICATED WITHIN ELECTRICAL AND MECHANICAL DRAWINGS AND SPECIFICATIONS.

PROVIDE SEPARATE PRICE #3 IN BID FOR ALL WORK ASSOCIATED WITH DEMOLITION OF EXISTING AHU-4 AND INSTALLATION OF NEW AHU-4, PUMP AND ROOF TOP RECEPTACLE. OVERALL SCOPE AS INDICATED WITHIN ELECTRICAL AND MECHANICAL DRAWINGS AND SPECIFICATIONS.

PROVIDE SEPARATE PRICE #4 IN BID FOR ALL WORK ASSOCIATED WITH DEMOLITION OF EXISTING AHU-5 AND INSTALLATION OF NEW AHU-5, PUMP AND ROOF TOP RECEPTACLE. OVERALL SCOPE AS INDICATED WITHIN ELECTRICAL AND MECHANICAL DRAWINGS AND SPECIFICATIONS.

PROVIDE SEPARATE PRICE #5 IN BID FOR ALL WORK ASSOCIATED WITH DEMOLITION OF EXISTING DH-2 AND INSTALLATION OF NEW DH-2, PUMP AND ROOF TOP RECEPTACLE. OVERALL SCOPE AS INDICATED WITHIN ELECTRICAL AND MECHANICAL DRAWINGS AND SPECIFICATIONS.

SEAL:

CONSULTANT:

Smith + Andersen
300 - 6400 Roberts Street Burnaby British Columbia V5G 4G9
604 294 8414 | 604 294 6405 smithandanderson.com

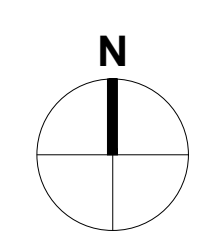
PROJECT TITLE:
**STRATHCONA
GARDENS RECREATION
COMPLEX - ENERGY
RETROFIT PHASE 2**

PROJECT ADDRESS:
225 S DOGWOOD STREET
CAMPBELL RIVER, BC
V9W 8C8

DRAWN BY: KG
CHECKED BY: RB
SCALE: AS NOTED
DATE: 01/07/2020

DRAWING TITLE:
**ROOF PLAN -
ELECTRICAL**

PROJECT NO. 18625.002.E
DRAWING NO. E-200



OUTLINE SPECIFICATION

1. GENERAL
1. Supply all labour, equipment, and materials necessary to install complete and operational, the electrical systems described herein and shown on the Drawings. The requirements of this Section are in addition to those contained in the General Conditions and other portions of the Contract Documents.

2. Refer to General Requirements.

3. Where the term "Provide" is used it shall be understood to include labour, materials and services necessary to supply and install items or work referred to.

2. DRAWINGS AND SPECIFICATIONS

1. It is the intent of these Drawings and Specifications to provide for an electrical installation complete and in operating condition. The responsibility for supplying and installing all material necessary to accomplish this, except where specifically noted that such work or materials is not included, shall be part of this Section.

3. CODES, PERMITS AND FEES

1. The complete installation shall be in accordance with the current edition of the Canadian Electrical Code (as amended by the authority having jurisdiction), and the bylaws of the city or municipal electrical energy inspection department whose authority covers the area in which the work is being done.

2. Obtain and pay for all permits and licenses required to execute the work.

4. SUBSTITUTIONS

1. Where materials, equipment and apparatus or other products are specified by the manufacturer's name, other manufacturers may be substituted upon obtaining written approval of the Engineer three days prior to opening of bids. Submit list of proposed equivalent products in duplicate to the Engineer via email in PDF format. Submittals by fax will not be accepted.

2. Where materials, equipment and apparatus or other products are noted as being "equal to" the specified manufacturer, products of equal or superior quality by other manufacturers may be substituted without approval of the Engineer.

3. Ensure that space requirements are met if using service and distribution equipment by alternate manufacturers.

5. MATERIALS

1. All materials supplied shall be new and of the quality indicated in the Specifications and shall conform to the standards of the CSA and the ULC and approved by these agencies where applicable.

2. In the event that a material specified does not bear CSA and ULC approval, obtain the approval of the local inspection authority, pay all charges levied by the inspection authority and make any modifications required, at no additional expense to the Owner.

6. EQUIPMENT LOCATIONS

1. Consult with the Owner and all other subtrades involved to confirm the locations of the various outlets and equipment and cooperate fully to ensure that no conflict arises during the installation.
2. Special care shall be taken that equipment, outlets, junction boxes or pullboxes will not be obstructed by other structure, equipment, pipes or ducts installed under this general contract by other trades.
3. No extra charge for materials and labour shall be added to the Contract for outlets moved within 10 feet from the location shown on the plans prior to rough-in.

7. GUARANTEES

1. Guarantee all work for one year, following final acceptance. This guarantee shall include all problems caused by improper installation or equipment failure.

8. SITE EXAMINATION

1. Examine the site of work and become familiar with all features and characteristics affecting this work.
2. No additional compensation will be given for extra work due to existing conditions, which such examination should have disclosed.
3. Report to the Engineer any unsatisfactory conditions, which may adversely affect the proper completion of this work.

9. RENOVATIONS IN EXISTING BUILDING

1. Remove all existing luminaires, feeders, outlet boxes, switches, receptacles, etc. not required for the renovated layout shown. All equipment removed and not reused shall become the property of the Owner. Unless otherwise noted, all equipment installed in renovated areas shall be new. All wiring shall be installed concealed.
2. Supply and install new breakers where required in existing panels to pick up additional circuits indicated on the drawings.

10. LIST OF EQUIPMENT

1. Submit complete list of equipment consisting of manufacturer's name and applicable catalogue numbers to the Electrical Engineer within 14 days of award of Tenders or issuance of Letter of Intent.
2. If list is not submitted, it will be assumed that all items will be supplied as specified and all other items including alternatives approved during the tender period will be rejected.

11. SHOP DRAWINGS

1. Prior to delivery of any products to the job site and sufficiently in advance to allow ample time for checking, submit Shop Drawings in PDF format for review of requirements as specified in this Division.
2. Show details, dimensions, construction, size, arrangement, operating clearances, performance characteristics and capacities of products and parts of the work.
3. Manufacture of products shall conform to reviewed Shop Drawings.
4. Where applicable include wiring, single line and schematic diagrams.
5. Include wiring drawings or diagrams showing interconnection with work of other Sections.
6. Keep one complete set of Shop Drawings at the job site during construction.

12. PROJECT RECORD DRAWINGS

1. The Electrical Contractor shall request in writing from the Engineer's Representative all electrical AutoCAD drawings. Contractor to request in writing the Conditions for Limited Use of CAD Drawings form and pay the Engineer's Representative directly the costs identified within the form prior to receiving the drawings. After the final as-built drawings have been reviewed, provide multiple copies of the drawings on CD or DVD or USB stick. One copy is to be returned to the Engineer's Representative for their records and a minimum of one copy with each set of maintenance manuals. Provide additional copies if required under the General Conditions. The Contractor is to use latest release of AutoCAD software, and provide electronic files saved in a version acceptable to the end user and engineer.
2. The contractor to identify the cost of Record Drawings and the Operation and Maintenance Manuals as a separate line item on their progress draw. The following values are to be broken out:
\$5,000
 For Electrical Contracts up to \$250,000
 2% of Electrical Contract
 For Electrical Contracts from \$250,000 to \$1,500,000
\$30,000
 For Electrical Contracts over \$1,500,000
 The project will remain incomplete and no money will be released until the final versions, both hard and electronic, of the drawings and manuals are received.
3. Final as-built prints/plots shall not contain markings or corrections by hand (i.e. marker, pen, pencil, etc.). References to the Architect and Engineer must be deleted from the drawings.
4. Final as-built drawings to include all revisions made to the drawings during construction, including all approved changes. The as-built drawings are to also include the routing of all feeders except for branch circuits, all junction boxes to be shown, drawing legend to be updated to include all symbols and lines used to show as-built conditions, quantity of wires in each conduit, and circuit numbers of wires in each conduit. Include slab layout drawings in as-built drawing package.

5. CADD Requirements.
1. A complete list of layer names and brief description of each layer's use shall accompany all files.
 2. Fonts for text shall be AutoCAD standard. Custom fonts, shape files, etc., are not to be used.
 3. Final as-built drawings shall be returned on CD ROM or DVD or USB stick.
 4. Each CD ROM or DVD or USB stick shall be clearly labelled with Engineer's Representative and Owner, Contract number, file names and Drawing number. If a complete listing exceeds the label size provide a "readme.txt" file in ASCII format with each CD ROM or DVD or USB stick. A printed copy of the readme file shall accompany each CD ROM or DVD or USB stick.
 5. All drawings shall be in the same units as issued on Bid Documents.
 6. Provide a complete list of symbol (block) names with a description of each symbol.
 7. Special effort shall be made to ensure that drafting is accurate: i.e. appropriate lines are indeed horizontal and vertical; lines that should intersect do but not over-intersect and ensure that entities are placed on correct layers.
6. The Electrical Contractor will maintain two sets of white prints on site on which the Electrical Contractor shall clearly mark, as the job progresses, all changes and deviations from that shown on Contract Drawings. After review and approval of service lines in trenches, the Electrical Contractor shall take "as-built" measurements, including all depths, prior to commencement of backfilling operations. The location of buried electrical ducts and conductors shall be shown on the drawings and dimensioned from fixed points. Drawings shall be kept up-to-date during construction and in addition to field measurements shall include variation orders, field instructions and all other changes.
7. On completion of the building, the Electrical Contractor shall forward to the Engineer's Representative the two sets of final drawings indicating all such changes and deviations for review by the Engineer's Representative. Each set shall include full size hard copy of the drawings, and electronic copy of the drawings on CD ROM or DVD or USB stick.
8. The AutoCAD as-built documents shall meet all the Owner's and Engineer's Representative's requirements

13. MAINTENANCE MANUALS

1. Before requesting final certificate, submit 1 PDF format copies of the maintenance manual as specified in this Division.
2. Include in the manuals information based on the following requirements:
 1. Operation and maintenance instructions to be sufficiently detailed with respect to design elements, construction features and component function and maintenance requirements to permit effective operation, maintenance, repair, modification, extension and expansion of any portion or feature of the installation.
 2. Technical data to be in form of approved Shop Drawings, supplemented by bulletins, technical descriptions of items, and parts lists. Advertising of sales literature will not be acceptable.
 3. Provide wiring and schematic diagrams and performance curves where necessary.
 4. Include names and addresses of nearest supplier for all items included in the maintenance manuals.
 5. Provide manual and seminar with Owner's forces to ensure proper operation of building prior to Substantial Performance.

14. MOUNTING HEIGHTS

1. Mounting heights of equipment is from finished floor to centerline of equipment unless specified or indicated otherwise.
2. If mounting height of equipment is not specified or indicated, verify before proceeding with installation.
3. Install electrical equipment at following heights unless indicated otherwise:
 1. Wall receptacles:
 1. General 450 mm (18 in.)
 2. Above top of continuous baseboard heater: 200 mm (8 in.)
 3. Above top of counters or counter splash backs: 175 mm (7 in.)
 4. In mechanical rooms: 1200 mm (48 in.)
 2. Panelboards: 2000 mm (78 in.) to top of panel.

15. DISTRIBUTION

1. 120/208V panels shall be equal to Eaton Type Pow-R-Line series complete with breakers to meet series rating and locking doors. 347/600V panels shall be equal to Eaton Type Pow-R-Line series complete with breakers to meet series rating and locking door. Tenant panels shall be complete with main breaker where required by code. Provide typewritten circuit directories, protected by a clear plastic cover. Identify all circuits with actual usage, including locations for all loads. Ensure that double-tub panels are factory approved for the application.
2. Integrated Equipment Ratings:
 1. Downstream panelboards must be either fully rated or integrated equipment (series) rated with the upstream protective device.
 2. Labelling of circuit breakers forming part of an approved series rated combination where necessary to confirm protection of downstream breaker shall be applied as per CEC 14-014 to indicate:
 1. Tested IER KA Rating
 2. Specific upstream protective device
 3. Permissible branch devices
 4. Panelboard designation
 5. Voltage
 3. Available fault current at main breaker for application of series rating analysis shall be as noted on one-line diagram. Breaker type and interrupting capacities shall be selected to provide approved protection.
 3. Provide sprinkler proof enclosures and drip hoods for all surface mounted electrical equipment.

16. FUSES

1. Main and feeder fuses rated 70A through 800A at 208V and 15A through 400A at 600V protecting circuit breakers shall be Bussman HRC-T Type JLN (208V) and JJS (600V). The fuses and breakers shall be a CSA approved series tested combination. Labelling of the equipment must be applied as per the local electrical code.
2. Fuses protecting motors rated 15A through 600A shall be Bussman HRC-J time delay Type LPJ-SP, unless otherwise noted.
3. Fuses rated 15A through 60A protecting circuit breakers and fuses rated 15A through 600A not otherwise specified above shall be Bussman HRC-J Type JK5.

17. GROUNDING

1. Provide bonding to all metal equipment, metallic waste water system, gas piping and building structure as required by Code.

18. DISCONNECT SWITCHES

1. Supply and install disconnect switches as indicated and as required by Code. Disconnect switches shall be equal to Eaton Type DH1, or Type DH3 (weatherproof) where noted. Bryant 30000/A0000/60000 series motor starters without overload protection may be used for loads rated 30/40/60A or less.

19. MOTOR STARTERS

1. Supply and install magnetic and manual motor starters where indicated. Starters shall be equal to Eaton Type A200 magnetic and MS or B-complete with 100 manual complete with built-in heaters sized for motor rating.
2. Provide control transformers and auxiliary contacts as required for control connections.

20. WIRING METHODS

1. All wiring shall be copper unless indicated otherwise.
2. Feeder conductors from service equipment to panelboards to be sized for maximum voltage drop of 2%.
3. Branch circuit wiring shall be min. #12 AWG 90C rated in EMT. AC-90 and NMD-90 may be used where permitted by Code. Where wire size is not indicated, ampacity must match or exceed that of protective device.
4. Feeders shall be 90C rated wire in EMT. Teck 90, ACWU 90, and AC-90 cables may be used for concealed wiring where permitted by Code, unless specifically noted otherwise.
5. Branch circuit wire sizes indicated on any equipment schedules are rated on 90C. Where equipment is marked with a maximum conductor termination temperature then wire size to be revised as per 4-006 of CEC.

6. Wiring penetrating any horizontal or vertical assembly required to have a fire-resistance rating shall be in accordance with the local building code. Conduits or cables shall be tightly fitted and fire stopped where necessary to maintain fire rating, as follows:

1. For penetrations through a Fire Separation wall provide a firestop system with a "F" Rating as determined by ULC or cUL as indicated below:

Fire Resistance Rating of Separation	Required ULC or cUL "F" Rating of Firestopping Assembly
30 minutes	20 minutes
45 minutes	45 minutes
1 hour	45 minutes
1.5 hours	1 hour
2 hours	1.5 hours
3 hours	2 hours
4 hours	3 hours

2. For combustible penetrations through a Fire Separation provide a firestop system with an "F" Rating as determined by ULC or cUL which is equal to the fire resistance rating of the construction being penetrated. Combustible cables and raceways shall be max. 25 mm diameter.
3. For penetrations through a Fire Wall or horizontal Fire Separation provide a firestop system with a "T" Rating as determined by ULC or cUL which is equal to the fire resistance rating of the construction being penetrated.
4. Install firestop materials in accordance with ULC Fire Resistance Directory or UL Products Certified for Canada (cUL) Directory.
5. Comply with manufacturer's instructions for installation of through-penetration materials.
 1. Seal all holes or voids made by penetrations to ensure air and water resistant seal.
 2. Protect materials from damage on surfaces subjected to traffic.

21. BASIC METHODS

1. Install wiring continuously within raceways or cables; splices will be permitted only at outlets and junction boxes. Sufficient slack shall be left at these points to permit proper connection of luminaires, devices, equipment, etc.
2. All wiring shall be run concealed in ceiling, walls or floor wherever possible. Any exposed conduits or cables shall be run parallel to or at right angles to building lines and in a neat manner.
3. Install pull boxes in the locations shown on the Drawings and as further required by the Canadian Electrical Code. Pull boxes shall be located in inconspicuous spaces.
4. Where devices are shown above fixed millwork, mount outlets 6" above counter or backsplash. Coordinate with millwork installer and ensure that outlets do not conflict with backsplash.

22. WIRING DEVICES

1. Receptacles shall be commercial grade, 15A, decorator style, white finish.
2. Wiring devices and coverplates shall be of one manufacturer; Bryant, G.E., Hubbell, Leviton or P & S.
3. All cover plates shall be stainless steel in finished areas. Provide stamped metal cover plates in other areas. Provide weatherproof "while in-use" covers for exterior receptacles.
4. Ground fault circuit interrupting (GFI) duplex receptacles shall be commercial grade complete with LED indicator light.

23. MECHANICAL AND OTHER EQUIPMENT

1. Provide wiring, connections, starters, disconnects and controls for mechanical equipment and for other equipment supplied and installed by others.
2. Provide flexible connections to mechanical equipment for vibration isolation. NMD-90 may be used for connections to ceiling mounted exhaust fans where permitted by Code. Connections to equipment roof mounted or in other damp or wet locations shall be liquid-tight.
3. In general, all control wiring will be by Mechanical Contractor unless otherwise noted. Where 120 volt power is required for mechanical equipment, wiring to the equipment terminals is the work of the Electrical Contractor.
4. Refer to the Mechanical Drawings and Specifications to confirm electric characteristics and controls for all mechanical equipment and systems.
5. Receptacles for maintenance of equipment located on roof shall be protected by GFCI, supplied by a circuit that does not supply and other outlets or equipment, CSA 5-20R, located within 7.5m of equipment, located not less than 750mm above finished roof and protected from mechanical damage as per local electric code.

24. NAMEPLATES

1. Provide and install laminated plastic nameplates with engraved letters to identify the following:
 1. Distribution breakers
 2. Panels
 3. Motor Starters
 4. Disconnect Switches
 5. Controls
- Nameplates/labels shall give either the designated name of the equipment (Panel A) or its function (Starter for Fan Coil Unit FC-1, Lighting Control, Exhaust Fan Switch, etc.).

25. FIELD REVIEWS

1. Call the Engineer for field reviews as required by the local Building Code at the following stages of construction:
 1. Substantial completion.
 2. Completion of deficiencies (if applicable).
2. Provide two working days' notice for all reviews.

26. SEISMIC RESTRAINT

1. Obtain the services of a Registered Professional recognized in the field of seismic design to provide the necessary design and details for a complete system of structural supports and bracing of all electrical equipment as required to comply with Part 4, Structural Design, of the BC Building Code. That Certified Professional shall be responsible for ensuring that the installation conforms to the design.
2. The Registered Professional shall complete and submit signed and sealed Schedule S Letters of Assurance and letter of compliance for all equipment that requires seismic restraint in accordance with latest codes, standards and requirements of the authorities having jurisdiction. The Registered Professional shall include additional documentation to identify the equipment and device types and quantities that were reviewed to ensure that all components requiring seismic restraint were completed.

27. SUBSTANTIAL COMPLETION

1. Prior to requesting substantial completion inspection, the following items must be complete:
 1. Provide Certificate of Acceptance from Electrical Inspection Department.
 2. Project Record Drawings must be submitted to Engineer for review.
 3. Maintenance manuals must be submitted to Engineer for review.
 4. All outlets must have coverplates installed.
 5. All electrical equipment not located in service rooms must have covers and/or doors installed complete.
 6. Any devices not installed must have the wiring made safe and terminated in an outlet box complete with cover.
 7. Continuity of fire separations at electrical penetrations must be complete.
 8. All seismic restraint requirements must be complete. Ensure that the pricing structure is acceptable to the client, and meets the project requirements based on size and complexity.



VICTORIA T 250-625-8999 F 250-625-9099
 VANCOUVER T 604-484-9974 F 604-484-9975
 CALGARY T 403-233-3333 F 403-233-3324
 VANCOUVER BC V6C 2E1 VANCOUVER BC V6C 2E1

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 THE CONTRACTOR SHALL CHECK AND VERIFY ALL DIMENSIONS AND REPORT ALL ERRORS AND OMISSIONS TO THE CONSULTANT PRIOR TO COMMENCING THE WORK.
 THESE DRAWINGS ARE NOT TO BE SCALED.

REV.	DATE	DESCRIPTION
1	JAN. 10. 2020	ISSUED FOR TENDER REVIEW
2	JAN. 22. 2020	ISSUED FOR TENDER

SEALED

SEAL:

CONSULTANT:

Smith + Andersen

300 - 6400 Roberts Street Burnaby British Columbia V5G 4C9
 604 294 8414 f 604 294 6405 smithandanderson.com

PROJECT TITLE:

**STRATHCONA
 GARDENS RECREATION
 COMPLEX - ENERGY
 RETROFIT PHASE 2**

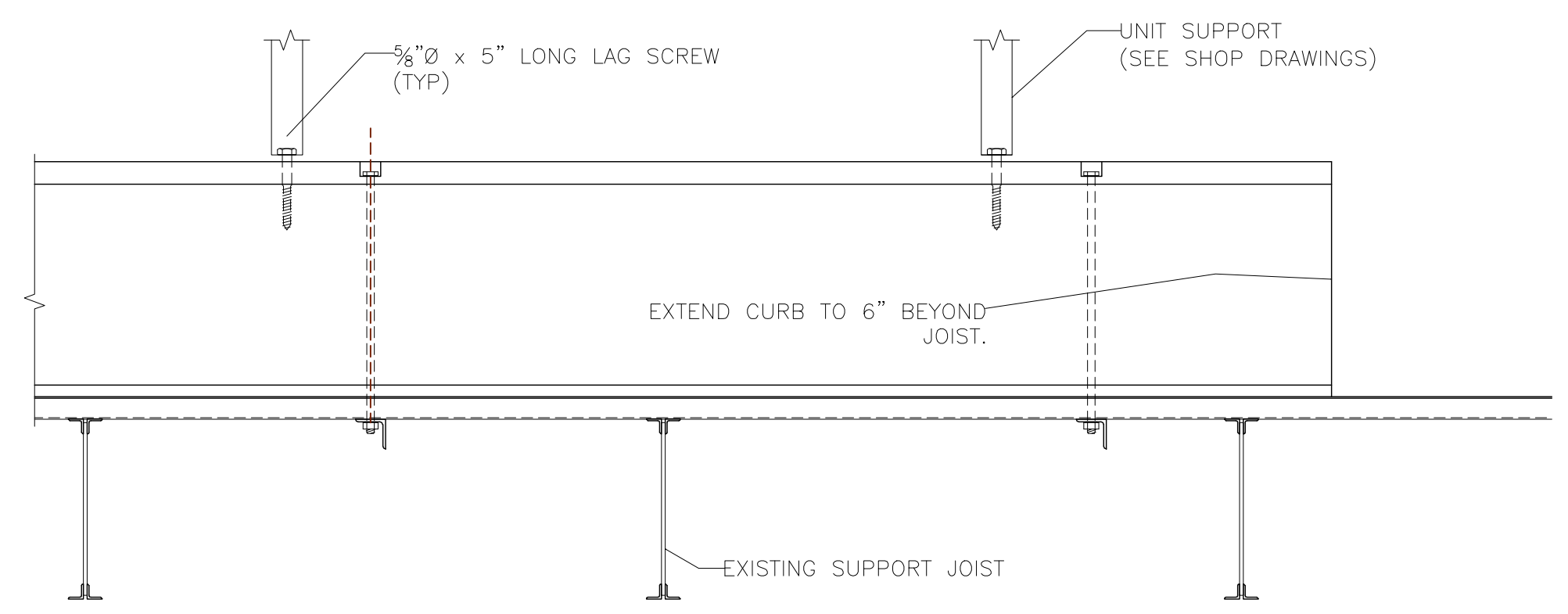
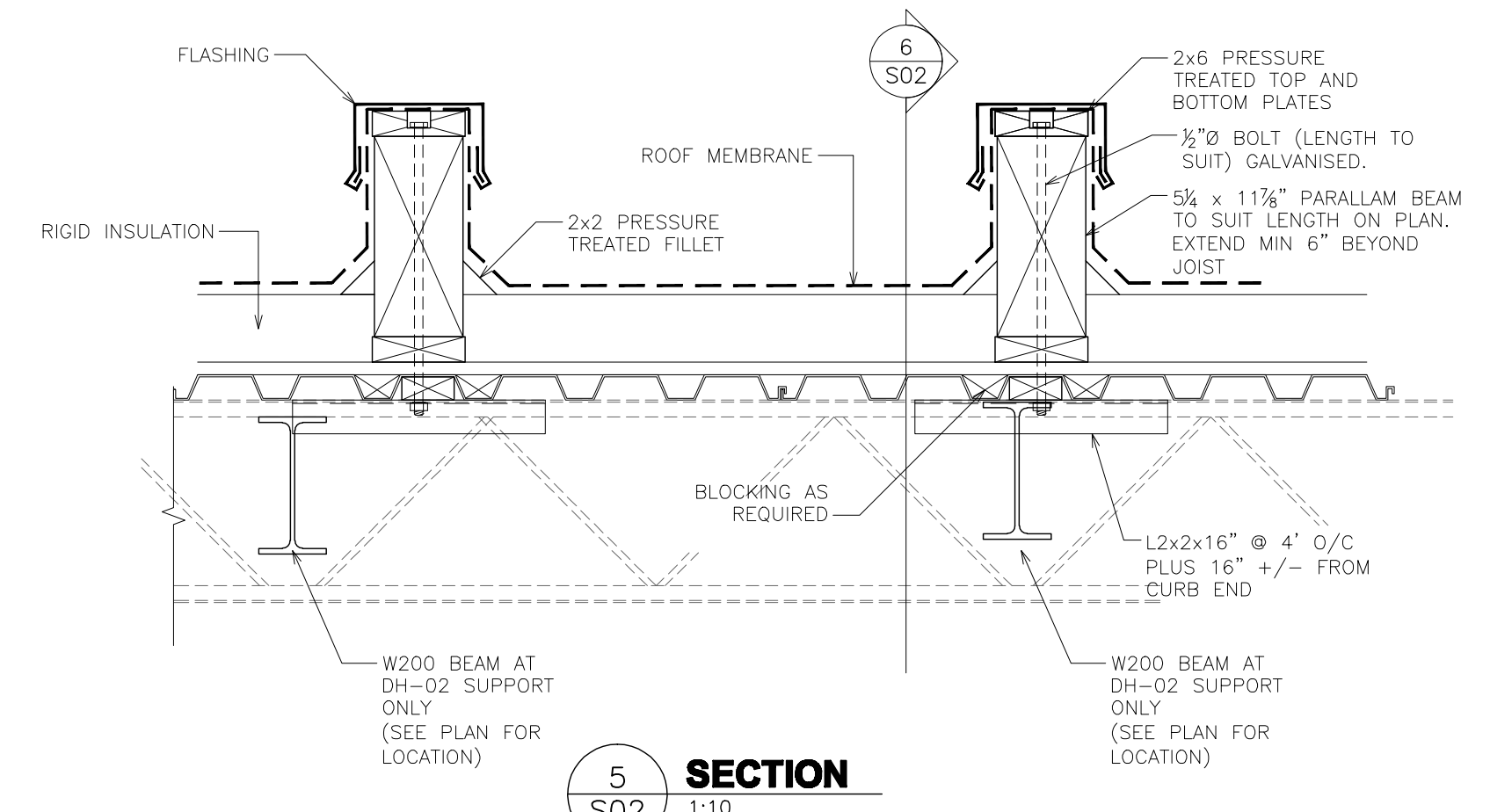
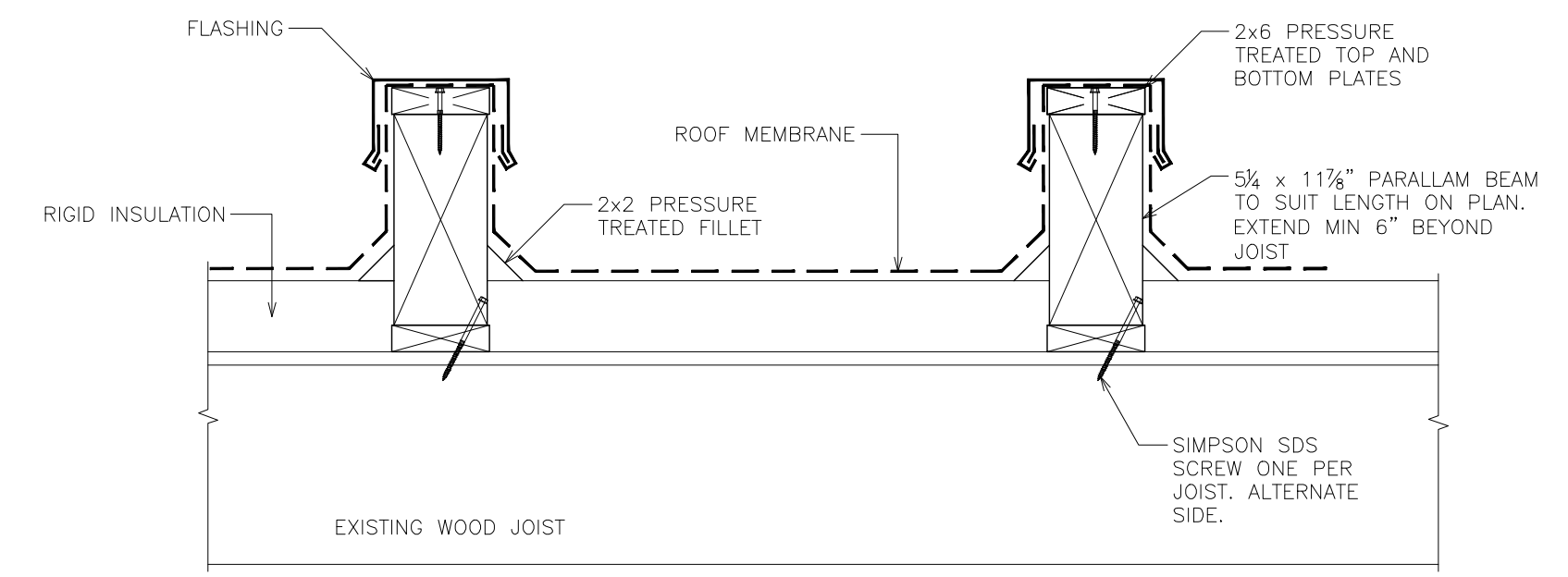
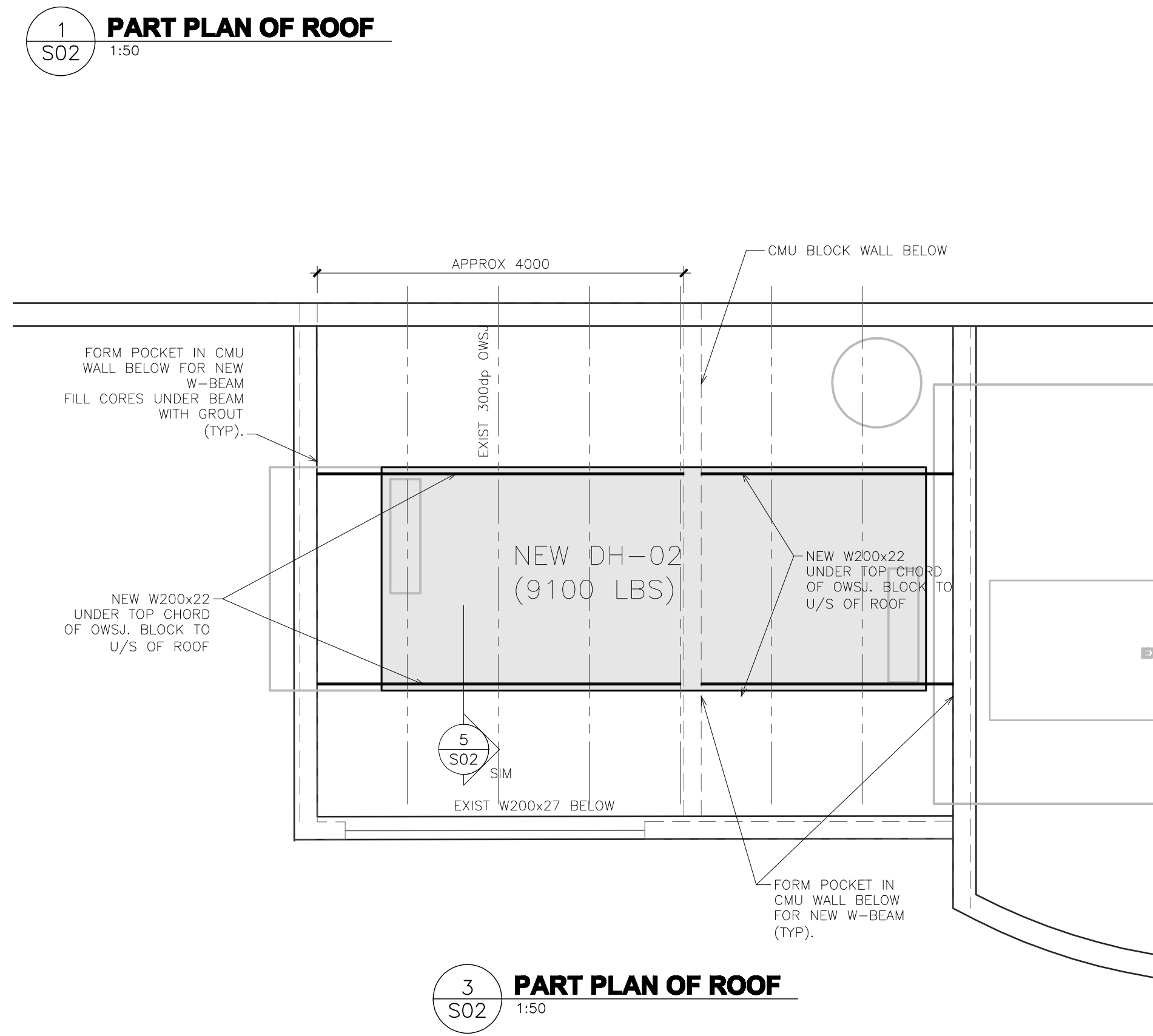
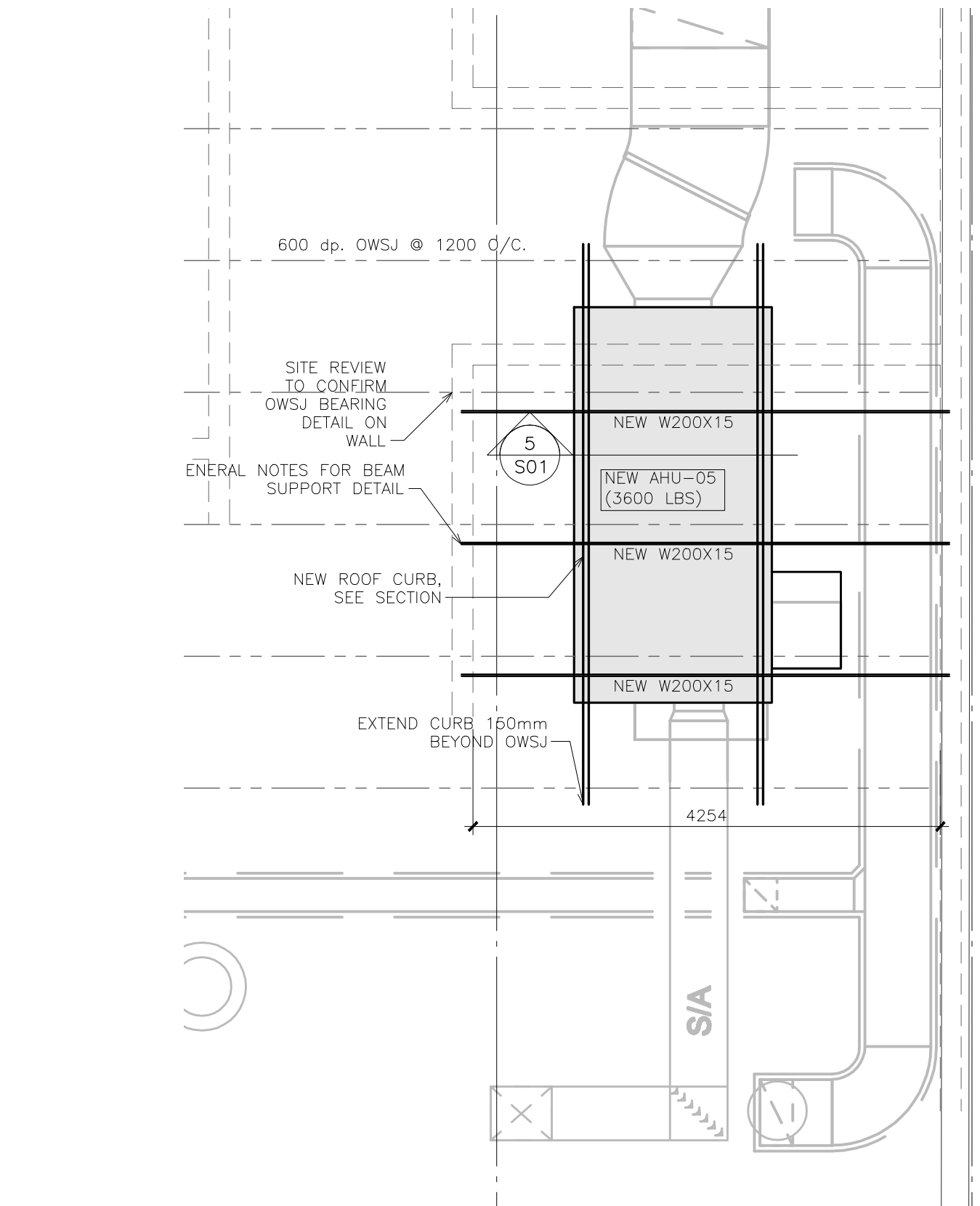
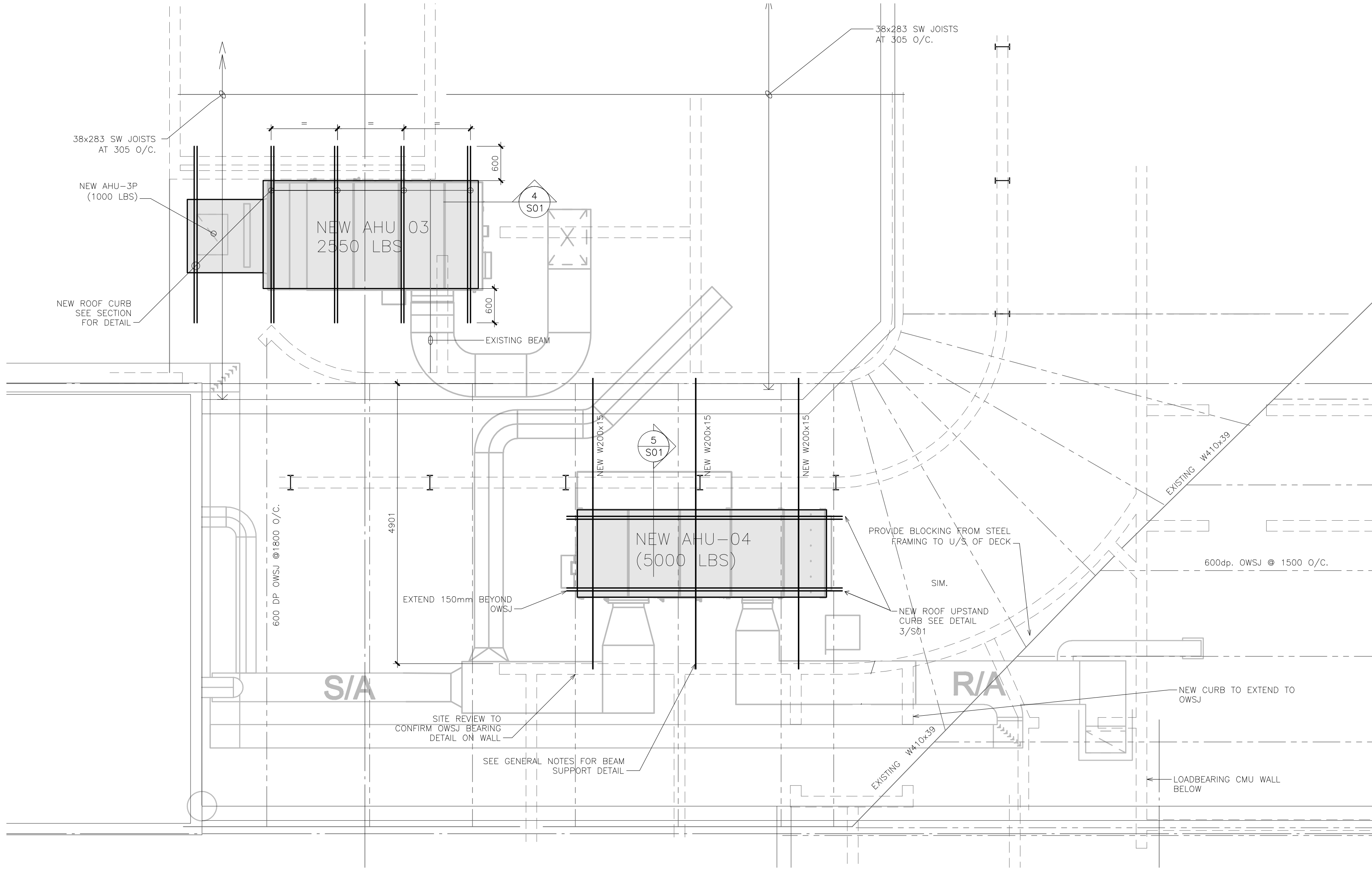
PROJECT ADDRESS:
 225 S DOGWOOD STREET
 CAMPBELL RIVER, BC
 V9W 8C8

DRAWN BY	KG
CHECKED BY	RB
SCALE	N.T.S.
DATE	01/07/2020

DRAWING TITLE:
**OUTLINE
 SPECIFICATION**

PROJECT NO.	DRAWING NO.
18625.002.E	E-300

REV.	DATE	DESCRIPTION
1.	2020.01.15	ISSUE FOR TENDER REVIEW
2.	2020.01.22	ISSUE FOR TENDER



CONSULTANT:

SEAL:

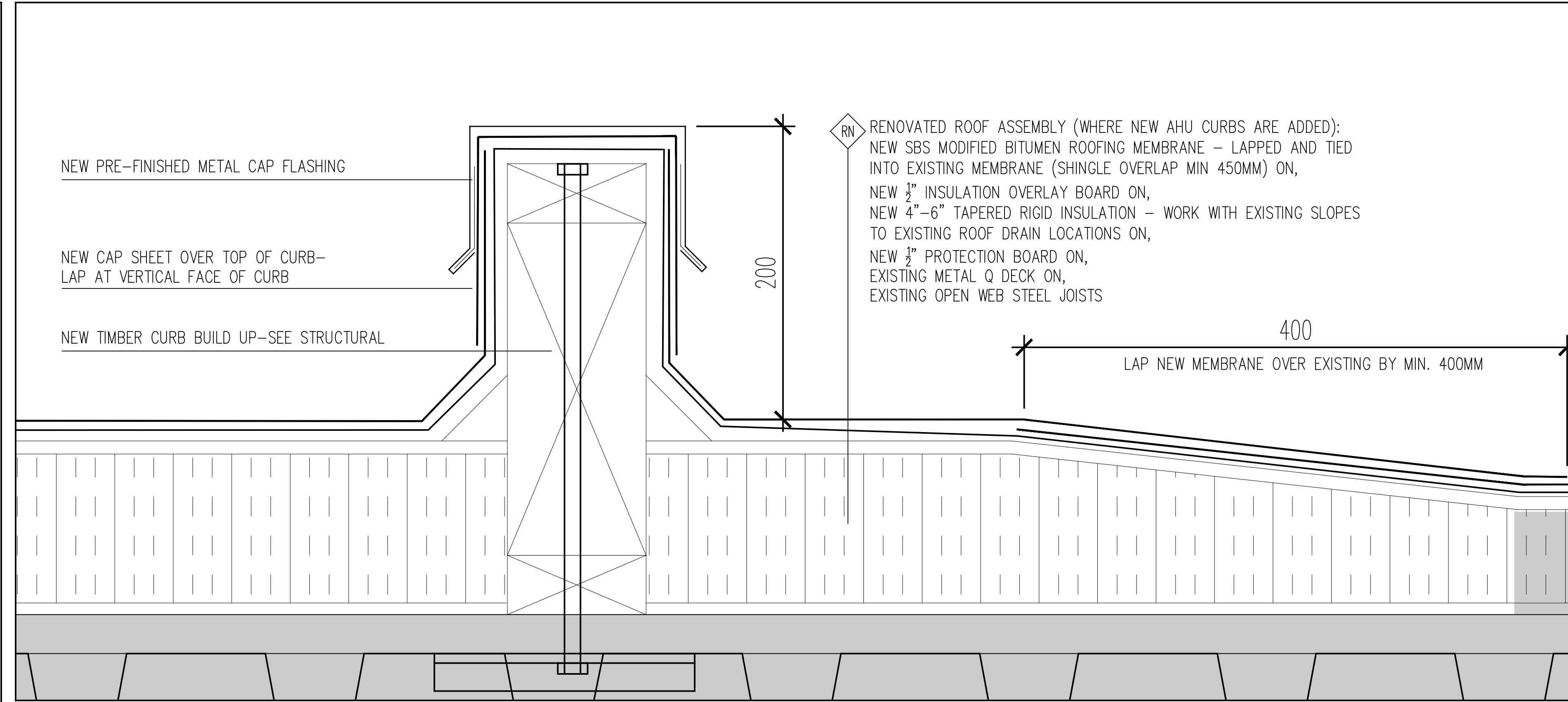
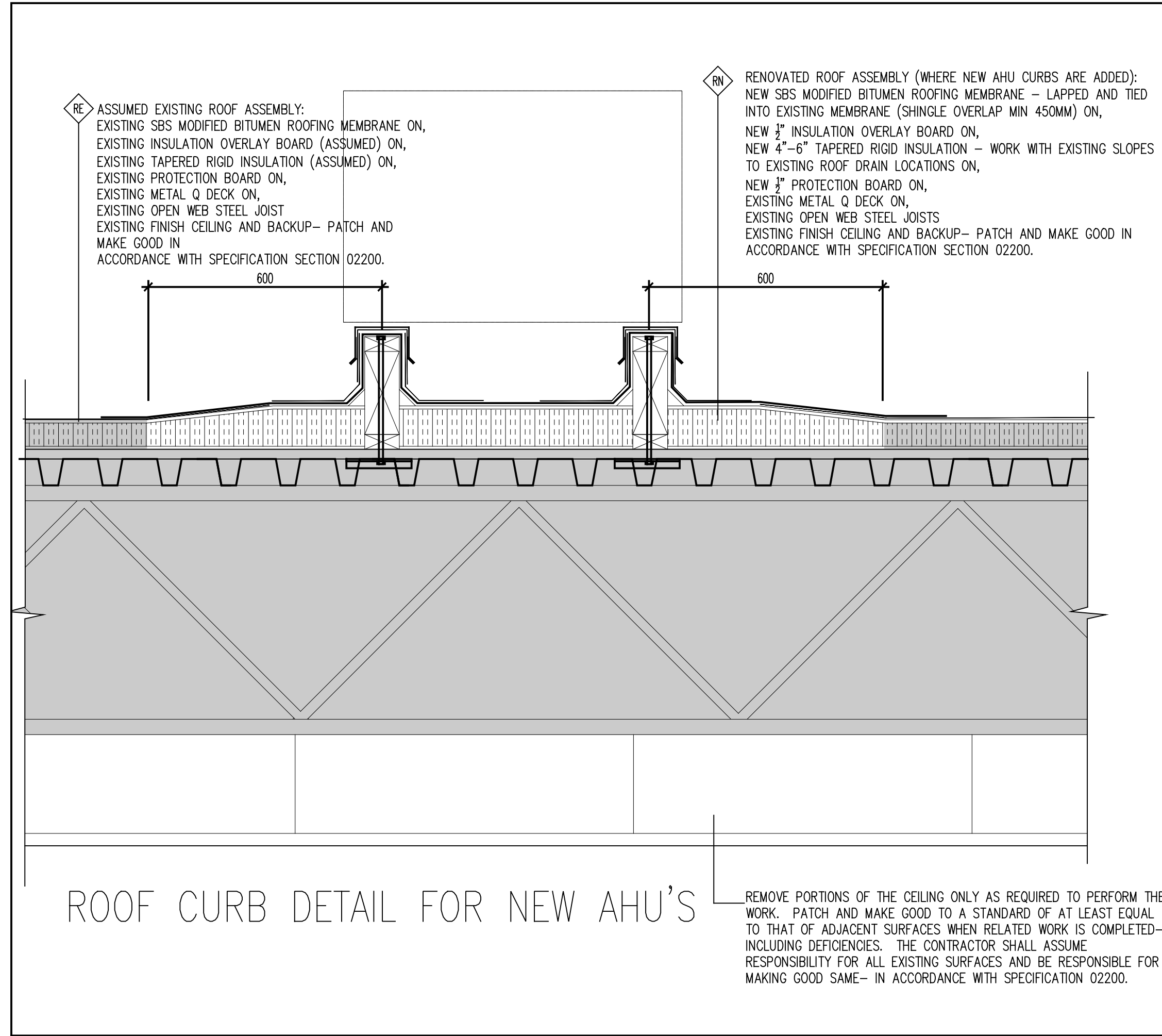
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STRATHCONA GARDENS RECREATION COMPLEX - ENERGY RETROFIT PHASE 2

PROJECT ADDRESS:
225 S DOGWOOD STREET
CAMPBELL RIVER, BC
V9W 8C8

DRAWN BY: DB
CHECKED BY:
SCALE: AS NOTED
DATE: 01/10/2020

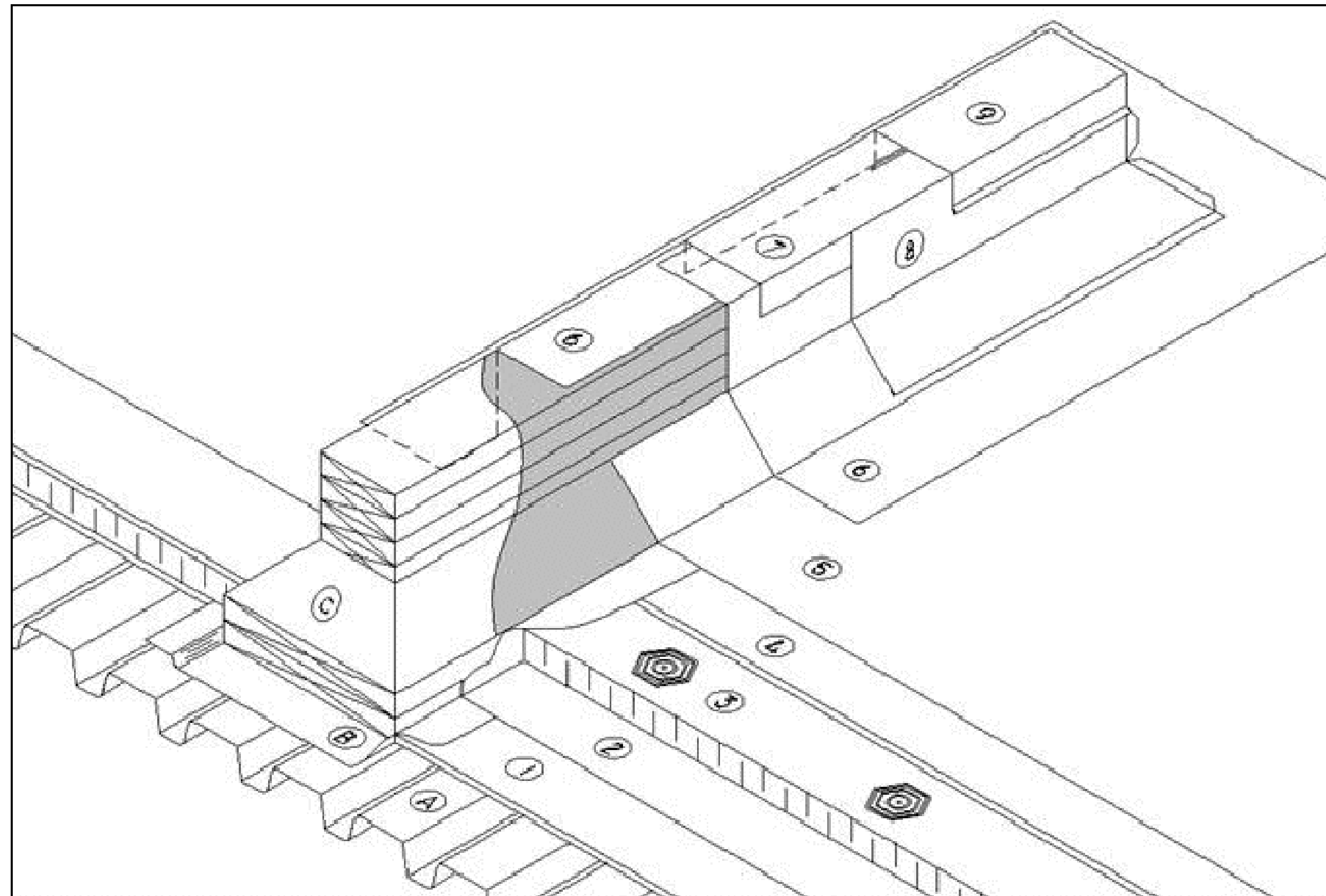
DRAWING TITLE:
ROOF PLAN - AHU NEW

PROJECT NO.: 009a-086-19
DRAWING NO.: S02



2 CURB DETAIL AT NEW AHU
 ASK1 1:2

1 ROOF SECTION AT NEW AHU- (EXISTING CONSTRUCTION IS SHADED GREY)
 ASK1 1:10



SBS ROOF CURB DETAIL

- 1-Supporting Deck overlay
 - 2-Air Vapour Control Layers
 - 3-Insulation
 - 4-Insulation Overlay- as required
 - 5-Primary Membrane + Membrane Protection
 - 6-Membrane Flashing
- Lap one ply from each side over top of sleeper (C) and mechanically fasten
- 7-Alternate Cap Flashing- May be used instead of lapping membrane flashing over sleeper.
 - 8-Metal Base Flashing- Mechanically fasten to top of wood blocking, standing seam at corners, optional on flexible membrane systems. Required on assemblies using gravel ballast filter mats.
 - 9-Metal Cap Flashing-Note 8 and 9 may be one piece.

SHADING INDICATES EXISTING CONSTRUCTION TO REMAIN

Section No.	Section Title
Division 21	
21 05 01	Common Works Results for Mechanical
Division 22	
22 07 11	Fire Stopping
Division 23	
23 01 31	Air Duct Cleaning – HVAC Systems
23 05 14	Variable Frequency Drives
23 05 15	Common Installation Requirements for HVAC Pipework
23 05 19	Meters and Gauges for Mechanical Piping
23 05 29	Hangers and Supports for Mechanical Piping and Equipment
23 05 48	Vibration and Seismic Control for Mechanical
23 05 53	Identification for Mechanical Piping and Equipment
23 05 93	Testing, Adjusting, and Balancing for HVAC
23 07 13	Duct Insulation
23 07 16	HVAC Equipment Insulation
23 07 19	HVAC Piping Insulation
23 08 00	Commissioning of Mechanical Systems
23 08 01	Performance Verification of Mechanical Piping Systems
23 21 13	Hydronic Piping
23 21 16	Hydronic Piping Specialties
23 21 23	Hydronic Pumps
23 25 00	HVAC Water Treatment
23 31 00	HVAC Ducts and Casings
23 32 00	Air Plenums and Casings
23 33 00	Duct Accessories
23 72 00	Air-to-Air Energy Recovery Equipment
23 73 11	Custom Air Handling Units
23 74 00	Packaged Outdoor HVAC Equipment
23 82 16	Air Coils
Division 25	
25 05 00	Common Work Results for Integrated Automation
25 08 00	Commissioning of Integrated Automation
25 90 00	Integrated Automation Control Sequences

1. GENERAL

1.1 Section Scope

- .1 This Section specifies general conditions for Divisions 21, 22, 23 and 25 and is to be read, interpreted, and coordinated with all other sections.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Drawings and General Provisions of the Contract, including General and Supplementary Conditions, Division 00 and Division 01 Specification Sections apply to work specified in this section.
- .3 Section 25 05 00 – Common Works Results for Integrated Automation.

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
- .2 British Columbia Codes:
 - .1 British Columbia Building Code 2018 (BCBC).
 - .2 British Columbia Fire Code 2018.
 - .3 British Columbia Plumbing Code 2018.
 - .4 Technical Safety BC regulations and regulatory notices.
- .3 American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE):
 - .1 ASHRAE 90.1- [16], Energy Standard for Buildings except Low-Rise Residential Buildings.
 - .2 ASHRAE 62.1- [01], Ventilation for Acceptable Indoor Air Quality.
 - .3 ASHRAE 62.1-07, Ventilation for Acceptable Indoor Air Quality.
- .4 Health Canada/Workplace Hazardous Materials Information System (WHMIS):
 - .1 Material Safety Data Sheets (MSDS).
- .5 Electrical Equipment Manufacturers' Association Council (EEMAC):

1.4 Definitions

- .1 "concealed" – means hidden from normal sight in furred spaces, shafts, ceiling spaces, walls and partitions.
- .2 "exposed" – means work normally visible, including work in equipment rooms, service tunnels, and similar spaces.
- .3 "finished" - means when in description of any area or part of an area or a product which receives a finish such as paint, or in case of a product may be factory finished.
- .4 "provision" or "provide" (and tenses of "provide") – means supply and install complete.
- .5 "install" (and tenses of "install") – means secure in position, connect complete, test, adjust, verify and certify.

- .6 "supply" – means to procure, arrange for delivery to site, inspect, accept delivery and administer supply of products; distribute to areas; and include manufacturer's supply of any special materials, standard on site testing, initial start-up, programming, basic commissioning, warranties and manufacturers' assistance to Contractor.
- .7 "delete" or "remove" (and tenses of "delete" or "remove") – means to disconnect, make safe, and remove obsolete materials; patch and repair/finish surfaces to match adjoining similar construction; include for associated re-programming of systems and/or change of documentation identifications to suit deletions, and properly dispose of deleted products off site unless otherwise instructed by Owner and reviewed with Consultant.
- .8 "BAS" – means building automation system; "BMS" – means building management system; "FMS" – means facility management system; and "DDC" means direct digital controls; references to "BAS", "BMS", "FMS", and "DDC" generally mean same.
- .9 "governing authority" and/or "authority having jurisdiction" and/or "regulatory authority" and/or "Municipal authority" – means government departments, agencies, standards, rules and regulations that apply to and govern work and to which work must adhere.
- .10 "OSHA" and "OHS" – stands for Occupational Safety and Health Administration and Occupational Health and Safety Act, and wherever either one is used, they are to be read to mean local governing occupational health and safety regulations that apply to and govern work and to which work must adhere, regardless if Project falls within either authority's jurisdiction.
- .11 "Mechanical Divisions" – refers to Divisions 20, 21, 22, 23, 25 and other Divisions as specifically noted, and which work as defined in Specifications and/or on drawings is responsibility of Mechanical Contractor, unless otherwise noted.
- .12 "Electrical Divisions" – refers to Divisions 26, 27, 28 and other Divisions as specifically noted, and which work as defined in Specifications and/or on drawings is responsibility of Electrical Contractor, unless otherwise noted.
- .13 "Consultant" – means person, firm, corporation identified as such in Agreement, or Documents, and is licensed to practice in Place of the Work, and has been appointed by Owner to act for Owner in a professional capacity in relation to the Work.
- .14 Wherever words "indicated", "shown", "noted", "listed", or similar words or phrases are used in Contract Documents they are understood, unless otherwise defined, to mean product referred to is "indicated", "shown", "listed", or "noted" on Contract Documents.
- .15 Wherever words "reviewed", "satisfactory", "as directed", "submit", or similar words or phrases are used in Contract Documents they are understood, unless otherwise defined, to mean that work or product referred to is "reviewed by", "to the satisfaction of", "submitted to", etc., Consultant.

1.5 General Scope

- .1 The current project consists generally of replacement of AHU-3, AHU-4, AHU-5 and the dehumidification unit serving arena 2 (Subsequently referred to as DH-2):
 - .1 Common Scope:
 - .1 Drain down of existing heat pump loop pipes, including retention/storage of existing hydronic fluid contained within.
 - .2 Testing of the existing PVC piping routed on the roof between the existing pool mechanical room and the existing refrigeration room to ensure it is still of sufficient integrity to re-use in the new low temperature heat pump loop.
 - .3 Remediation or replacement of all duct and piping supports, except ductwork or piping that is included in a different Separate Price if that Separate Price is not accepted.

- .4 Installation of new parallel main circulation pumps, boiler loop injection pump, and refrigeration plant heat recovery pump.
- .5 Installation of piping and all required accessories to make a working system for the boiler injection loop to and from the boiler plant (including scanning and coring of floor in location shown and firestopping of penetrations).
- .6 Installation of new, and remediation of existing, piping in refrigeration plant room, including all required accessories to make a working system for the heat recovery loop, and to accommodate installation of new pump recovering heat from plant, as well as new tees and isolation valves as shown to set up for connection to new DH-2-2020.
- .7 Installation of tee fittings, isolation valves and caps for current or future connection to heat pump loop piping as shown on plans.
- .8 Completion of connection between existing original heat pump loop piping on roof and existing heat pump loop piping installed as part of Phase 1. Location is outside to east of existing refrigeration plant room.
- .9 Reintroduction of stored hydronic fluid, including chemical treatment thereof in order to match the existing fluid/chemical mix (including propylene glycol) to match both the existing boiler hydronic fluid and the existing refrigeration low grade temperature loop hydronic fluid.
- .10 Insulation of all new and existing heat pump piping and fittings, valves, etc., located outside the building.
- .11 Commissioning, controls and balancing, etc., of equipment and systems associated with Common Scope.
- .2 Separate Price #1:
 - .1 Demolition of existing AHU-03 and installation of new AHU-03-2020 as described in Contract Documents, including, but not limited to, any and all work involved with unit or associated ductwork, piping, insulation, coil, pumps, enclosures, curbs, duct/pipe supports, roof work, commissioning, controls, balancing, structural, architectural, electrical, etc.
- .3 Separate Price #2:
 - .1 Demolition of existing AHU-04 and installation of new AHU-04-2020 as described in Contract Documents, including, but not limited to, any and all work involved with unit or associated ductwork, piping, insulation, pumps, enclosures, curbs, duct/pipe supports, roof work, commissioning, controls, balancing, structural, architectural, electrical, etc.
- .4 Separate Price #3:
 - .1 Demolition of existing AHU-05 and exhaust fans as noted and installation of new AHU-05-2020 as described in Contract Documents, including, but not limited to, any and all work involved with unit or associated ductwork, piping, insulation, coil, pumps, enclosures, curbs, duct/pipe supports, roof work, commissioning, controls, balancing, structural, architectural, electrical, etc.
- .5 Separate Price #4:
 - .1 Demolition of existing DH-02 and installation of new DH-02-2020 as described in Contract Documents, including, but not limited to, any and all work involved with unit or associated ductwork, piping, insulation, coil, pumps, enclosures, curbs, duct/pipe supports, roof work, commissioning, controls, balancing, structural, architectural, electrical, etc.
- .6 Separate Price #5:

- .1 5A - Provide a Separate Price for cleaning of any outside air, supply air, return air, or exhaust air ductwork associated with AHU-3. Include in this Separate Price the cost to clean any duct accessories, coils, sensors, etc., associated with the ductwork systems.
- .2 5B - Provide a Separate Price for cleaning of any outside air, supply air, return air, or exhaust air ductwork associated with AHU-4. Include in this Separate Price the cost to clean any duct accessories, coils, sensors, etc., associated with the ductwork systems.
- .3 5C - Provide a Separate Price for cleaning of any outside air, supply air, return air, or exhaust air ductwork associated with AHU-5, EF-11 and EF-13. Include in this Separate Price the cost to clean any duct accessories, coils, sensors, etc., associated with the ductwork systems.
- .4 5D - Provide a Separate Price for cleaning of any supply air or return air air ductwork associated with DH-02. Include in this Separate Price the cost to clean any duct accessories, coils, sensors, etc., associated with the ductwork systems.
- .7 Separate Price #6:
 - .1 Provide a Separate Price for removal and replacement of existing heat pump loop piping in full, matching existing routing. New piping to be painted or otherwise protected during installation from UV exposure according to the manufacturers recommendations/requirements until insulation is installed.
- .8 Separate Price #7:
 - .1 Provide a Separate Price for deletion of controls scope from this Contract. Separate Price to be divided according to other Separate Price scopes noted above – Common Scope, AHU-03, AHU-04, AHU-05 and DH-02
- .2 The scope of Section 23 HVAC, and Section 25 Control is for building services within the project structure and 1m from the building.
- .3 Provide complete, fully tested, and operational systems to meet the requirements described herein and in complete accord with applicable codes and ordinances.
- .4 Contract documents and drawings of this Division are diagrammatic and approximately, to scale unless detailed otherwise. They establish scope, material, and installation quality but are not detailed installation instructions.
- .5 Follow manufacturers' recommended installation instructions, details, and procedures for equipment, supplemented by requirements of the Contract Documents.
- .6 Install equipment generally in locations and routes indicated. Run piping and ductwork close to building structure, parallel to building lines, maximize headroom and maintain minimum interference with other services and free space. Remove and replace improperly installed equipment to satisfaction of the Consultant at no extra cost.
- .7 For work within existing facilities, confirm locations and elevations of existing piping and equipment prior to commencement of new work.
- .8 Install equipment to provide service access, maintain service clearances and for ease of maintenance.
- .9 Connect to equipment specified in other Sections and to equipment supplied and installed by other Contractors or by the Owner. Uncrate equipment, move in place and install complete; start up and test.
- .10 Install control valves, control dampers, thermal wells, and other devices on piping and ductwork, furnished by Division 25.

1.6 Coordination of Work

- .1 Cooperate and coordinate with other trades on the project.
- .2 Make reference to electrical, mechanical, structural, and architectural drawings or details when setting out work. Consult with respective Divisions in setting out locations for ductwork, equipment, and piping, so that conflicts are avoided and symmetrical even spacing is maintained. Jointly work out all conflicts on site before fabricating or installing any materials or equipment.
- .3 Where dimensional details are required, work with the applicable architectural and structural drawings.
- .4 Full size and detailed drawings shall take precedence over scale measurements from drawings. Specifications shall take precedence over drawings.
- .5 Any areas indicated as space for future materials or equipment shall be left clear.

1.7 Permits and Fees

- .1 All work shall comply with provincial, municipal, bylaws and authorities having jurisdiction.
- .2 Obtain all permits and pay all fees applicable to the scope of work.
- .3 Contractor shall arrange for inspections of the work by the authorities having jurisdiction and shall provide certificates indicating Final Approval.

1.8 Examination of Site

- .1 Before submitting tender, visit and examine the site and note all characteristics and features affecting the work. No allowances will be made for any difficulties encountered or any expenses incurred because of any conditions of the site or item existing thereon, which is visible or known to exist at the time of tender.

1.9 Tender Price Breakdown

- .1 Submit a tender price breakdown within thirty (30) days of tender closing and before first progress claim, in a format agreed to with the Consultant.
- .2 As a minimum, include the following in the tender price breakdown:
 - .1 Mechanical: Equipment, materials, labour
 - .2 Sheet Metal: Equipment, materials, labour
 - .3 Controls: Equipment, materials, labour

1.10 Submittals

- .1 Submittals shall be in accordance with Division 01 - Submittal Procedures, Division 01 – Closeout Procedures, Division 01 – Closeout Submittals and the following:
 - .1 Installed materials and equipment shall meet specified requirements regardless of whether or not shop drawings are reviewed by the Consultant.
 - .2 No work may begin on any segment of this project until submittals have been successfully reviewed for conformity with the design intent.
 - .3 Shop drawings shall be reviewed by the General Contractor and Mechanical Sub-Contractor indicating that the shop drawings have been reviewed, coordinated with the work and that the shop drawings are submitted without qualifications. Shop drawings shall bear the 'reviewed' stamp dated and initialed by the General Contractor and Mechanical Sub-Contractor prior to submitting the shop drawings to the consultant. Shop drawings, which do not bear the contractors and sub-trades 'reviewed' stamp, initials and date will be rejected and sent back as 'not reviewed'.

- .4 Submit samples, in addition to drawings, of all items, which in the Consultant's judgment, can be better examined for capacity, quality, finish or detail by sample rather than by drawings. Samples shall be submitted before equipment or material is ordered.
- .5 If shop drawings are rejected technically after 3 submissions, the Contractor at no additional expense to the Owner shall revert to the specified product and manufacturer for this project.
- .2 Contractor shall provide and submit to the Consultant Assurance of Professional Design and Commitment for Field Review by Supporting Registered Professional Schedule S-B and Assurance of Professional Field Review and Compliance by Supporting Registered
- .3 Requirements for Contractor Retained Engineers
 - .1 Professional engineers retained to perform consulting services with regard to Project work, i.e. seismic engineer, fire protection engineer or structural engineer, are to be members in good standing with local Association of Professional Engineers, and are to carry and pay for errors and omissions professional liability insurance in compliance with requirements of governing authorities in Place of the Work.
 - .2 Retained engineer's professional liability insurance is to protect Contractor's consultants and their respective servants, agents, and employees against any loss or damage resulting from professional services rendered by aforementioned consultants and their respective servants, agents, and employees in regards to the Work of this Contract.
 - .3 Unless otherwise specified in Division 00 or 01, liability insurance requirements are as follows:
 - .1 Coverage is to be a minimum of \$1,000,000.00 CDN inclusive of any one occurrence;
 - .2 Insurance policy is not to be cancelled or changed in any way without insurer giving Owner minimum thirty days written notice;
 - .3 Liability insurance is to be obtained from an insurer registered and licensed to underwrite such insurance in the Place of the Work.
 - .4 Retained consultants are to ascertain that sub-consultants employed by them carry insurance in the form and limits specified above.
 - .5 Evidence of the required liability insurance in such form as may be required is to be issued to Owner, Owner's Consultant, and Municipal Authorities as required prior to commencement of aforementioned consultant's services.
- .4 Submit shop drawings for all products identified in the relevant specification sections of Divisions 21, 22, 23 and 25. Provide drawings as electronic files (file format: .dwg, .dxf, pdf, or comparable). 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 a complete bill of materials of equipment to be used indicating quantity, manufacturer, model number, and other relevant technical data.
- .5 Submit the following shop drawings stamped and signed by professional engineer registered or licensed in Province of British Columbia.
 - .1 Fastening details for Seismic restraints.
 - .2 Mounting details for spring isolation of equipment.
 - .3 Sprinkler drawings including hydraulic calculations as per NFPA.

- .6 Shop drawings and product data shall be accompanied by:
 - .1 Detailed drawings of bases, supports, and anchor bolts.
 - .2 Acoustical sound power data, where applicable.
 - .3 Capacity and performance characteristics indicated on performance curves.
 - .4 Manufacturer to certify current model production.
 - .5 Certification for compliance to applicable codes.
- .7 Shop drawings to indicate:
 - .1 Material Specification including CSA or ULC reference numbers.
 - .2 Clearly mark submittal material using arrows, underlining or circling to show differences from specified ratings, capabilities and options being proposed. Cross out non-applicable material. Specifically note on the submittal specified features such as special tank linings, pumps, seals, material, or painting.
 - .3 Dimensioned construction drawings with plans and sections showing size, arrangement and necessary clearances, with mounting point loads.
 - .4 Weights of all major equipment for review by the appropriate Consultant.
 - .5 Mounting arrangements and installation details to suit the applications on this project.
 - .6 Motor efficiencies on motors 1H.P. and larger.
 - .7 List of the manufacturers and figure numbers for all valves, traps and strainers.
 - .8 Control explanation and internal wiring diagrams for packaged equipment.
 - .9 Control system drawings including a written description of control sequences relating to the schematic diagrams. Refer to additional requirements in controls sections.
 - .10 Operating and maintenance requirements.
 - .11 Submit as a shop drawing, an electrical equipment list for any equipment supplied by the mechanical contractor or his subtrades. The list is to be submitted in a timely fashion so that the electrical contractor can utilize the list as a final check prior to ordering motor control centres, starters, or disconnects. The list is to indicate the following:
 - .1 The horsepower size and number of motors.
 - .2 The minimum circuit amps (MCA) for packaged equipment such as roof top units.
 - .3 The voltage and phase of the motors.
 - .4 Whether or not a starter or a disconnect is included as part of the package.
- .8 Material Safety Data Sheets (MSDS):
 - .1 Submit Material Safety Data Sheets (MSDS) in accordance with Division 01 - Submittal Procedures for the following products. Indicate VOC emissions, prior to installation or use:
 - .1 Adhesives.
 - .2 Caulking compounds.
 - .3 Sealants.
 - .4 Insulating materials.
 - .5 Fireproofing or fire stopping materials.
- .9 Closeout Submittals:

- .1 Provide mechanical operation and maintenance data in compliance with Division 01 - Closeout Submittals and the following:
 - .1 The Contractor shall furnish and pay for three (3) complete sets of operating and maintenance manuals for the complete mechanical installation plus two (2) copies of the digital version of the manuals on USB type flash drive.
 - .2 Supply indexed copies of equipment manufacturers' operating and maintenance (O&M) instruction data manuals. Consolidate each copy of data in an identified hard cover three "D" ring binder. Each binder to include:
 - .1 Front cover: project name; wording – "Mechanical Systems Operating and Maintenance Manual"; and date;
 - .2 Introduction sheet listing Consultant, Contractor, and Subcontractor names, street addresses, telephone and fax numbers, and e-mail addresses;
 - .3 Equipment manufacturer's authorized contact person name, telephone number and company website;
 - .4 Table of Contents sheet, and corresponding index tab sheets;
 - .5 Copy of each "REVIEWED" or clean, updated "REVIEWED AS NOTED" shop drawing or product data sheet, with manufacturer's/supplier's name, telephone and fax numbers, email address, company website address, and email address for local source of parts and service; when shop drawings are returned marked "Reviewed As Noted" with revisions marked on shop drawing copies, they are to be revised by equipment supplier to incorporate comments marked on "Reviewed" shop drawings and a clean updated copy is to be included in operating and maintenance manuals;
 - .3 Operation and maintenance manual approved by, and final copies deposited with the Consultant a minimum of 7-days before final inspection.
 - .4 Operation data to include but not limited to:
 - .1 Pressure test reports, and certificates issued by governing authorities
 - .2 Control schematics for systems including environmental controls.
 - .3 Wiring and connection diagrams.
 - .4 A description of the systems and associated controls.
 - .5 Description of operation of systems at various loads together with reset schedules and seasonal variances.
 - .6 Operational instructions for systems and associated components.
 - .7 A description of actions to be taken in the event of equipment failure.
 - .8 Valves schedule and flow diagrams.
 - .9 Colour coding chart.
 - .5 Maintenance data to include:
 - .1 Servicing, maintenance, operation, and trouble-shooting instructions for each item of equipment.
 - .2 Data to include schedules of tasks, frequency, tools required and task time.
 - .3 Recommended maintenance practices and precautions.
 - .4 Complete parts lists with numbers.

- .6 Performance data to include:
 - .1 Equipment manufacturer's performance datasheets indicating point of operation as left after commissioning is complete.
 - .2 Equipment performance verification test results and final commissioning report.
 - .3 Special performance data as specified.
 - .4 Testing, adjusting, and balancing.
- .7 Digital Version of Manuals
 - .1 The digital version of the manuals and the hard copy version shall be prepared by the same company.
 - .2 Utilize latest version of Adobe Acrobat, Portable Document Format (pdf).
 - .3 The digital manual shall be enhanced with the following features: Bookmarks, Internet Links, Internal Documents Links and Optical Character Recognition (OCR).
 - .4 All shop drawings shall be scanned to a minimum 8.5" x 11" size. If the original page is 11" x 17", the digital copy shall also be 11" x 17".
 - .5 Provide a minimum 300 DPI for all scanned pages.
 - .6 All scanned material may be searched for text with minimum 60% Optical Character Recognition (OCR).
 - .7 Rotation of scanned page images/texts shall be displayed within +/- 20 degrees.
 - .8 Digital manual shall be organized in the same manner as the hard copy manual. Bookmark all major tabs and sub-sections and each set of shop drawings. Link the Table of Contents to the referenced section. Insert Internet Links to the Mechanical Equipment Manufacturers/Suppliers/Contractors official websites
- .8 Approvals:
 - .1 Submit 1 copy of draft Operation and Maintenance Manual to Consultant for approval. Submission of individual data will not be accepted unless directed by Consultant.
 - .2 Make changes as required and re-submit as directed by Consultant.
- .9 Warranties
 - .1 Include copy of all equipment warranty and extended warranty certificates into the Operation and Maintenance Manual.
- .10 Additional data:
 - .1 Prepare and insert into operation and maintenance manual additional data when need as it becomes apparent during demonstrations and instructions.
 - .2 Chemical treatment reports.
 - .3 Back-flow preventer test certificates.
 - .4 Results of Owner's Orientation (demonstrations).
 - .5 List of spare parts turned over to owner's forces.
- .2 Site records:

- .1 Contractor shall maintain 1 set of white prints at contractors cost to mark changes as work progresses and as changes occur.
 - .2 Use different colour waterproof ink for each service. Do not use pencil or black ink.
 - .3 Transfer information weekly to show work as actually installed.
 - .4 Make available for reference purposes and inspection.
 - .5 Before applying for a Certificate of Substantial Performance of the Work, update a clean copy of Contract Drawing set in accordance with marked up set of "as-built" white prints including deviations from original Contract Drawings, thus forming an "as-built" drawing set. Submit "as-built" site drawing prints to Consultant for review. Make necessary revisions to drawings as per Consultant's comments, to satisfaction of Consultant.
- .3 Record drawings:
- .1 Prior to start of Testing, Adjusting and Balancing for Mechanical, finalize production of record drawings.
 - .2 Use final reviewed "as-built" drawing set to provide CAD files of drawings thus forming true "as-built" set of Contract Drawings. Identify set as "Project Record Copy". Load digital copies of final reviewed by Consultant as-built drawings onto USB type flash drive. Provide 2 complete sets of "as-built" drawings on separate USBs. Submit "as-built" sets of white prints and USBs to Consultant
 - .3 Identify each drawing in lower right hand corner in letters at least 12 mm high as follows: - "AS BUILT DRAWINGS: THIS DRAWING HAS BEEN REVISED TO SHOW MECHANICAL SYSTEMS AS INSTALLED" (Signature of Contractor) (date).
 - .4 Submit to Consultant for approval and make corrections as directed.
 - .5 Perform testing, adjusting and balancing for HVAC using record drawings.
 - .6 Submit completed reproducible record drawings with Operating and Maintenance Manuals.
 - .7 Cost to transfer record information onto reproducible media & Auto-CAD are this contractor's responsibility. Consultant will release drawings to contractor after signing a copyright form.
 - .8 Should the Contractor choose to utilise this consultant for transferring as built information, allow \$400 / sheet for all drawings in the construction set. This will cover costs for drafting time & printing costs.
 - .9 Submit copies of record drawings for inclusion in final testing and balancing report
 - .10 Submitted drawings are to be of same quality as original Contract Drawings. CAD drawing files are to be compatible with AutoCAD software release version confirmed with Consultant.

1.11 Construction Detail Samples

- .1 Samples of repetitive items encountered during the construction of this project are required to establish quality control.
- .2 Samples shall be provided within 30 days of contract award or 14 days prior to installation on site of specific samples.
- .3 Construction details are samples specifically required for this project and are required as follows:

- .1 Ductwork Fittings - high pressure (including joints and sealer).
 - .2 Ductwork Fittings - low pressure (including joints and sealer).
 - .3 Pipe anchor and sleeve detail.
 - .4 Internal duct insulation c/w butt joints, open ended duct, high velocity and low velocity details.
 - .5 Pipe hangers.
 - .6 Typical seismic restraint details for equipment, ductwork and piping.
- .4 Acceptance of the standard of the sample is strictly at the discretion of the Consultant.
 - .5 Once the quality of the sample has been accepted it shall establish the quality expected throughout the remainder of the project.

1.12 Spare Parts Submittals

- .1 Furnish spare parts in accordance with Division 01 - Closeout Submittals and as follows:
 - .1 One set of packings for each pump.
 - .2 One casing joint gasket for each size pump.
 - .3 One head gasket set for each heat exchanger.
 - .4 One set of V-belts for each piece of machinery.
 - .5 One filter cartridge or set of filter media for each filter or filter bank in addition to final operating set.
- .2 Additional spare parts shall also be included as outlined in their appropriate sections.
- .3 Provide one set of special tools if required to service equipment as recommended by manufacturers.

1.13 Quality of Work

- .1 All work shall be by qualified tradesmen with valid Provincial Trade Qualification Certificates. Spot checks will be made by the Consultant.
- .2 Work, which does not conform to standards accepted by the Consultant and the trade, may be rejected by the Consultant. The Contractor shall redo rejected work to the accepted standard at no cost to the Owner.

1.14 Metric Conversion

- .1 All units in this division are expressed in SI units.
- .2 Submit all shop drawings and maintenance manuals in SI units.
- .3 On all submittals (shop drawings etc.), use the same SI units as stated in the specification.
- .4 Equivalent Nominal Diameters of Pipes - Metric and Imperial:
 - .1 Where pipes are specified with metric dimensions and Imperial sized pipes are available, provide equivalent nominal Imperial sized pipe as indicated in the table, and provide at no extra cost adapters to ensure compatible connections to all metric sized fittings, equipment, and piping.
 - .2 When CSA approved SI Metric pipes are provided, the Contractor shall provide at no extra cost adapters to ensure compatible connections between the SI Metric pipes and all new and existing pipes, fittings, and equipment.

Equivalent Nominal Diameter Of Pipes					
mm	inches (NPS)	mm	inches (NPS)	mm	inches (NPS)
3	1/8	40	1-1/2	200	8
6	1/4	50	2	250	10
10	3/8	65	2-1/2	300	12
15	1/2	75	3	375	15
20	3/4	100	4	450	18
25	1	125	5	500	20
30	1-1/4	150	6	600	24

.5 Metric Duct Sizes:

- .1 The Metric duct sizes are expressed as 25 mm = 1 inch.

1.15 Drawings and Specifications

- .1 Drawings and specifications are complementary to each other, and what is called for by one shall be binding as if called for by both.
- .2 Should any discrepancy appear between drawings and specifications, which leaves the Contractor in doubt as to the true intent and meaning of the plans, and specifications, obtain written clarification from the Consultant during the tender period. Without a written clarification, the better quality and/or greater quantity of work or materials shall be estimated, performed and furnished within the tendered price.
- .3 Examine all contract documents, including all drawings and specifications, and work of other trades to ensure that work is satisfactorily carried out without changes to building.

1.16 Cutting, Patching and Coring

- .1 Provide holes and sleeves, cutting and fitting required for mechanical work. Relocate improperly located holes and sleeves.
- .2 Drill for expansion bolts, hanger rods, brackets, and supports.
- .3 Perform x-rays and obtain written approval from the Structural Consultant before cutting or burning structural members.
- .4 Provide openings and holes required in precast members for mechanical work. Cast holes 100 mm or larger in diameter. Field cut smaller than 100 mm.
- .5 Patch building where damaged from equipment installation, improperly located holes etc. Use matching materials as specified in the respective section.
- .6 Removal of any existing pipe, conduit, or ductwork within a slab core hole or slab opening through floors and roofs must be removed completely, including any associated sleeving, in a safe manner. Provisions are to be made during the removal process to protect any occupants and/or fabric of the space below. The Consultant is to be advised of all existing mechanical service penetration locations, such that site visits and field reviews can be fully co-ordinated and undertaken before and after the opening is closed in and filled.
- .7 Filling of any existing slab core or opening is to be with an engineered design of concrete fill complete with doweling for adhesion and/or fire stopping system as appropriate.

1.17 Excavation and Backfill

- .1 Refer to the requirements of Division 31.
- .2 Provide all excavating to facilitate installation of the mechanical work, including shoring, pumping, 150 mm compacted sand bedding under and first 300 mm of compacted sand over piping and ducting.

- .3 Refer to drawing details as applicable.

1.18 Installation of Equipment

- .1 Pipe all equipment drains to building drains except systems containing glycol.
- .2 Unions and flanges shall be provided in piping or ductwork to permit easy removal of equipment.
- .3 Maintain permanent access to equipment for maintenance.

1.19 Connections to Existing Services

- .1 Maintain liaison with the Owner and provide a mutually acceptable schedule to interrupt, reroute or connect to existing building services with the minimum of interruption of those services.
- .2 Major services shall not be interrupted before all preparatory work is completed and all required materials are on site. Provide a minimum of 48 hours' notice for all service shutdowns. Allow for major service interruptions outside of normal operating hours of the facility.
- .3 Interruptions and shutdowns of existing services shall be by the building/plant maintenance staff. Advise building/plant maintenance staff of the duration of service interruption or shut down.
- .4 The local Fire Department shall be advised of any shut down or disruption of the fire suppression systems.

1.20 Selective Demolition

- .1 Reference Standards
 - .1 Unless otherwise specified, carry out demolition work in accordance to CSA S350-M1980 Code of Practice for Safety in Demolition of Structures.
- .2 Remove from site all equipment, ducting or piping which is no longer required because of work under this Contract.
- .3 Existing Conditions
 - .1 Visit and examine the site and note all characteristics and irregularities affecting the work of this Section.
- .4 Protection
 - .1 Prevent movement or settlement of adjacent work. Provide and place bracing or shoring and be responsible for safety of such work. Be liable for any such movement or settlement and any damage or injury caused.
 - .2 Cease operations and notify the Prime Consultant immediately for special protective and disposal instructions when any asbestos materials are uncovered during the work in this Section.
 - .3 Prevent debris from blocking surface drainage inlets and all types of drainage piping systems which remain in operation
- .5 Salvageable Materials
 - .1 Except as otherwise stated, salvageable materials from area of demolition shall become the property of the Owner at his discretion. All material not taken over by the Owner or removed from the building under this contract shall be removed from this site and disposed of as required by any applicable disposal regulations.
 - .2 Turnover to and deliver to the Owner's storage area all items which have been determined to have salvage value and has been removed due to the Work.

1.21 Equipment and Materials

- .1 Materials and equipment installed shall be new, CSA approved and of quality specified.
- .2 Each major component of equipment shall bear manufacturer's name, address, catalog and serial number in a conspicuous place.
- .3 Where two or more products of the same type are required, products shall be of the same manufacturer.
- .4 Notify the Consultant in writing ten (10) days prior to the tender close, any materials or equipment specified which is not currently available or will not be available for use as called for herein. Failing this, the contract will assume that the most expensive alternate has been included in the tender price.
- .5 All equipment supplied to the project will meet efficiencies as defined in ASHRAE Standard 90.1 and NECB (current versions)

1.22 Cleaning

- .1 During construction, keep site reasonably clear of rubbish and waste material resulting from work on a daily basis to the satisfaction of Owner and Consultant. Before applying for a Certificate of Substantial Performance of the Work, remove rubbish and debris, and be responsible for repair of any damage caused as a result of work.
- .2 Clean equipment and devices installed as part of this project

1.23 Delivery, Storage and Handling

- .1 Deliver, store and handle materials in accordance with Division 01 - Common Product Requirements, the manufacturer's written instructions and the following:
- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials and equipment in accordance with the manufacturer's recommendations in a clean, dry, well-ventilated area.
 - .2 Store and protect equipment from nicks, scratches, and blemishes.
 - .3 Replace defective or damaged materials with new.
- .4 Protect equipment and materials in storage on site during and after installation until final acceptance. Leave factory covers in place. Take special precautions to prevent entry of foreign material into working parts of piping, equipment and duct systems.
- .5 Protect equipment and open-end duct with polyethylene covers and maintain equipment on crates until installation.
- .6 Operate, drain and flush out unsealed bearings and refill with fresh oil before final acceptance.
- .7 Thoroughly clean piping, ducts and equipment of dirt, cuttings and other foreign substances.
- .8 Protect bearings and shafts during installation. Grease shafts and sheaves to prevent corrosion. Supply and install necessary extended nipples for lubrication purposes.
- .9 Ensure that existing equipment is carefully dismantled and not damaged or lost. Do not reuse existing materials and equipment unless specifically indicated.
- .10 Develop a Construction Waste Management Plan or Waste Reduction Work plan as related to Work of this Section in accordance with Division 01 - Waste Management and Disposal or local requirements.

1.24 Fire Stopping and Smoke Seals

- .1 Provide fire stopping and smoke seals in accordance with Section 22 07 11.

1.25 Access Doors

- .1 General
 - .1 Provide access doors for maintenance or adjustment of all parts of the mechanical system. This shall apply but not be limited to valves, dampers, cleanouts and controls.
 - .2 Where equipment is concealed by a T-bar ceiling, the location of equipment shall be indicated by coloured markings. Refer to Section 23 05 53 Identification for Mechanical Piping and Equipment.
 - .3 Where equipment is concealed by a continuous structural or architectural surface, supply access doors of design to suit and match the surface in which they will be installed.
 - .4 Provide stainless steel doors in walls of washrooms, kitchen, janitor rooms and laundry rooms.
 - .5 Provide Drywall type access doors in all public drywall spaces requiring access to equipment.
 - .6 All fasteners on access panels shall be tamper proof, contractor shall provide three (3) sets of keys.
 - .7 Locate all access doors outside of secure areas where possible. Where not possible, review the locations of panels with the Owner's Consultant prior to installation. All access panels within secure areas are to be of penal quality, lockable, vandal-proof and ligature resistant.
 - .8 Provide 300 mm x 300 mm minimum size for inspection and hand access.
 - .9 600 mm x 600 mm minimum size, larger if indicated on drawings, where entry is required and access is difficult.
 - .10 Size to suit masonry modules when located in a masonry wall.
 - .11 When located in a finished floor with tile, stonework, terrazzo, etc., a recessed bearing type access door is required. The door surface shall have a recess to take the particular surface material and pattern if this is available at the time the units are ordered.
 - .12 Security Access Doors:
 - .1 Access doors for security areas shall be 1.70 mm [14 gauge] thick double skinned internally reinforced at 150 mm [6"] on centre, 4.76 mm [3/16"] thick, insulated in pressed sink wiped cold rolled steel metal frame (similar to door frame) complete with necessary preparation to receive security lock escutcheon and hinges.
- .2 Submittals:
 - .1 Submit shop drawings for all access doors anticipated on this project.

1.26 Single Point Electrical Connection

- .1 If the equipment is indicated on the schedules or within the motor list (both included in the mechanical drawings) as a single point connection, the equipment shall be provided with all integral HOA type starters, internal wiring to all motors, starters, lighting, service outlets etc. such that a single electrical connection can be utilized to power all components within the unit. The unit shall also incorporate the required step-down transformers and wiring to connect all of these internal components including controls wiring. Coordinate with the controls subcontractor for the supply, installation, and wiring of control components.

1.27 Electrical Motors

- .1 Supply mechanical equipment complete with electrical motors.
- .2 Quality Assurance
 - .1 Provide motors designed, manufactured, and tested in accordance with the latest edition of the following codes and standards: NEMA, EEMAC, CSA, CEC Part 1, IEEE and ANSI. All motors to be UL listed and CSA labelled.
 - .2 All motors to be approved for use in the designated area classification by the Provincial Electrical Protection Branch.
 - .3 All motors intended for use with a [variable speed drive] [variable frequency drive] (VFD) shall be inverter duty rated.
 - .4 Motors connected to VFD(s) shall be wound using inverter spike resistant magnet wire capable of 1600V.
 - .5 The noise level of each motor shall comply with NEMA standards, less than 80 dBA at 1 meter.
 - .6 Minimum certified motor efficiency shall be as outlined in current version of ASHRAE 90.1 and NECB.
- .3 Unless specified otherwise, provide motors designed for full voltage starting, EEMAC Design B. Motors driving high torque or high inertia loads may be EEMAC Design C or D.
- .4 Provide motors rated for continuous duty with 1.15 service factor unless specified otherwise in the driven equipment specifications. Provide all motors with thermal overload protection.
- .5 Motors less than 3/4-hp shall be 120 V, 60 Hz, 1 phase. Motors 3/4-hp and larger shall be 3 phase at the indicated voltage.
- .6 All motors shall be 1800 rpm unless otherwise noted.
- .7 Provide motors complete with equipment except where indicated.
- .8 Provide motors with grease or oil lubricated anti-friction type ball or roller bearings.
- .9 Provide motors designed with Class B insulation, Class F insulation for totally enclosed motors.
- .10 Motors exposed to outdoor temperature to be lubricated with lubricants suitable for operation at 6 deg. C. below the lowest temperature recorded by ASHRAE or the Climatic Information (Supplement to the National Building Code), for the location in which they are installed.
- .11 All motors 10 hp and larger that are controlled by a VFD are to use a dielectric grease bearings and a grounding kit with a system of brass or stainless steel brushings.
- .12 Refer to electrical specifications for voltage, frequency, and phase data. This shall take precedence over any reference in Divisions 21, 22, 23 and 25.
- .13 Where motor power is stated in watts or kilowatts, nominal motor horsepower multiplied by 746 or 0.746 respectively, has been used as the conversion factor.

- .14 All motors used with fire pumps shall be listed for fire pump service.
- .15 Submittals
 - .1 Submit data of test method used and motor efficiencies with shop drawings.

1.28 Motor Starters and Accessories

- .1 Motor starters must be capable of starting associated motors under the imposed loads. Confirm starter voltage matches motor prior to ordering.
- .2 Unless otherwise specified, starters for 1-phase motors are to be 115 volt; thermal overload protected manual starting switches with a neon pilot light, a surface or recessed enclosure to suit the application, and, where automatic operation is required, a separate H-O-A switch in an enclosure to match starter enclosure.
- .3 Unless otherwise specified, starters for 3-phase motors less than 50 HP are to be combination "quick-make" and "quick-break" fused disconnects and full voltage non-reversing across-the-line starters, each complete with and overload relay per phase, an enclosure to suit the application, and, a H-O-A switch, pilot lights, control transformer, auxiliary contacts, and other accessories as per motor starter schedule.
- .4 Unless otherwise specified, starters for 3-phase motors 50 HP to 150 HP are to be reduced voltage, non-reversing, auto-transformer type starters complete with one overload relay per phase, an enclosure to suit the application, and, a H-O-A switch, pilot lights, control transformer, auxiliary contacts, and other accessories as per motor starter schedule.
- .5 Unless otherwise specified, starters for 3-phase motors 150 HP and larger are to be reduced voltage, non-reversing, closed transition "wye-delta" starters complete with one overload relay per phase, an enclosure to suit the application, and, a H-O-A switch, pilot lights, control transformer, auxiliary contacts, and other accessories as per motor starter schedule.
- .6 Starters for 2-speed double winding motors are to be generally as specified above but suitable for motor and equipped with a 45 second time delay to permit equipment to coast down to low speed before it is operated at low speed.
- .7 Starters for 2-speed single winding motors are to be generally as specified above but suitable for motor and equipped with a 45 second time delay to permit equipment to coast down to low speed before it is operated at low speed.
- .8 Starters for reversible motors for cooling towers are to be generally as specified above but suitable for motor and equipped with a 45 second time delay to allow fan(s) to coast down to a stop before being operated in reverse rotation.
- .9 Unless otherwise specified, motor starter enclosures are to be in accordance with following NEMA ratings:
 - .1 Enclosures located in sprinklered areas – Type 2;
 - .2 Enclosures exposed to the elements – Type 3R, constructed of stainless steel;
 - .3 Enclosures inside the building in wet areas – Type 3R, constructed of stainless steel;
 - .4 Enclosures in explosion rated area – Type 7 with exact requirements to suit the area and application;
 - .5 Enclosures except as noted above – Type 1;
 - .6 Enclosures located in finished areas – as above but recess type with brushed stainless steel faceplate.

- .10 Motor control centres are to be multi-unit, 2.28 m (9') high, NEMA Class 1, type "B", factory assembled, dead front, floor mounted, freestanding motor control centre with tin plated copper bus and an NEMA Type 1 or Type 2 enclosure as for loose starters specified above. Each motor control centre is to be complete with starters as specified above, load and control wiring terminal boards, and required facilities for line and load side power wiring connections.
- .11 Disconnect switches for motor control centres are to be heavy-duty, CSA certified, front operated switches as per motor starter schedule, each complete with a handle suitable for padlocking in "off" position and arranged so that door cannot be opened with handle in "on" position and an NEMA enclosure as specified for loose starters. Fusible units are to be complete with fuse clips to suit fuse types specified below.
- .12 Fuses are to be, unless otherwise scheduled or specified, English Electric Ltd. HRC fuses, Form I Class "J" for constant running equipment and Form II Class "C" for equipment that cycles on and off

1.29 Miscellaneous Metals

- .1 Provide all necessary miscellaneous to hang or support materials, equipment and provide access for work under this contract.
- .2 All miscellaneous metals shall be prime painted.
- .3 Miscellaneous metals shall include but not limited to:
 - .1 Hangers for equipment, piping and ductwork.
 - .2 Support for equipment.
 - .3 Access platforms and catwalks.

1.30 Scaffolding, Hoisting and Rigging

- .1 Unless otherwise specified or directed, supply, erect and operate scaffolding, rigging, hoisting equipment and associated hardware required for work, and subject to approval from Owner.
- .2 Immediately remove from site scaffolding, rigging and hoisting equipment when no longer required.
- .3 Do not place major scaffolding/hoisting equipment loads on any portion of structure without approval from Owner.

1.31 Pipe Sleeves

- .1 Pipe sleeves shall be provided for piping passing through walls and floors. Minimum schedule 40 steel pipes or factory fabricated, flanged, high-density polyethylene sleeves with reinforced nail bosses. Sleeves shall extend 25 mm on either side of the wall.
- .2 Schedule 40 steel pipes shall be used as floor pipe sleeves in wet areas with a 50 mm up-stand.
- .3 Review and coordinate sleeve diameters with fire stop installation details as applicable.

1.32 Water Proofing Materials

- .1 Modular, mechanical seal assemblies consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and pipe sleeve or wall opening, assembled with stainless steel bolts and pressure plates and designed so when bolts are tightened the links expand to seal the opening watertight. Select seal assemblies to suit pipe size and sleeve size or wall opening size.
- .2 Acceptable products are:

- .1 Thunderline Corp. (Power Plant Supply Co.) "LINK SEAL" Model S-316;
- .2 The Metraflex Co. "MetraSeal" type ES

1.33 Escutcheons and Plates

- .1 Provide escutcheons and plates on all piping and ductwork passing through finished walls, floors and ceilings.
- .2 Escutcheons shall be one piece, stainless or chrome plated steel.

1.34 Temporary Heat

- .1 Do not use the permanent system for temporary heating purposes without written permission from the Consultant.
- .2 If approved, permanent mechanical systems in building may be used for temporary heating during construction subject the following conditions:
 - .1 Each entire system is complete, pressure tested, cleaned, and flushed out.
 - .2 Specified water treatment system has been commissioned, and treatment is being continuously monitored.
 - .3 Thoroughly clean and overhaul permanent equipment used during the construction period, replace worn or damaged worn or damaged parts before final inspection.
 - .4 Use of permanent systems for temporary heat shall not modify terms of warranty.
 - .5 Operate heating systems under conditions, which ensure no temporary or permanent damage. Operate with proper safety devices and controls installed and fully operational. Operate systems only with treated water as specified.
 - .6 Air systems shall not be used for temporary heating.
 - .7 When permanent systems are used for temporary heat, provide alarm indicating system failure. Connect alarm to independent alarm company system.
 - .8 Where pumps are used for temporary heating, replace mechanical seals, regardless of condition, with new mechanical seals.
 - .9 Energy costs are to be paid by Contractor.
 - .10 During this period of construction, such systems/equipment to not become property of Owner or be Owner's responsibility for maintenance or service. Systems/equipment are to remain property of respective manufacturers/suppliers or Contractor, who are responsible for full maintenance and servicing of systems/equipment in order to maintain validity of warranties after turn over to Owner.
 - .11 Prior to application for a Certificate of Substantial Performance of the Work and turn over to Owner, such systems/equipment to be cleaned, restored to "new" condition, paint finishes "touched-up", filters cleaned or replaced, etc.

1.35 Progress Claim Breakdown

- .1 Prior to submittal of first progress payment draw, submit a detailed breakdown of work cost to assist Consultant in reviewing and approving progress payment claims.
- .2 Payment breakdown is subject to Owner's approval and Consultant's review. Progress payments will not be processed until an approved breakdown is in place. Breakdown is to include one-time claim items such as mobilization and demobilization, insurance, bonds (if applicable), shop drawings and product data sheets, commissioning including testing, adjusting and balancing, system testing and verification, and project closeout submittals.

- .3 Indicate equipment, material and labour costs for site services (if applicable) and indicate work of each trade in same manner as indicated on progress draw.
- .4 Progress claims will not be certified nor payment made beyond 95% on the overall Mechanical contract and beyond 70% on the Control systems contract, until commissioning and verification of the systems are complete. (The 70% limit on Controls is included in the overall fig.). This procedure is to allow for any necessary deficiency holdbacks on items, which do not become apparent until the systems are commissioned.

1.36 Notice for Required Field Reviews

- .1 Whenever there is a requirement for Consultant to perform a field review prior to concealment of any work, to inspect/re-inspect work for deficiencies prior to Substantial Performance of the Work, for commissioning demonstrations, and any other such field review, give minimum 5 working days' notice in writing to Consultant.
- .2 If Consultant is unable to attend a field review when requested, arrange an alternative date and time.
- .3 Do not conceal work until Consultant advises that it may be concealed.
- .4 When Consultant is requested to perform a field review and work is not ready to be reviewed, reimburse Consultant for time and travel expenses

1.37 Changes in the Work

- .1 Whenever Consultant proposes in writing to make a change or revision to design, arrangement, quantity or type of work from that required by Contract Documents, prepare and submit to Consultant for review, a quotation being proposed cost for executing change or revision.
- .2 Quotation is to be a detailed and itemized estimate of product, labour, and equipment costs associated with change or revision, plus overhead and profit percentages and applicable taxes and duties.
- .3 Make requests for changes or revisions to work to Consultant in writing and, if Consultant agrees, will issue Notice of Change.
- .4 Do not execute any change or revision until written authorization for the change or revision has been obtained from Consultant.

1.38 Temporary or Trial Usage

- .1 Temporary or trial usage by the Owner or Consultant of mechanical equipment supplied under contract shall not represent acceptance.
- .2 Repair or replace permanent equipment used temporarily.
- .3 Repair or otherwise rectify damage caused by defective materials or workmanship during temporary or trial usage.
- .4 Avoid thermal shock to heating system by coordination with the Owner during planning, construction and operation of temporary heating system.

1.39 Instruction to Owner

- .1 Refer to equipment and system operational and maintenance training requirements specified in Division 01.
- .2 Train Owner's designated personnel in aspects of operation and maintenance of equipment and systems as specified. Demonstrations and training are to be performed by qualified technicians employed by equipment/system manufacturer/supplier. Supply hard copies of training materials to each attendee.

- .3 Unless where specified otherwise in trade Sections, minimum requirements are for manufacturer/suppliers of each system and major equipment, to provide minimum two separate sessions each consisting of minimum 4 hours on site or in factory training (at Owner's choice), of Owner's designated personnel, on operation and maintenance procedures of system.
- .4 For each item of equipment and for each system for which training is specified, prepare training modules as specified below. Use Operating and Maintenance Manuals during training sessions. Training modules include but are not limited to:
 - .1 Operational Requirements and Criteria – equipment function, stopping and starting, safeties, operating standards, operating characteristics, performance curves, and limitations;
 - .2 Troubleshooting – diagnostic instructions, test and inspection procedures;
 - .3 Documentation – equipment/system warranties, and manufacturer's/supplier's parts and service facilities, telephone numbers, email addresses, and the like;
 - .4 Maintenance – inspection instructions, types of cleaning agents to be used as well as cleaning methods, preventive maintenance procedures, and use of any special tools;
 - .5 Repairs – diagnostic instructions, disassembly, component removal and repair instructions, instructions for identifying parts and components, and review of any spare parts inventory.
- .5 Before instructing Owner's designated personnel, submit to Consultant for review preliminary copy of training manual and proposed schedule of demonstration and training dates and times. Incorporate Consultant's comments in final copy.
- .6 Obtain in writing from Owner a list of Owner's representatives to receive instructions. Submit to Consultant prior to application for Certificate of Substantial Performance of the Work, complete list of systems for which instructions were given, stating for each system:
 - .1 Date instructions were given to Owner's staff;
 - .2 Duration of instruction;
 - .3 Names of persons instructed;
 - .4 Other parties present (manufacturer's representative, consultants, etc.).
- .7 Obtain signatures of Owner's staff to verify they properly understood system installation, operation and maintenance requirements, and have received operating and maintenance instruction manuals and "as-built" record drawings

1.40 Guarantee / Warranty

- .1 Furnish a written guarantee stating that all work executed in this contract will be free from defective workmanship and materials for a period of one (1) year from the date of Substantial Performance. The Contractor shall, at his own expense, repair and replace any work, which fails or becomes defective during the term of the guarantee/warranty, providing such work is not due to improper usage. The period of guarantee specified shall not in any way supplant any other guarantees of a longer period but shall be binding on work not otherwise covered.
- .2 Use of permanent systems for temporary heat shall not modify terms of the manufacturers' warranty or the guarantee.
- .3 If the equipment is used during construction, the warranty or guarantee period shall not be shortened or altered.

1.41 Substantial and Total Performance

- .1 Prior to requesting an inspection for Substantial Performance, provide a complete list of items, which are deficient.
- .2 A certificate of Substantial Performance will not be granted unless the following items are completed and available to the Owner's Consultant:
 - .1 Final Gas Inspection Certificate from the Authority having Jurisdiction.
 - .2 Schedule S-C for seismic engineering.
 - .3 Commissioning checklists are completed and submitted as per Division 01.
 - .4 Fire stopping test letter
 - .5 Vibration isolation supplier's inspection report
 - .6 Systems have been chemically cleaned. Flushed and water treatment initiated. Provide report from manufacturer's representative to confirm status of treatment and final inspection.
 - .7 Major equipment – suppliers start-up test sheets and letters certifying start up. (Boilers, chillers, packaged equipment)
 - .8 Draft Operating/Maintenance Manuals have been submitted for review.
 - .9 All mechanical systems have been commissioned and are capable of operation with alarm controls functional and automatic controls in operation.
 - .10 Air and water systems have been balanced with draft report submitted to the Consultant.
 - .11 Mechanical identification is complete.
 - .12 Warranty forms have been mailed to the manufacturer. Provide copy of the original warranty for equipment, which has a warranty period longer than one year.
 - .13 Operating and Maintenance demonstrations have been provided to the Owner.
 - .14 Written inspection report by manufacturer's representative has been submitted for noise and vibration control devices and flexible connections.
 - .15 Record drawings have been submitted.
 - .16 Fan plenums have been cleaned, and temporary filters have been replaced with permanent filters.
 - .17 All previously identified deficiencies have been corrected and accepted.
 - .18 Heat trace megger test reports for each circuit, submitted on manufacturer's letterhead.
- .3 Prior to a Total Performance Inspection, provide declaration in writing that deficiencies noted at time of substantial performance inspection have been corrected and the following items completed prior to the total performance inspection:
 - .1 Submit final air and water balance reports.
 - .2 Submit final operating and maintenance manuals.
 - .3 Complete final calibration.
- .4 The Consultant shall provide one (1) visitation for the purpose of total performance inspection. Subsequent visitations if required shall be at the expense of the Contractor.
- .5 The Contractor shall provide qualified personnel in appropriate numbers to operate the facility until substantial performance is declared.

1.42 Alternate Materials and Equipment

- .1 The price submitted for this contract shall be based on the use of materials and equipment as specified or as contained within the Acceptable Manufacturers List.
- .2 Requests for alternate equivalent materials or equipment must be submitted to the Consultant no later than seven (7) working days prior to the Mechanical trades' closing tender date. Submit all applicable technical data, including performance curves and physical details for review. Approval of requests shall only be given by addendum.
- .3 Approved equivalents and/or alternatives to specified products shall be equal to the specified product in every respect, operate as intended, and meet the space, capacity, and noise requirements outlined.
- .4 The Contractor shall be fully responsible for any additional labour and materials required by any trades or other Contractors to accommodate the use of other than specified materials or equipment. The Contractor shall bear any and all costs for design/system modifications to accommodate the "alternate" equipment. Extras will not be approved to cover such work.

2. PRODUCTS

2.1 Acceptable Manufacturers

- .1 Refer to Section 23 05 01 Acceptable Manufacturers.

2.2 Existing Services

- .1 Disconnect and cap all mechanical services in accordance with requirements of the authority having jurisdiction. Natural gas supply lines shall be removed by the local gas company or by a qualified tradesman in accordance with gas company instructions.
- .2 Building Mechanical Services: Maintain activity of all building services during demolition/removal of existing services required of this contract.
- .3 Maintain all trap seals and cap open-end pipe to ensure no sewer gas enters the building during renovations or demolition work. Maintain all existing sewer piping in a wet condition daily.

2.3 Demolition

- .1 Completely demolish the items scheduled and remove all materials from the premises unless otherwise requested by the Owner.
- .2 Carry out demolition in a manner to cause as little inconvenience to the occupied building area as building area as possible. Co-ordinate this activity with the Owner and/or the Consultant.
- .3 Carry out demolition in an orderly and careful manner.
- .4 All coring, patching and removal of existing equipment, pipes, and ductwork, which may affect the operation of occupied areas of the building, shall be carried out outside of regular office hours or as scheduled with the Owner.

2.4 Asbestos

- .1 The intent is for a Haz-Mat Contractor to remove all asbestos containing material prior to the proposed project work taking place. Notify the Consultant if asbestos containing material is suspected to remain on site.
- .2 When new work is required to be connected to existing plumbing, piping, ductwork or equipment, which contains asbestos insulation or products the following, shall apply:
 - .1 Keep disruption to existing piping and equipment to a minimum

- .2 Protect the site and all Contractors from the work
- .3 Remove the asbestos at piping and equipment for new connections and carry out work in accordance with Work Safe BC requirements for asbestos removal.

2.5 Core Drilling

- .1 Clearly identify all proposed piping penetrations through existing slabs, walls etc. and advise the General Contractor. Obtain x-rays of the locations to ensure penetration will avoid any existing post tension cables or reinforced steel. Advise the Structural Consultant of any conflicts as a result of the x-rays and obtain the Structural Consultant approval before any coring take place.

2.6 Fire Stopping and Smoke Seals

- .1 Provide fire-stopping materials as per Section 22 07 11 Fire Stopping.

2.7 Access Doors

- .1 Drywall Surface: Extruded aluminum frame with gypsum board inlay and structural corner elements. Hinge to be concealed 2-point hinge, non-corroding with screwdriver operated cam latch.
- .2 Masonry Surface: Universal design, steel door (16ga) and steel frame (18ga), door flush to frame, rounded safety corners, continuous concealed hinge, screwdriver operated cam latch, prime coat grey painted finish.
- .3 Tile Surface: Universal design, stainless steel door (16ga) and stainless steel frame (18ga), door flush to frame, rounded safety corners, continuous concealed hinge, screwdriver operated cam latch, #4 satin stainless steel finish.
- .4 Plaster Walls and Ceiling: steel door (14ga) and steel frame (14ga), door flush to frame edge, expansion casing bead and 75 mm wide galvanized lath surround recessed 18 mm to receive plaster, continuous concealed hinge, screwdriver operated cam latch, prime coat grey painted finish.
- .5 Acoustic Plaster: Steel door (16ga) and steel frame (14ga), door recessed 12 mm lined with self-furring lath, 75 mm wide galvanized lath surround recessed 18 mm to receive plaster flush to frame edge, concealed pivoting rod type hinge, screwdriver operated cam latch, prime coat grey painted finish.
- .6 Acoustical Tile Ceilings: Steel door (16ga) and steel frame (14ga), door recessed 25 mm to receive acoustic tile, concealed pivoting rod type hinge, screwdriver operated cam latch, prime coat grey painted finish.
- .7 Fire Rated Walls:
 - .1 Non-combustible construction: Uninsulated steel door (16ga) and steel frame (16ga), door flush to frame edge, 25mm mounting frame with masonry anchor straps, concealed self-closing hinge, flush key latch, prime coat grey painted finish, ULC rated 2 hour 'B' label.
 - .2 Combustible construction: Insulated steel door (20ga) for maximum 250°C rise after 30 minutes and steel frame (16ga), door flush to frame edge, 25mm mounting frame with masonry anchor straps, concealed self-closing hinge, flush key latch, prime coat grey painted finish, ULC rated 1-1/2 hour 'B' label.
- .8 Fire Rated Ceilings: 50mm Insulated steel door (16ga) and steel frame (16ga), door flush to frame edge, 25mm mounting frame with masonry anchor straps, concealed upswing self-closing hinge, L handle latch, white baked enamel finish, size 600mm x 600mm (24" x 24") ULC rated 2 hour 'B' label.

- .9 Ductwork: Ultra low leakage type, flat oval design, galvanized steel frame (22ga), double skin galvanized steel door (22 ga) with 25mm insulation fully enclosed in panel, bulb type seal integrally fastened to door, lever cam locks. Provide stainless steel in lieu of galvanized steel in stainless steel ductwork.

2.8 Electrical Motors

- .1 All Motors, 1 H.P. motors and larger, shall be energy efficient design and have a minimum and nominal full load efficiency, which will meet or exceed the values listed in accordance CAN/CSA C390-1. The minimum efficiency shall be guaranteed.
- .2 Belt Drives: Provide belt drives to the following requirements:
 - .1 Provide steel, cast iron or aluminum sheaves for motors less than 3/4 H.P.
 - .2 Provide steel or cast iron sheaves keyed to shafts, for motors 3/4 H.P. and larger.
 - .3 For motors less than 10 H.P. provide standard adjustable pitch drive sheaves having +/-10% range. Use mid-position of range for specified RPM.
 - .4 For motors 10 H.P. and larger, provide fixed pitch drive sheaves with split tapered bushing and keyway. Provide final drive sheaves of size to suit final balancing.
 - .5 Match drive and driven sheaves.
 - .6 V-belts shall conform to the American Belt Manufacturers standards. Multiple belts shall be matched sets.
 - .7 Not less than a 2-belt configuration is required for each drive for motors 3/4 H.P. and larger.
 - .8 Poly Chain GT belt drives shall be used on all motors 10HP and larger.
 - .9 Minimum drive rating shall be 150% of nameplate rating of motor. Keep overhung loads within manufacturer's design requirements on prime mover shafts.
 - .10 Motor slide rail adjustment baseplate with double draw bolt, shall allow for centre line adjustment.
 - .11 Tension belts to manufacturers recommendations before start up and after 100 hours of operation using calibrated belt tensioning gauge.
 - .12 Provide one spare set of belts for each piece of equipment with each belt separately identified for the equipment item to be served.
- .3 Shaft Couplings: Shaft couplings shall be of the pin or jaw neoprene insert type, gear type, or flexing steel insert type and shall allow coupling inserts to be easily removed without disassembly of the equipment.
- .4 Guards:
 - .1 Provide removable protective guards on all exposed V-belt drives and shaft couplings in accordance with Worker's Compensation Board requirements.
 - .2 Guards for drives shall have:
 - .1 1 mm [18ga.] expanded metal screen welded to 25 mm [1"] steel angle frame.
 - .2 1.5 mm [16ga.] thick galvanized sheet metal tops and bottoms.
 - .3 Removable side[s] for servicing.
 - .4 38 mm [1-1/2"] dia. holes on both shaft centres for insertion of tachometer.
 - .5 Sectionalize if necessary so one man can handle removal.
 - .3 Provide means to permit lubrication and use of test instruments with guards in place.

- .4 Fabricate and install belt guards for V-belt drives to permit movement of motors for adjusting belt tension and for belt slap.
- .5 Provide removable "U" shaped guards for flexible couplings with 2.5 mm [12ga.] thick galvanized frame and 1.2 mm [18ga.] thick expanded mesh face.
- .6 Provide guards on all unprotected fan inlets and outlets. Guards to be provided by fan manufacturer.
- .7 Prime coat guards and finish paint to match equipment.
- .8 Secure guards to equipment allowing for ease of removal.

3. EXECUTION

3.1 Painting Repairs and Restoration

- .1 Do painting in accordance with base building standard.
- .2 Prime and touch up marred finished paintwork to match original.
- .3 Restore to new condition, finishes which have been damaged.
- .4 Clean exposed bare metal surfaces supplied under Divisions 21, 22, 23 and 25. Apply at least one coat of corrosion resistant primer paint to all supports and equipment fabricated from ferrous metal.
- .5 Paint all pipe hangers and exposed sleeves, in exposed areas, with a rust inhibiting primer.

3.2 System Cleaning

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

3.3 Field Quality Control

- .1 Manufacturer's Field Services:
 - .1 Obtain written reports from manufacturers' verifying compliance of the work, in handling, installing, applying, protecting, cleaning and start-up of a product.
 - .2 Submit Manufacturer's Field Reports as described in PART 1 - Submittals.
 - .3 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.

3.4 Demonstration

- .1 Consultant and/or Owners representative may use equipment and systems for test purposes prior to acceptance. Supply labour, material, and instruments required for testing.
- .2 Supply tools, equipment and personnel to demonstrate and instruct the operating and maintenance personnel in operating, controlling, adjusting, trouble-shooting and servicing of all systems and equipment during regular work hours, prior to acceptance.
- .3 Where specified elsewhere in Division 21, 22, 23 or 25 manufacturers to provide demonstrations and instructions.
- .4 Use operation and maintenance manual, record drawings, and audio visual aids as part of instruction materials.
- .5 Instruction duration requirements shall be as specified in the appropriate sections.
- .6 Contractor will record these demonstrations on digital video for future reference.

3.5 Fire Stopping and Smoke Seals

- .1 Refer to Section 22 07 11.

3.6 Access Doors

- .1 Installation:
 - .1 Provide all access doors required to access work installed by Divisions 21, 22, 23 and 25. Be responsible for coordinating locations, cutting opening and installing panels. Any secondary supports, blocking etc. will be by the ceiling or wall contractor.
 - .2 Access doors in mechanical equipment to be provided by this Division.
 - .3 Access panel requirements and locations shall be fully coordinated with all involved contractors prior to the installation of any mechanical systems or equipment.
- .2 Location:
 - .1 Ensure that equipment is within view and accessible for operating, inspecting, adjusting, servicing without using special tools.
- .3 Provide 3 sets of each type of access door key to the Owner at substantial completion. Obtain a signed receipt indicating date, quantity of keys and person receiving keys. Submit receipt to the Owner's Consultant.

3.7 Electrical Motors

- .1 Manufacturer's instructions:
 - .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.
- .2 Installation:
 - .1 Unless otherwise noted starters and protection devices will be included under Division 26 - Electrical.
 - .2 Co-ordinate with Division 26 Contractor to ensure proper connection, correct thermal overload protection and correct motor controls.
 - .3 Where starters are included in this Division as an integral part of packaged equipment, they shall contain thermal overload protection in all ungrounded lines.
 - .4 Equipment, which has more than one voltage rating, shall be fed from a single power source through a disconnect switch.
 - .5 Fasten securely in place.
 - .6 Make removable for servicing, easily returned into, and positively in position.
- .3 Setting and Alignment:
 - .1 Employ a journeyman millwright to align all V-belt drives and/or shaft coupling drives. The millwright shall check that centrifugal fan wheels are properly centred on fan shafts.
 - .2 Align shaft couplings, using a dial indicator, to within +/-0.051 mm [0.002"] after grouting is complete and the piping system is operational.
 - .3 Align V-belt drives using a straight edge.
 - .4 Submit a certificate from the millwright employed, certifying that all shaft couplings and V-belt drives have been aligned and centrifugal fan wheels centred prior to initial start-up and checked again after final system balance adjustment.

3.8 Protection

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

END OF SECTION

1. GENERAL

1.1 Summary

- .1 Section Includes:
 - .1 Fire stopping of mechanical services penetrating fire separations.
- .2 Related Sections:
 - .1 This section of the Specification forms part of the Contract Documents and shall be read, interpreted and coordinated with all other parts of the Contract Documents.

1.2 Intent

- .1 This Section includes through penetration fire stopping and smoke seal systems for penetrations through the following fire resistance rated assemblies, including both empty openings and openings containing penetrating items:
 - .1 Floors
 - .2 Walls and partitions
 - .3 Smoke barriers
 - .4 Construction enclosing compartmentalized areas
- .2 The specification section provides requirements for Rated Systems or systems requiring Engineered Judgements:
 - .1 Use of materials that have not been tested in a system or that are not capable of obtaining an engineered judgement will not be acceptable for use on the Project.
 - .2 Materials having only a ULC label will not be acceptable for use on the Project, unless supporting documentation is provided indicating its use in a listed assembly.

1.3 Scope:

- .1 Provide fire stopping for all mechanical work in Divisions 21, 22, 23 and 25.
- .2 For renovation, projects, in addition to the necessary new penetrations, provide the fire stopping for all existing mechanical assemblies where fire stopping is damaged, discontinued or absent.

1.4 References

- .1 Applicable Building Code - Refer to Section 21 05 01.
- .2 Applicable Fire Code - Refer to Section 21 05 01.
- .3 ASTM E84-18a – Standard Test Method for Surface Burning Characteristics of Building Materials.
- .4 ASTM E119-18a – Standard Test Methods for Fire Tests of Building Construction and Materials.
- .5 ASTM E814-13a (2017) – Standard Test Method for Fire Tests of Penetration Firestop Systems.
- .6 ASTM E1966-15 – Standard Test Method for Fire-Resistive Joint Systems.
- .7 ASTM E 2174 – 18, “Standard Practice for On-Site Inspection of Installed Firestops
- .8 CAN/ULC-S101-14 - Fire Endurance Tests of Building Construction and Materials.

- .9 CAN/ULC-S102-10 – Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.
- .10 CAN/ULC-S115-11 (R2016) – Standard Method of Fire Tests of Firestop Systems.
- .11 International Firestop Council Guidelines for Evaluating Firestop Systems Engineering Judgments.
- .12 NFPA 101-2012 – Life Safety Code.
- .13 NFPA 251 – Standard Methods of Tests of Fire Resistance of Building Construction and Materials.
- .14 UL 263 – Standard for Fire Tests of Building Construction and Materials (ASTM E119, NFPA 251).
- .15 UL 1709 – Standard for Rapid Rise Fire Tests of Protection Materials for Structural Steel.
- .16 UL 1479 – Standard for Fire Tests of Penetration Firestops. (ASTM E814).
- .17 UL 2079 – Standard for Tests for Fire Resistance of Building Joint Systems.
- .18 ULC (Underwriters Laboratories of Canada) - List of Equipment and Materials for:
 - .1 Building Materials.
 - .2 Fire Resistance.
 - .3 Firestop Systems and Components.
- .19 Underwriters Laboratories of Canada (ULC) of Scarborough runs CAN4-S115-M under their designation of ULC-S115-M and publishes the results in their "FIRE RESISTANCE RATINGS DIRECTORY" that is updated annually.
- .20 Underwriters Laboratories (UL) of Northbrook, IL runs ASTM E-814 under their designation of UL 1479 and publishes the results in their "FIRE RESISTANCE DIRECTORY" that is updated annually. UL tests that meet the requirements of ULC-S115-M are given a cUL listing and are published by UL in their "Products Certified for Canada (cUL) Directory."

1.5 Definitions

- .1 Fire stopping: Material or combination of materials used to retain integrity of fire-rated construction by maintaining an effective barrier against the spread of flame, smoke, and hot gases through penetrations in fire rated wall and floor assemblies.

1.6 System Description

- .1 Fire stopping systems installed to resist spread of fire and passage of smoke and other gases at penetrations through fire resistance rated wall, floor assemblies, materials, and components.

1.7 Performance Requirements

- .1 Materials, accessories, and application procedures listed by ULC cUL, or tested in accordance with CAN/ULC-S115 to comply with building code requirements.
- .1 Fire stopping Materials: CAN/ULC-S101 ASTM E119 ASTM E814 to achieve a fire rating as noted on Drawings.
- .2 Surface Burning: CAN/ULC-S102 ASTM E84 with a flame spread/smoke developed rating of 25/50.

1.8 Administrative Requirements

- .1 Coordination: Coordinate with other work having a direct bearing on work of this section.
- .2 Pre-installation Meetings: Convene one (1) week before starting work of this section.

1.9 Submittals for Review

- .1 Submit shop drawings for all firestop systems anticipated on this project in accordance with Division 01 - Submittal Procedures.
- .2 Submit Product Data: Manufacturer's specifications and technical data for each material including the composition and limitations, documentation of ULC or cUL firestop systems to be used and manufacturer's installation instructions.
- .3 Shop drawings shall be complete with a systems directory for system details.
- .4 Submit material safety data sheets provided with product delivered to job-site.
- .5 System Design Listings: Submit system design listings, including illustrations from a qualified testing and inspection agency that is applicable for each firestop configuration.

1.10 Quality Assurance

- .1 Products of This Section: Manufactured to ISO 9000 and 14000 certification requirements.
- .2 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three (3) years documented experience and FAIC Manufacturer Member in good standing.
- .3 Installer Qualifications: Company specializing in performing the work of this section with minimum three (3) years documented experience, approved by the manufacturer and as follows:
 - .1 Installer shall be certified, licensed, or otherwise qualified by the fire stopping manufacturer as having the necessary training to install the manufacturer's products to specified requirements. On request, the certified installer shall provide documented proof of certification from the firestop system manufacturer. A manufacturer's willingness to sell its firestop products to the Contractor or to an Installer engaged by the Contractor does not in itself confer qualification on the buyer.
 - .2 Single Source Responsibility: Obtain firestop systems for each type of penetration and construction situation from a single primary firestop systems manufacturer.
- .4 For those firestop applications that exist for which no ULC or cUL tested system is available through a manufacturer, a manufacturer's engineering judgment derived from similar ULC or cUL system designs or other tests will be submitted to local authorities having jurisdiction for their review and approval prior to installation. Engineer judgment drawings must follow requirements set forth by the International Firestop Council and the Authorities having jurisdiction and be sealed by a Professional Engineer registered in the Province of British Columbia.

1.11 Regulatory Requirements

- .1 Conform to applicable code for fire resistance ratings and surface burning characteristics.
- .2 Provide certificate of compliance from authority having jurisdiction indicating approval of materials used.

1.12 Delivery, Storage and Protection

- .1 Deliver fire stopping products in original, unopened containers with labels intact and legible, identifying product and manufacturer.
- .2 Store and handle fire stopping materials to manufacturer's instructions.

2. PRODUCTS

2.1 Fire Stopping – General

- .1 Use the same product for all like applications.
- .2 Use the same manufacturer throughout the project and compatible materials for restoration work.
- .3 Asbestos-free materials and systems capable of maintaining an effective barrier against flame, smoke, and gases in compliance with requirements of CAN 4-S115-M and not exceeding intended opening sizes.
- .4 Fire stopping components compatible with each other, substrates forming openings and items penetrating the fire stopping under conditions of service and application.
- .5 Provide components for each fire stopping system that are needed to install fill material. Use only components specified by the fire stopping manufacturer and approved by the qualified testing agency for the designated fire-resistance-rated systems.
- .6 Where 'cast-in-place' fire stopping materials are used, provide fire stopping devices prior to concrete placement.
- .7 Firestop System Rating:
 - .1 For penetrations through a fire wall or horizontal fire separation provide a firestop system with a 'FT' rating as determined by ULC or cUL which is equal to the fire resistance rating of the construction being penetrated.
 - .2 For combustible pipes, tubing, ducts, chimneys, optical fibre cables, electrical wires and cables, totally enclosed non-combustible raceways, electrical outlet boxes and similar building services that penetrate through a fire separation provide a firestop system with an 'F' Rating as determined by ULC or cUL as indicated below:.

Separation Fire Resistance Rating	Fire Stopping Required ULC or cUL 'F' Rating
30 minutes	20 minutes
45 minutes	45 minutes
1 hour	45 minutes
1.5 hours	1 hour
2 hours	1.5 hours
3 hours	2 hours

- .3 For joints provide a firestop system with an Assembly Rating as determined by CAN4-S115-M, ULC-S115-M or UL 2079 which is equal to the fire resistance rating of the construction being penetrated.

2.2 Manufacturers

- .1 Subject to compliance with through penetration firestop systems and joint systems listed in the ULC Fire Resistance Directory – Volume III or UL Products Certified for Canada (cUL) Directory, provide products of the following acceptable manufacturers:
 - .1 Refer to Section 23 05 01 Acceptable Manufacturers.
 - .2 JV-Industries Sleeves and Firestop Devices c/w Tremco Firestop materials.
 - .3 Emseal Emshield WFR2.
 - .4 Other manufacturers listed in the above noted reference Standards.

2.3 Accessories

- .1 Fibre Insulation: Alumina-silica refractory fibre insulation in blanket or bulk form with service temperature limit of 1315 degrees C, melting point of more than 1760 degrees C, specific gravity 2.56, thickness to suit application.
- .2 Primers: to manufacturer's recommendation for specific material, substrate, and end use.
- .3 Water (if applicable): potable, clean and free from injurious amounts of deleterious substances.
- .4 Damming and backup materials, supports and anchoring devices: to manufacturer's recommendations, and in accordance with tested assembly being installed as acceptable to authorities having jurisdiction.
- .5 Sealants for vertical joints: non-sagging.

2.4 Materials

- .1 Use only firestop products that have been ULC or cUL tested for specific fire-rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements, and fire-rating involved for each separate instance.
- .2 Pre-Installed firestop devices for use with non-combustible and combustible pipes (closed and open systems) penetrating concrete floors and/or gypsum walls:
 - .1 Hilti Cast-In Place Firestop Device (CP 680-P)
 - .1 Add Aerator Adaptor when used in conjunction with aerator system.
 - .2 Hilti Tub Box Kit (CP 681) for use with tub installations.
 - .3 Hilti Cast-In Place Firestop Device (CP 680-M) for use with noncombustible penetrants.
 - .4 Hilti Speed Sleeve (CP 653) for use with cable penetrations.
 - .5 Hilti Firestop Drop-In Device (CFS-DID) for use with noncombustible and combustible penetrants.
 - .6 Hilti Firestop Block (CFS-BL)
 - .7 Acceptable substitution product listed in the ULC Fire Resistance Directory – Volume III or UL Products Certified for Canada (cUL) Directory.
- .3 Sealants or caulking materials for use with non-combustible items including steel pipe, copper pipe, rigid steel conduit, and electrical metallic tubing (EMT):
 - .1 3M Fire Stop Sealant 2000.
 - .2 3M Fire Barrier CP25 WB.
 - .3 Hilti CP 606 Flexible Firestop Sealant.
 - .4 Hilti CP 601s Elastomeric Firestop Sealant.
 - .5 Hilti FS-One Max Intumescent Firestop Sealant.
 - .6 Hilti FS 604 Self Levelling Firestop Sealant.
 - .7 Hilti CP-620 Fire Foam.
 - .8 Tremco Tremstop Fyre-Sil Sealant.
 - .9 Tremco Fyre-Sil SL.
 - .10 Acceptable substitution product listed in the ULC Fire Resistance Directory – Volume III or UL Products Certified for Canada (cUL) Directory.
- .4 Sealants or caulking materials for use with sheet metal ducts:

- .1 Hilti CP 601s Elastomeric Firestop Sealant.
 - .2 Hilti CP 606 Flexible Firestop Sealant.
 - .3 Hilti FS-One Max Intumescent Firestop Sealant.
 - .4 Hilti FS 604 Self Leveling Firestop Sealant.
 - .5 Tremco Fyre-Sil SL Sealant.
 - .6 Acceptable substitution product listed in the ULC Fire Resistance Directory – Volume III or UL Products Certified for Canada (cUL) Directory.
- .5 Sealants, caulking or spray materials for use with fire-rated construction joints and other gaps:
- .1 3M Firestop Sealant 2000.
 - .2 Hilti CFS-SP WB Firestop Joint Spray.
 - .3 Hilti CP 601s Elastomeric Firestop Sealant.
 - .4 Hilti CP 606 Flexible Firestop Sealant.
 - .5 Hilti FS 604 Self Leveling Firestop Sealant.
 - .6 Tremco TREMstop Acrylic.
 - .7 Tremco Dymonic FC.
 - .8 Acceptable substitution product listed in the ULC Fire Resistance Directory – Volume III or UL Products Certified for Canada (cUL) Directory.
- .6 Intumescent sealants or caulking materials for use with combustible items (penetrants consumed by high heat and flame) including insulated metal pipe, PVC jacketed flexible cable or cable bundles and plastic pipe:
- .1 3M Fire Barrier CP25 WB.
 - .2 Hilti FS-One Max Intumescent Firestop Sealant.
 - .3 Tremco TREMstop IA.
 - .4 Tremco TREMstop WS.
 - .5 Acceptable substitution product listed in the ULC Fire Resistance Directory – Volume III or UL Products Certified for Canada (cUL) Directory.
- .7 Intumescent sealants, caulking, or putty materials for use with low voltage cabling, communication cabling, and IT cabling:
- .1 Hilti CP 653 Speed Sleeve.
 - .2 Hilti CP 680 Cast-in-Place Firestop Device.
 - .3 Hilti FS 657 Fire Block.
 - .4 Tremco TREMstop IA.
 - .5 Acceptable substitution product listed in the ULC Fire Resistance Directory – Volume III or UL Products Certified for Canada (cUL) Directory.
- .8 Non-curing, re-penetrable intumescent sealants, caulking, or putty materials for use where future penetrations of low voltage cabling, communication cabling, or IT cabling may occur:
- .1 Hilti CP 653 Speed Sleeve.
 - .2 Acceptable substitution product listed in the ULC Fire Resistance Directory – Volume III or UL Products Certified for Canada (cUL) Directory.

- .9 Wall opening protective materials for use with cUL/ULC listed metallic and specified non-metallic outlet boxes:
 - .1 Hilti CP 617 Firestop Putty Pad.
 - .2 Tremco TREMstop MP.
 - .3 Acceptable substitution product listed in the ULC Fire Resistance Directory – Volume III or UL Products Certified for Canada (cUL) Directory.
- .10 Firestop collar or wrap devices attached to assembly around combustible plastic pipe (closed and open piping systems) tested to 50 Pa differential:
 - .1 3M Fire Barrier PPD Plastic Pipe Device.
 - .2 Hilti CP 648E/648S Wrap Strips
 - .3 Hilti CP 643N Firestop Collar.
 - .4 Hilti CP-644 Firestop Collar.
 - .5 Tremco TREMstop WS.
 - .6 Acceptable substitution product listed in the ULC Fire Resistance Directory – Volume III or UL Products Certified for Canada (cUL) Directory.
- .11 Materials for large size/complex penetrations made to accommodate cable trays, multiple steel and copper pipes, electrical busways in raceways:
 - .1 3M Firestop Foam 2001.
 - .2 3M Fire Barrier CS-195 Composite Sheet.
 - .3 Hilti CP-637 Firestop Mortar.
 - .4 Hilti CP 675T Firestop Board.
 - .5 Hilti CFS-BL Firestop Block.
 - .6 Hilti CP 620 Fire Foam.
 - .7 Tremco TREMstop PS.
 - .8 Acceptable substitution product listed in the ULC Fire Resistance Directory – Volume III or UL Products Certified for Canada (cUL) Directory.
- .12 Non-curing, re-penetrable materials used for large size/complex penetrations made to accommodate cable trays, multiple steel and copper pipes, electrical busways in raceways:
 - .1 Hilti CFS-BL Firestop Block.
 - .2 Hilti CP 675T Firestop Board.
 - .3 Tremco TREMstop PS.
 - .4 Acceptable substitution product listed in the ULC Fire Resistance Directory – Volume III or UL Products Certified for Canada (cUL) Directory.
- .13 Sealants or caulking materials used for openings between structurally separate sections of wall and floors:
 - .1 3M Fire Barrier CP 25 WB.
 - .2 Hilti CFS-SP WB Firestop Joint Spray.
 - .3 Hilti CP 601s Elastomeric Firestop Sealant.
 - .4 Hilti CP 606 Flexible Firestop Sealant.
 - .5 Hilti FS 604 Self Leveling Firestop Sealant.
 - .6 Tremco TREMstop Fyre-Sil.

- .7 Tremco Dymonic FC.
- .8 Emseal Emshield WRF2.
- .9 Acceptable substitution product listed in the ULC Fire Resistance Directory – Volume III or UL Products Certified for Canada (cUL) Directory.
- .14 Materials for locations of high re-penetration of low voltage wiring:
 - .1 Hilti CP635 Speed Sleeve.
- .15 For blank openings made in fire-rated wall or floor assemblies, where future penetration of pipes, conduits, or cables is expected:
 - .1 Hilti FS 657 Fire Block (for walls and floors)
 - .2 Hilti CP 658T Firestop Plug (for walls and floors)
 - .3 Hilti CP 680 Cast-In Place Firestop Device (for floors only)

3. EXECUTION

3.1 General

- .1 The Owner's Consultant shall conduct mandatory destructive reviews for each type of installation. Destructive testing shall be at the discretion of the Owner's Consultant and Authority having jurisdiction
- .2 Allow for destructive testing of 5% of fire stopping applications. Should installations not conform to manufacturer's listed assembly, an additional 25% of installations may be destructively tested and should there be more failures, the contractor will be responsible to remove all fire stopping products and reinstall products correctly, at no additional cost to the project.

3.2 Preparation

- .1 Verification of Conditions: Examine areas and conditions under which work is to be performed and identify conditions detrimental to proper or timely completion.
 - .1 Verify penetrations are properly sized and in suitable condition for application of materials.
 - .2 Ensure surfaces to which firestop materials will be applied are free of dirt, grease, oil, rust, laitance, release agents, water repellants, and any other substances that may affect proper adhesion.
 - .3 Ensure all service lines are in place, tested and acceptable to the authority having jurisdiction, prior to application of fire stopping and smoke seal.
 - .4 Provide masking and temporary covering to prevent soiling of adjacent surfaces by fire stopping materials.
 - .5 Comply with manufacturer's recommendations for temperature and humidity conditions before, during, and after installation of fire stopping.
 - .6 Do not proceed until satisfactory conditions have been corrected.

3.3 Coordination

- .1 Installation is not to proceed until shop drawings have been reviewed.
- .2 Obtain fire resistance ratings and classifications for all wall and floor assemblies from the Architectural contract documents.
- .3 Coordinate location and proper selection of cast-in-place firestop devices with trade responsible for the work. Ensure device is installed before placement of concrete.

- .4 Provide adequate spacing of field run pipes to allow for installation of cast-in-place firestop devices without interference.
- .5 Fire stopping of floor and roof slab penetrations must precede steel stud track installation.
- .6 Fire stopping must precede fireproofing installation.
- .7 Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration fire stop systems.
- .8 Coordinate fire stopping with other trades so that obstructions are not placed in the way prior to the installation of the fire stop systems.
- .9 Fire stopping must precede mechanical pipe insulation. Vapour barriers must be continued along with FPI – ASJ jacketing.

3.4 Installation

- .1 Regulatory Requirements: Install fire stopping and smoke seal material and components in accordance with ULC or cUL Certification and manufacturer's instructions.
- .2 Manufacturer's Instructions: Comply with manufacturer's instructions for installation of through-penetration joint materials.
 - .1 Seal holes or voids made by through penetrations, poke-through termination devices, and unpenetrated openings or joints to ensure continuity and integrity of fire separation are maintained by providing an air and water resistant seal.
 - .2 Consult with related trades before installation of ULC or cUL firestop systems that might hamper the performance of fire dampers in ductwork.
 - .3 Provide temporary forming as required and remove forming only after materials have gained sufficient strength and after initial curing.
 - .4 Tool or trowel exposed surfaces to a neat finish.
 - .5 Remove excess compound promptly as work progresses and upon completion.
 - .6 Protect materials from damage on surfaces subjected to traffic.
 - .7 Where possible, use metal sleeves for floor penetrations to prevent/mitigate the consequences of leakage or flooding.

3.5 Field Quality Control

- .1 Notify Consultant when ready for inspection and prior to concealing or enclosing fire stopping materials and service penetration assemblies.
- .2 Examine sealed penetration areas to ensure proper installation before concealing or enclosing areas.
- .3 Keep areas of work accessible until inspection by applicable code authorities.
- .4 Inspection of through-penetration fire stopping shall be performed in accordance with ASTM E 2174, "Standard Practice for On-Site Inspection of Installed Fire Stops" or other recognized standard.
- .5 Use primers whenever recommended by manufacturer.
- .6 Perform patching and repairing of fire stopping caused by cutting or penetrating of existing firestop systems already installed by other trades.
- .7 Tag all penetrations and every 3 meters of joint seal with printed tags
 - .1 Tags shall indicate:
 - .1 Fire stop products used.

- .2 Indicate the fire stop system # used, ULC or cUL.
 - .3 Date installed.
 - .4 Re-penetrated by & Date.
 - .5 F or FT rating.
 - .6 Installed by: (name and phone number of subcontractor).
 - .7 Person to contact and phone number in case of modification or new penetration of fire stop system.
- .2 Tags shall state:
- .1 CAUTION! FIRESTOP - DO NOT REMOVE, PUNCTURE OR DISCONTINUE UNLESS PREPARED TO RE-SEAL IMMEDIATELY WITH SPECIFIED PRODUCT

3.6 Clean Up

- .1 Remove temporary dams after initial set of fire stopping and smoke seal materials.
- .2 Remove excess materials and debris and clean adjacent surfaces immediately after application.
- .3 Clean all surfaces adjacent to sealed holes and joints to be free of excess firestop materials and soiling as work progresses.
- .4 Dispose of waste materials in conformance with Construction Waste Management Plan.

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 This section defines the minimum requirements necessary to render HVAC components clean, and to verify the cleanliness through inspection and/or testing in accordance with applicable Standards.
- .2 The Contractor shall be responsible for the removal of visible surface contaminants and deposits from within the HVAC system in strict accordance with these specifications.
- .3 The HVAC system includes any interior surface of the facility's air distribution system for conditioned spaces and/or occupied zones. This includes the entire heating, air-conditioning and ventilation system from the points where the air enters the system to the points where the air is discharged from the system. The return air grilles, return air ducts to the air handling unit (AHU), the interior surfaces of the AHU, mixing box, coil compartment, condensate drain pans, humidifiers and dehumidifiers, supply air ducts, fans, fan housing, fan blades, air wash systems, spray eliminators, turning vanes, filters, filter housings, reheat coils, and supply diffusers are all considered part of the HVAC system. The HVAC system may also include other components such as dedicated exhaust and ventilation components and make-up air systems.
- .4 The HVAC systems to be cleaned are as follows:
 - .1 All duct systems associated with current scope of work that are connected to the existing equipment being removed, or are being connected to the new equipment installed, including:
 - .1 Fresh Air
 - .2 Supply Air
 - .3 Return Air
 - .4 Exhaust Air

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical.
- .3 Section 23 33 00 – Duct Accessories.

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
 - .1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE):
 - .1 Standard 62 Ventilation for Acceptable Indoor Air Quality,
 - .2 National Air Duct Cleaners Association (NADCA):
 - .1 Standard for Assessment Cleaning Restoration of HVAC Systems (ACR).

1.4 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:

- .1 Material Safety Data Sheets (MSDS) for all chemical products used in the cleaning process.
- .2 Proof of qualification requirements for HVAC system cleaning Contractor.
- .3 Post Cleaning Inspection Report.

1.5 Definitions

- .1 Ductwork:
 - .1 All structures designed to transfer air to or from conditioned spaces. For the purposes of this specification section, ductwork will include all structures and internal control devices (dampers, turning vanes, probes, grills and diffusers, etc.) leading to or from air handler units and their enclosures.
- .2 Air Handlers:
 - .1 All structures and contained equipment, fans, motors, dampers, sensors, coils, filter frames, etc. used to move air from one location to another.

1.6 Qualification of the HVAC System Cleaning Contractor

- .1 The HVAC system cleaning contractor shall be a certified member of the National Air Duct Cleaners Association (NADCA), or shall maintain membership in a nationally recognized non-profit industry organization dedicated to the cleaning of HVAC systems.
- .2 The HVAC system cleaning contractor shall have a minimum of one (1) Air System Cleaning Specialist (ASCS) certified by NADCA on a full time basis, or shall have staff certified by a nationally recognized certification program and organization dedicated to the cleaning of HVAC systems.
- .3 The HVAC system cleaning contractor shall submit records indicating five (5) years' experience in the field of HVAC system cleaning. Records shall only be considered from firms which are regularly engaged in HVAC system maintenance with an emphasis on HVAC system cleaning and decontamination.

1.7 General

- .1 The HVAC system cleaning contractor shall possess and furnish all necessary equipment, materials, and labor to adequately perform the specified services.
- .2 The contractor shall confirm in writing that its employees for this project have received safety equipment training, medical surveillance programs, individual health protection measures, and manufacturer's product and material safety data sheets (MSDS) as required for the work.
- .3 The HVAC system cleaning contractor shall perform the services specified here in accordance with the current published standards of the National Air Duct Cleaners Association (NADCA).

2. PRODUCTS

2.1 Acceptable Manufacturers

- .1 Refer to Section 23 05 01 – Acceptable Manufacturers.

2.2 Cleaning Equipment

- .1 Provide equipment and materials for cleaning, repairing and inspection work including scaffolding, wire brushes, rotary brushes, filters, air lances, mechanical agitators, fiber-optic borescopes, vacuums or other equipment and materials necessary for workmen to perform work specified.

- .2 Any chemicals utilized in this project shall have MSDS (Material Safety Data Sheet) submitted to the maintenance department before product usage, and shall be pre-approved by the Consultant.

2.3 System Filters

- .1 Supply and install new pre-filters for each HVAC System cleaned.

2.4 Access Doors

- .1 All access doors and hatches shall comply with Section 23 33 00 Duct Accessories.

3. EXECUTION

3.1 HVAC System Component Inspections and Site Preparations

- .1 Contractor shall conduct a site evaluation, and establish a specific, coordinated plan which details a lay out plan for video survey, identifies camera and cleaning apparatus insertion points and how each area of the building will be protected during the various phases of the project.
- .2 Prior to the commencement of any cleaning work, the HVAC system cleaning contractor shall perform a visual inspection of the HVAC system. Determine appropriate methods, tools, and equipment required to satisfactorily complete this project.
- .3 The cleanliness inspection should include air handling units and representative areas of the HVAC system components and ductwork. In HVAC systems that include multiple air handling units, a representative sample of the units should be inspected.
- .4 The cleanliness inspection shall be conducted without negatively impacting the indoor environment through excessive disruption of settled dust, microbial amplification or other debris. In cases where contamination is suspected, and/or in sensitive environments where even small amounts of contaminant may be of concern, environmental engineering control measures should be implemented.
- .5 Damaged system components found during the inspection shall be documented and brought to the attention of the Consultant.

3.2 General HVAC System Cleaning Requirements

- .1 Debris removed during cleaning shall be collected and precautions must be taken to ensure that debris is not otherwise dispersed outside the HVAC system during the cleaning process.
- .2 Where the particulate collection equipment is exhausting inside the building, HEPA filtration with 99.97% collection efficiency for 0.3-micron size (or greater) particles shall be used.
- .3 When the particulate collection equipment is exhausting outside the building, mechanical cleaning operations shall be undertaken only with particulate collection equipment in place, including adequate filtration to contain debris removed from the HVAC system.
- .4 When the particulate collection equipment is exhausting outside the building, precautions shall be taken to locate the equipment down wind and away from all air intakes and other points of entry into the building.
- .5 Measures shall be employed to control odors and/or mist vapors during the cleaning process.
- .6 Upon completion, all components must be returned to those settings recorded just prior to cleaning operations.

- .7 Dampers and any air-directional mechanical devices inside the HVAC system must have their position marked prior to cleaning and, upon completion, must be restored to their marked position.
- .8 The contractor shall utilize service openings, as required for proper cleaning, at various points of the HVAC system for physical and mechanical entry, and inspection. Utilize existing service openings in the HVAC system where possible. Create new service openings in the system as necessary in order to accommodate cleaning of otherwise inaccessible areas. New openings created shall comply with Section 23 33 00 – Duct Accessories.
- .9 Cutting service openings into flexible duct is not permitted. Flexible duct shall be disconnected at the ends as needed for proper cleaning and inspection.
- .10 Clean all air distribution devices, air handling units, terminal units (VAV, Dual duct boxes, etc.), blowers, and exhaust fans.
- .11 Clean supply return, and exhaust fans and blowers. Include blowers, fan housings, plenums (except ceiling supply and return plenums), scrolls, blades, or vanes, shafts, baffles, dampers, and drive assemblies.
- .12 All visible surface contamination deposits shall be removed in accordance with NADCA Standards.
- .13 Assure that a suitable operating drainage system is in place prior to beginning wash down procedures.
- .14 Clean all coils and related components, including evaporator fins.
- .15 Replace air handler pre-filters on completion of cleaning. Advise the Owner if mid or final filters are requiring replacement.
- .16 Source Removal Cleaning Methods:
 - .1 It is the contractor's responsibility to select source removal methods that will render the HVAC system visibly clean and capable of passing cleaning verification methods and other specified tests, in accordance with all general requirements.
 - .2 No cleaning method, or combination of methods, shall be used which could potentially damage components of the HVAC system or negatively alter the integrity of the system.
 - .3 All methods used shall incorporate the use of vacuum collection devices that are operated continuously during cleaning. A vacuum device shall be connected to the downstream end of the section being cleaned through a predetermined opening. The vacuum collection device must be of sufficient power to render all areas being cleaned under negative pressure, such that containment of debris and the protection of the indoor environment are assured.
 - .4 All vacuum devices exhausting air inside the building shall be equipped with HEPA filters (minimum efficiency), including hand-held vacuums and wet-vacuums.
 - .5 All vacuum devices exhausting air outside the facility shall be equipped with particulate collection including adequate filtration to contain debris removed from the HVAC system. Such devices shall exhaust in a manner that will not allow contaminants to re-enter the facility. Release of debris outdoors must not violate any outdoor environmental standards, codes, or regulations.
 - .6 All methods require mechanical agitation devices to dislodge debris adhered to interior HVAC system surfaces, such that debris may be safely conveyed to vacuum collection devices. Acceptable methods will include those, which will not potentially damage the integrity of the ductwork, nor damage porous surface materials such as liners inside the ductwork or system components.
- .17 Methods of Cleaning Glass Fibre Insulated Components

- .1 Glass fibre thermal or acoustical insulation elements in equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment, while the HVAC system is under constant negative pressure, and not permitted to get wet.
 - .2 Cleaning methods used shall not cause damage to fibrous glass components and will render the system capable of passing cleaning verification tests as per the NADCA Standards.
- .18 Damaged Glass Fibre Material
- .1 If there is any evidence of damage, deterioration, delaminating, friable material, mold or fungus growth, or moisture such that fibrous glass materials cannot be restored by cleaning or resurfacing with an acceptable insulation repair coating, they shall be identified to the Consultant for replacement.
 - .2 Replacement of damaged insulation is not covered by this Section.
- .19 Cleaning of coils
- .1 Any cleaning method may be used which will render the coil visibly clean and capable of passing coil cleaning verification.
 - .2 Coil drain pans shall be subject to non-porous surfaces cleaning verification. The drain for the condensate drain pan shall be operational.
 - .3 Cleaning methods shall not cause any appreciable damage to, displacement of, inhibit heat transfer, or erosion of the coil surface or fins, and shall conform to coil manufacturer recommendations when available.
 - .4 Coils shall be thoroughly rinsed with clean water to remove any latent residues.
- .20 Antimicrobial Agents and Coatings
- .1 Antimicrobial agents shall only be applied if active fungal growth is reasonably suspected, or where unacceptable levels of fungal contamination have been verified through testing.
 - .2 Application of any antimicrobial agents used to control the growth of fungal or bacteriological contaminants shall be performed after the removal of surface deposits and debris.
 - .3 When used, antimicrobial treatments and coatings shall be applied in strict accordance with the manufacturer's written recommendations.
 - .4 Coatings shall be sprayed directly onto interior ductwork surfaces, rather than "fogged" downstream onto surfaces.

3.3 Cleanliness Verification

- .1 Verification of HVAC System cleanliness will be determined after mechanical cleaning and before the application of any treatment or introduction of any treatment-related substance to the HVAC system, including biocidal agents and coatings.
- .2 The HVAC system shall be inspected using [robotic camera and other] [visual inspection methods] to ensure that no visible contaminants are present. If no contaminants are evident through visual inspection, the HVAC system shall be considered clean; however, the Consultant reserves the right to further verify system cleanliness through "Surface Comparison Testing" or the NADCA vacuum test specified in the NADCA standard ACR.
- .3 If visible contaminants are evident through visual inspection, those portions of the system where contaminants are visible shall be re-cleaned and subjected to re-inspection for cleanliness.
- .4 Verification of Coil Cleaning

- .1 Cleaning must restore the coil pressure drop to within 10 percent of the pressure drop measured when the coil was first installed. If the original pressure drop is not known, the coil will be considered clean only if the coil is free of foreign matter and chemical residue, based on a thorough visual inspection.

3.4 Post Cleaning Inspection Report

- .1 Post Cleaning Inspection Report: submit [4] copies of Final Inspection Report, including data collected, observations and recommendations as well as following information:
 - .1 Name and address of facility;
 - .2 Name and address of HVAC cleaning contractor;
 - .3 Description of HVAC systems with drawings or sketches identifying systems cleaned;
 - .4 Identification scheme for location points in systems that were inspected with accompanying notes describing methods of inspection or tests used;
 - .5 Identify systems tested, observations, actions taken and recommendations for future maintenance.

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 Complete Variable Frequency Drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use with a standard NEMA Design B induction motor.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical
- .3 Division 25 – Integrated Automation
- .4 Division 26 – Electrical

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
 - .1 Applicable Building Code - Refer to Section 21 05 01
 - .2 Institute of Electrical and Electronic Engineers (IEEE)
 - .1 IEEE 519-2014, IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems.
 - .2 IEEE C62.41.1 – Guide on the Surges Environment in Low-Voltage (1000V and Less) AC Power Circuits.
 - .3 IEEE C62.41.2 – Recommended Practice on Characterization of Surges in Low-Voltage (1000V and Less) AC Power Circuits.
 - .3 Underwriters Laboratories
 - .1 UL508 UL Standard for Safety Industrial Control Equipment
 - .2 UL508C UL Standard for Safety Power Conversion Equipment
 - .4 National Electrical Manufacturer's Association (NEMA)
 - .1 ICS 7.0, AC Adjustable Speed Drives
 - .5 International Electrotechnical Commission (IEC)
 - .1 EN/IEC 61800-3
 - .6 National Electric Code (NEC)
 - .1 NEC 430.120, Adjustable-Speed Drive Systems
 - .7 International Building Code (IBC)
 - .1 IBC 2012 Seismic – referencing ASC 7-05 and ICC AC-156

1.4 General

- .1 The drive manufacturer shall supply the drive and all necessary options as herein specified.
- .2 The manufacturer shall have been engaged in the production of this type of equipment for a minimum of ten years.
- .3 All VFDs installed on this project shall be from the same manufacturer.
- .4 All VFDs and ancillary components must be procured by one supplier in order to assure an integrated system and one point of contact for service.

1.5 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:
 - .1 For each VFD provide:
 - .1 Outline dimensions, conduit entry locations, and weight.
 - .2 Customer connection and power wiring diagrams.
 - .3 Complete technical product description including a complete list of options provided.
 - .4 Seismic Certification and Installation requirements.
 - .5 Any portions of this specification not met must be clearly indicated on a separate page and cross-referenced to the specification or the supplier and contractor shall be liable to provide all additional components required to meet this specification.
 - .2 Closeout submittals: submit all maintenance and test schedules and reviewed shop drawings for incorporation into manual specified in Section 21 05 01 – Common Work Results - Mechanical

1.6 Coordinating Responsible Party

- .1 The contractor that supplies the VFD will be the responsible party for the coordination and installation of the drive.
- .2 The contractor will be responsible for all of the VFD implementation requirements associated with the installation.
- .3 The contractor shall engage the appropriate trade for the work to be performed if outside of the supplying contractor's standard installation requirements.
- .4 The responsible party is to ensure that all requirements of the installation have been satisfactory provided even if not specifically indicated in other contractor's scope of work.

1.7 Supplier Spare Parts Availability

- .1 The supplier is to have a distributor organization, which locally stocks standard drives, modification kits, and spare parts.

1.8 Warranty

- .1 The VFD supplier shall provide warranty coverage for a minimum period of 3 years upon the date of project substantial completion.
- .2 The warranty shall include parts, labor, travel costs, and living expenses incurred by the supplier to provide factory authorized service.
- .3 The Contractor shall be responsible to bring the supplier's factory representative to site to reset, repair, and re-commission the VFD if problems arise with the normal operation of the VFD during the warranty period.
- .4 Items repaired or replaced shall be warranted for an additional period of at least twelve (12) months from the date that the VFD becomes functional again.
- .5 The VFD supplier shall be responsible to coordinate all warranty works with the Owner's forces during the warranty period.

2. PRODUCTS

2.1 Acceptable Manufacturers

- .1 Refer to Section 23 05 01 – Acceptable Manufacturers

2.2 Product Qualifications

- .1 VFD shall be UL508 listed as a complete assembly.
- .2 VFD shall be ULC listed and CSA (cUL) certified.
- .3 The VFD assembly and associated options and peripherals shall comply with the applicable requirements of the latest standards of ANSI, IEEE, NEMA, and the Canadian Electrical Code.
- .4 The VFD, including the bypass (if specified), shall conform to the European Union Electromagnetic Compatibility directive and be CE marked.
- .5 The VFD shall meet product standard EN 61800-3 for the First Environment restricted level (Category C2). Base drives that only meet the Second Environment (Category C3, C4) shall be supplied with filters to bring the drive in compliance with the First Environment levels.
- .6 The VFD assembly, including the bypass (if specified), shall be seismically certified and labeled as such in accordance with the 2012 International Building Code (IBC):
 - .1 Seismic importance factor of 1.5 rating is required, and shall be based upon actual shake table test data as defined by ICC AC-156.

2.3 Variable Frequency Drives

- .1 General:
 - .1 Furnish complete variable frequency drive(s) as specified herein for the equipment designated on the drawing schedules or control sequences with variable speed controls.
 - .2 Each VFD, with all standard and optional features, shall be factory packaged in a ULC rated and listed enclosure most appropriate for each application and location, completely assembled and tested by the manufacturer in an ISO9001 facility.
 - .3 VFDs sized less than 100 HP to be of the 6-pulse Pulse-Width Modulated (PWM) type with a full wave diode bridge converter to convert incoming fixed voltage/frequency to a fixed DC voltage. The PWM strategy shall incorporate a microprocessor to handle all logic functions as well as the complex, sine-coded PWM generating algorithms that control output stage switching.
 - .4 VFDs sized from 100 HP to 199 HP to be of the 6-pulse Pulse-Width Modulated (PWM) type with a full wave diode bridge converter to convert incoming fixed voltage/frequency to a fixed DC voltage. The PWM strategy shall incorporate a microprocessor to handle all logic functions as well as the complex, sine-coded PWM generating algorithms that control output stage switching. VFDs sized from 100 HP to 199 HP shall include a harmonic filter.
 - .5 The variable frequency drives shall convert three-phase, 60 Hz utility power to proportionally variable voltage and frequency, three-phase, AC power using the latest insulated-gate bipolar transistor (IGBT) technology for step less motor speed control of one or more three-phase induction motors. The VFD output waveform to be the PWM or Vector type waveform producing smooth torque at low frequencies and low motor current harmonics.
 - .6 Drives shall be capable of controlling and set up for either variable or constant torque loads, as follows:

- .1 Variable torque: loads such as centrifugal fans, pumps and compressors
- .2 Constant torque: loads such as positive displacement pumps and reciprocating or screw compressors
- .7 The VFD shall provide full rated output from a line of $\pm 10\%$ of nominal voltage.
- .8 The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute in every 10 minutes.
- .9 VFDs shall be capable of continuous full load operation under the following environmental operating conditions:
 - .1 -10°C to 40°C (14 to 104°F) ambient temperature.
 - .2 Altitude 0 to 1015m (0 to 3300 ft) above sea level.
 - .3 Humidity less than 95%, non-condensing.
- .10 All VFDs shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating.
- .11 The VFD shall have cooling fans. The fans shall be replaceable without requiring VFD removal or removal of circuit boards. The VFD cooling fans shall cycle via thermal sensing not operate continuously.
- .12 Any options shall be furnished and mounted by the drive manufacturer as defined on the VFD schedule. All optional features shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.
- .2 Features:
 - .1 Loss-of-load (broken belt / broken coupling) relay output. The drive shall be programmable to signal the loss-of-load condition via keypad warning, relay output, and / or over the serial communications bus.
 - .2 If the input reference is lost, the VFD shall give the user the option of either (1) stopping and displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last good reference received, or (4) cause a warning to be issued, as selected by the user.
 - .3 The VFD shall be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to set point without tripping or component damage (flying start).
 - .4 The VFD shall have the ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable.
 - .5 The VFD shall also be capable of DC injection braking that can be employed to stop a free wheeling motor before starting to avoid overvoltage nuisance tripping.
 - .6 The VFD shall be capable of automatically extending the ramp down time to keep the drive from tripping on overvoltage caused by regeneration of power by the load.
- .3 Line Conditioning and Filtering:
 - .1 The VFD shall have a dual 5% impedance DC link reactor (or 5% line reactor) on the positive and negative rails of the DC bus to minimize power line harmonics and protect the VFD from power line transients. The chokes shall be non-saturating. Swinging chokes that do not provide full harmonic filtering throughout the entire load range are not acceptable.

- .2 Provide a coordinated AC transient surge protection system consisting of 4 MOVs (phase to phase and phase to ground), a capacitor clamp, 1600 PIV Diode Bridge, and internal chokes. The MOV's shall have a minimum 125 joule rating per phase across the diode bridge. VFDs that do not include coordinated AC transient surge protection shall include an external TVSS (Transient Voltage Surge Suppressor).
- .3 Provide EMI / RFI filters. VFD assembly to be CE Marked and comply with product standard EN 61800-3 for the First Environment restricted level (Category C2). Second environment (Category C3, C4) is not acceptable. Submit certified test reports with the shop drawing submittal confirming compliance.
- .4 Provide an additional output (load) reactor directly downstream of the inverter, for all applications where the motor wiring downstream of the inverter exceeds 30m (98ft).
- .4 Adjustments:
 - .1 Three (3) programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed. The lockout range must be fully adjustable, from 0 to full speed.
 - .2 Two (2) PID Set point controllers, allowing pressure, or flow signals to be connected to the VFD. The VFD shall have 250 ma of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by others. The PID set point shall be adjustable.
 - .3 Two (2) programmable analog inputs with oscillation filters
 - .4 Two (2) programmable analog outputs (0-20ma or 4-20 ma)
 - .5 Six (6) programmable digital inputs
 - .6 Three (3) programmable, digital relay outputs
 - .1 Rated for maximum switching current 8 amps at 24 VDC and 0.4 A at 250 VAC; Maximum voltage 300 VDC and 250 VAC; continuous current rating of 2 amps RMS
 - .7 The VFD shall automatically reduce applied motor voltage to the motor to optimize energy consumption and reduce audible motor noise. The VFD shall have selectable software for optimization of motor noise, energy consumption, and motor speed control.
- .5 VSD Interface:
 - .1 Provide a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (alphanumeric codes are not acceptable). All VFD faults shall be displayed in English words.
 - .2 The keypad shall include Hand-Off-Auto selections and manual speed control.
 - .3 The drive shall incorporate "bump less transfer" of speed reference when switching between "Hand" and "Auto" modes.
 - .4 There shall be a built-in time clock in the VFD keypad. The clock shall have a battery backup with 10 years minimum life span. The clock shall date and time stamp faults and record operating parameters at the time of fault. VFD programming shall be held in non-volatile memory and is not dependent on battery power.
 - .5 All applicable operating values shall be capable of being displayed in engineering (user) units. Minimum display values shall be:
 - .1 Output Frequency
 - .2 Motor Speed (RPM, %, or Engineering units)
 - .3 Motor Current

- .4 Motor Torque
- .5 Motor Power (kW)
- .6 DC Bus Voltage
- .7 Output Voltage
- .6 Provide a fireman's override input. Upon receipt of a fire panel input signal, the VFD shall operate in one of two modes: 1) Operate at a programmed predetermined fixed speed ranging from -500Hz (reverse) to 500Hz (forward). 2) Operate in a specific fireman's override PID algorithm that automatically adjusts motor speed based on override set point and feedback while overriding all other inputs, except customer defined safety run interlocks.
- .6 Serial Communications
 - .1 The VFD shall have a TIA-485 (RS-485) port as standard. The standard protocols shall be:
 - .1 Modbus
 - .2 Johnson Controls N2
 - .3 Siemens Building Technologies FLN
 - .4 BACnet
 - .2 All protocols shall be "certified" by the governing authority (i.e. BTL Listing for BACnet). Use of non-certified protocols is not allowed.
 - .3 Serial communication minimum capabilities shall include:
 - .1 Run-stop controls
 - .2 Speed set adjustment
 - .3 Output speed / frequency, current (in amps)
 - .4 % torque
 - .5 Power (kW), kilowatt hours (resettable),
 - .6 Operating hours (resettable)
 - .7 Drive temperature.
 - .8 All diagnostic warning and fault information shall be transmitted over the serial communications bus.
 - .9 The BAS shall also be capable of monitoring the VFD relay output status, digital input status, and all analog input and analog output values.
 - .10 Remote VFD fault reset.
- .7 Serial communication in bypass
 - .1 Minimum capabilities shall include:
 - .1 Bypass run-stop control.
 - .2 The BAS shall be capable of monitoring the bypass relay output status, and all digital input status.
 - .3 All bypass diagnostic warning and fault information shall be transmitted over the serial communications bus.
 - .4 Remote bypass fault reset.
 - .5 The VFD / bypass shall allow the BAS to control the drive and bypass digital and analog outputs via the serial interface.

- .8 BYPASS – Bypasses shall be furnished and mounted by the drive manufacturer as defined on the VFD schedule. All VFD with bypass configurations shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.
 - .1 A complete factory wired and tested bypass system consisting of a door interlocked; pad lockable circuit breaker, output contactor, bypass contactor, and fast acting VFD input fuses. UL Listed motor overload protection shall be provided in both drive and bypass modes.
 - .2 Standalone keypad with LCD display.
 - .3 The VFD and bypass package shall have a UL listed short circuit current rating (SCCR) of 100,000 Amps and this rating shall be indicated on the UL data label.
 - .4 Motor protection from single phase power conditions - the bypass system must be able to detect a single phase input power condition while running in bypass, disengage the motor in a controlled fashion, and give a single phase input power indication.
 - .5 The bypass system shall be designed for stand-alone operation and shall be completely functional in both Hand and Automatic modes even if the VFD has been removed from the system for repair / replacement. Serial communications shall remain functional even with the VFD removed. Bypass systems that do not maintain full functionality with the drive removed are not acceptable.
 - .6 Serial communications – the bypass shall be capable of being monitored and / or controlled via serial communications that match the VSD.
 - .7 The bypass serial communications shall allow control of the drive/bypass (system) digital outputs via the serial interface. This control shall be independent of any bypass function or operating state. All system analog and digital I/O shall be capable of being monitored by the BAS system.
 - .8 Provide manual or automatic transfer to bypass. Drive faults for automatic transfer to bypass mode shall be user selectable for the following drive fault conditions:
 - .1 Over current
 - .2 Over voltage
 - .3 Under voltage
 - .4 Loss of analog input
 - .9 The bypass shall include the ability to select the operating mode of the system (VFD/Bypass) from either the bypass keypad or digital input.
 - .10 Provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external safety interlocks shall remain fully functional whether the system is in VFD or Bypass mode. The remote start/stop contact shall operate in VFD and bypass modes. The terminal strip shall allow for independent connection of up to four (4) unique safety inputs.
 - .11 Fireman's Override Mode: Programmable override input which will allow the user to configure the unit to acknowledge some digital inputs, all digital inputs, ignore digital inputs or any combination of the above to suit the local Authority Having Jurisdiction (AHJ). The Override action may be initiated via the serial communications link.

3. EXECUTION

3.1 Installation

- .1 The contractor shall install the drive in accordance with the recommendations of the VFD manufacturer as outlined in the VFD installation manual.

- .2 Power wiring shall be completed by Division 26.

3.2 Testing

- .1 VFD assemblies are to be factory tested prior to shipment. Testing is to be performed at the factory or at the VFD OEM or integrator facility. Provide confirmation of actual tests completed and results.
- .2 Provide certified copies of production test results required by CSA and EEMAC, prior to acceptance of the equipment. Test results are to be provided to the Consultant prior to shipment of the equipment.
- .3 A copy of all factory production tests shall also be shipped with the drives.
- .4 Field Testing
 - .1 The VFD supplier shall provide on-site startup, fine-tuning, field support during commissioning, provision of final setup information prior to turnover and operator training and instruction.
 - .2 The VFD supplier shall provide site functionality test reports indicating loading / current levels during testing as well as control point proving results. Reports shall be submitted to the commissioning agent and the Consultant.
 - .3 The VFD supplier shall ensure shaft-to-ground voltage does not exceed 1.5 volts at any speed or load requirement.
- .5 Harmonics Testing
 - .1 The VFD supplier shall, with the aid of the detailed electrical power single line diagram showing all impedances in the power path to the VFDs, perform an analysis to initially demonstrate the supplied equipment will meet the IEEE 519 recommendations after installation. If, as a result of the analysis, it is determined that additional filter equipment is required to meet the IEEE recommendations, then include the cost of providing the equipment. Provide complete harmonics testing and analysis compliance with IEEE 519 after complete VFD startup.
 - .2 Fine tune VFD with signal from controls, inspect, verify motor load RPM at 25%, 50%, 75%, 90% and 100%. Motor RPM should match the percentage indicated.
 - .3 If motor RPM does not match the percentage indicated, motors/fans shall be re-sheaved. Record all measured values (minimum of RPM, frequency, current and voltage input/output).
 - .4 Calibrate VFD display values with Building Controls System display output.
 - .5 Verify motor RPM values with a calibrated tachometer. Motor RPM shall match the percentage indicated. If not motors/fans shall be re-sheaved.
 - .6 Conduct a minimum of four (4) samples. (Testing to be provided to 25%, 50%, 75%, 90%, and 100% of motor output RPM.)
 - .7 Contractor is to submit a signed copy of the completed test results, certifying proper system operation demonstrating compliance with the specification requirements.

END OF SECTION

1. GENERAL

1.1 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical.
- .3 Section 22 07 11 – Fire Stopping.
- .4 Section 23 05 48 - Vibration and Seismic Control for Mechanical.
- .5 Section 23 25 00 – HVAC Water Treatment.

1.2 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
 - .1 Applicable Building Code - Refer to Section 21 05 01
 - .2 Applicable Fire Code - Refer to Section 21 05 01
- .2 Canadian General Standards Board (CGSB)
 - .1 CAN/CGSB-1.181-[99], Ready-Mixed Organic Zinc-Rich Coating.
- .3 Canadian Standards Association (CSA International)
 - .1 CSA B139-[15], Installation Code for Oil Burning Equipment.
 - .2 CAN/CSA B149.1-[15], Natural Gas and Propane Installation Code
 - .3 CAN/CSA B149.2-[15], Propane Storage and Handling Code
- .4 Green Seal Environmental Standards (GSES)
 - .1 Standard GS-11-[2015, Edition 3.2], Green Seal Standard for Paints, Coatings, Stains, and Sealers.
- .5 South Coast Air Quality Management District (SCAQMD), California State, Regulation XI. Source Specific Standards
 - .1 SCAQMD Rule 1113-[A2016], Architectural Coatings.
 - .2 SCAQMD Rule 1168-[A2017], Adhesive and Sealant Applications.

1.3 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:
- .2 Provide manufacturer's printed product literature, specifications and datasheets for piping and equipment and include product characteristics, performance criteria, physical size, finish and limitations.

1.4 Delivery, Storage and Handling

- .1 Deliver, store and handle materials in accordance with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements:
 - .1 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .3 Packaging Waste Management: remove for reuse and return to supplier of packaging materials.

2. PRODUCTS

2.1 Material

- .1 Paint: zinc-rich to CAN/CGSB-1.181.
 - .1 Primers, Paints, Coatings: in accordance with manufacturer's recommendations for surface conditions.
 - .2 Primer: maximum VOC limit [250] g/L to Standard GS-11 and to SCAQMD Rule 1113.
 - .3 Paints: maximum VOC limit [150] g/L to Standard GS-11 and to SCAQMD Rule 1113.
- .2 Sealants: in accordance with Section 07 92 00 - Joint Sealants.
 - .1 Sealants: maximum VOC limit to SCAQMD Rule 1168 and to GSES GS-36.
- .3 Sealants: maximum VOC limit to SCAQMD Rule 1168 and to GSES GS-36.
- .4 Adhesives: maximum VOC limit to SCAQMD Rule 1168 and to GSES GS-36.
- .5 Fire Stopping: in accordance with Section 22 07 11 - Fire Stopping.

3. EXECUTION

3.1 Application

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

3.2 Connections to Equipment

- .1 In accordance with manufacturer's instructions unless otherwise indicated.
- .2 Provide line sized isolation valves at each piece of equipment.
- .3 Install unions or flanges downstream of isolation valves and at equipment or apparatus connection for ease of maintenance and assembly. Do not use direct welded or threaded connections to valves, equipment, or other apparatus.
 - .1 Unions are not required in installations using grooved mechanical couplings (The couplings shall serve as unions).
- .4 Install removable sections of pipe or 300 mm (12") spool pieces on the suction side of end suction pumps and where required for ease of maintenance.
- .5 Arrange piping connections to allow ease of access and for removal of equipment.
- .6 Align and independently support piping connections adjacent to equipment to prevent piping stresses being transferred.
- .7 Do not reduce equipment connection sizes by bushing.
- .8 Use double swing joints when equipment mounted on vibration isolation and when piping subject to movement.
- .9 The flexible type grooved joint couplings may be used in lieu of a flexible connector at equipment connections for vibration attenuation and stress relief. Couplings shall be placed in close proximity to the source of the vibration, as per manufacturer's recommendations.

3.3 Clearances

- .1 Provide clearance around systems, equipment and components for observation of operation, inspection, servicing, maintenance and as recommended by manufacturer and National Fire Code of Canada. Maintain a minimum of 25 mm (1") space between adjacent flanges or pipe insulation, whichever has the larger diameter.
- .2 Provide space for disassembly, removal of equipment and components as recommended by manufacturer or as indicated whichever is greater without interrupting operation of other system, equipment, components.
- .3 Provide adequate clearance for installation of insulation.

3.4 Drains

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

3.5 Air Vents

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

3.6 Dielectric Couplings

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

3.7 Pipework Installation

- .1 Install pipework to manufacturer's instructions and requirements.
- .2 Installation by certified journeyman.
- .3 Screwed fittings jointed with Teflon tape or pipe dope as recommended by manufacturer.
- .4 Grooved joint couplings and fittings shall be installed in accordance with the manufacturer's written installation instructions.
 - .1 Grooved ends shall be clean and free from indentations, projections, or roll marks.
 - .2 Gaskets shall be verified as suitable for the intended service prior to installation. Gaskets shall be molded and produced by the coupling manufacturer.
 - .3 The coupling manufacturer's factory trained representative shall provide on-site training for the contractor's field personnel in the use of grooving tools and installation of product. The representative shall periodically visit the job site to ensure best practices in grooved product installation are being followed and report their findings to the Consultant. A distributor's representative is not considered qualified to conduct the training or jobsite visit(s). Contractor shall remove and replace any joints deemed improperly installed.

- .5 During construction, protect all openings in piping and equipment, by capping or plugging to prevent entry of foreign material.
- .6 Install to isolate equipment and allow removal without interrupting operation of other equipment or systems.
- .7 Assemble piping using fittings manufactured to ANSI standards.
- .8 Saddle type branch fittings may be used on mains if branch line is no larger than half the size of main.
 - .1 Hole saw (or drill) and ream main to maintain full inside diameter of branch line prior to welding saddle.
- .9 Install exposed piping, equipment, rectangular cleanouts and similar items parallel or perpendicular to building lines.
- .10 Install concealed pipework to minimize furring space, maximize headroom, conserve space.
- .11 Slope piping, except where indicated, in direction of flow for positive drainage and venting.
- .12 Install, except where indicated, to permit separate thermal insulation of each pipe.
- .13 Group piping wherever possible and as indicated.
- .14 Ream pipe ends. Clean scale and dirt, inside and outside before and after assembly. Remove welding slag or other foreign material from piping.
- .15 Use eccentric reducers at pipe size changes to ensure positive drainage and venting.
- .16 Provide for thermal expansion as indicated.
 - .1 Engage manufacturer to provide piping system design services to accommodate thermal movement, seismic movement, and for the settlement of the piping system. The service includes required grooved piping components detailed in CAD on an overlay of the mechanical contract drawing(s), including anchor load calculations and placement of anchors. A calculation report showing thermal movement and accommodation shall also be provided. A design stamped by a qualified professional engineer from the jurisdiction in which the grooved piping products manufacturer is located or where the project is being constructed is required. Include cost in the tender price.
- .17 Valves:
 - .1 Install in accessible locations.
 - .2 Remove interior parts before soldering.
 - .3 Install with stems above horizontal position unless otherwise indicated.
 - .4 Valves accessible for maintenance without removing adjacent piping.
 - .5 Install globe valves in bypass around control valves.
 - .6 Use ball valves at branch take-offs for isolating purposes except where otherwise specified.
 - .7 Install butterfly valves on chilled water and related condenser water systems only.
 - .8 Install butterfly valves between weld neck flanges to ensure full compression of liner.
 - .9 Install plug cocks or ball valves for glycol service.
 - .10 Use chain operators on valves NPS 2-1/2 and larger where installed more than 2400 mm above floor in Mechanical Rooms.
- .18 Check Valves:
 - .1 Install silent check valves on discharge of pumps and in vertical pipes with downward flow and elsewhere as indicated.

- .2 Install check valves in horizontal lines on discharge of pumps and elsewhere as indicated.
- .19 At each seismic joint or seismic separation, provide flexible connections along with support of these systems on each side of the seismic joint or separation. Refer to this Section and Section 23 05 16 Vibration and Seismic Control for Mechanical.

3.8 Sleeves

- .1 General: Install where pipes pass through masonry, concrete structures, fire rated assemblies, and elsewhere as indicated.
- .2 Material: Schedule 40 black steel pipe.
- .3 Construction: Foundation walls and where sleeves extend above finished floors to have annular fins continuously welded on at mid-point.
- .4 Sizes: 6 mm minimum clearance between sleeve and uninsulated pipe or between sleeve and insulation for insulated pipe.
- .5 Installation:
 - .1 Concrete, masonry walls, and concrete floors on grade: Terminate flush with finished surface.
 - .2 Other floors: Terminate 25 mm above finished floor.
 - .3 Before installation, paint exposed exterior surfaces with heavy application of zinc-rich paint to CAN/CGSB-1.181.
- .6 Sealing:
 - .1 Foundation walls and below grade floors: Fire retardant, waterproof non-hardening mastic.
 - .2 Elsewhere: Provide space for fire stopping. Maintain fire rating integrity.
 - .3 Sleeves installed for future use: Fill with lime plaster or other easily removable filler.
 - .4 Ensure no contact between copper pipe or tube and sleeve.

3.9 Escutcheons

- .1 Install on pipes passing through walls, partitions, floors, and ceilings in finished areas.
- .2 Construction: One piece type with set screws. Chrome or nickel plated brass or type 302 stainless steel.
- .3 Sizes: Outside diameter to cover opening or sleeve. Inside diameter to fit around pipe or outside of insulation if so provided.

3.10 Preparation for Fire Stopping

- .1 Material and installation within annular space between pipes, ducts, insulation and adjacent fire separation to Section 23 07 11 – Fire Stopping.
- .2 Uninsulated unheated pipes not subject to movement: No special preparation.
- .3 Uninsulated heated pipes subject to movement: Wrap with non-combustible smooth material to permit pipe movement without damaging fire topping material or installation.
- .4 Insulated pipes and ducts: Ensure integrity of insulation and vapour barriers.

3.11 Flushing Out of Piping Systems

- .1 Before start-up, clean interior of piping systems in accordance with requirements of Section 01 74 00 - Cleaning supplemented as specified in Section 23 25 00 HVAC Water Treatment.
- .2 Preparatory to acceptance, clean and refurbish equipment and leave in operating condition, including replacement of filters in piping systems.

3.12 Pressure Testing of Equipment and Pipework

- .1 Advise Consultant or project manager 48 hours minimum prior to performance of pressure tests.
- .2 Pipework: Test as specified in relevant sections of Divisions 21, 22 & 23.
- .3 Maintain specified test pressure without loss for 4 hours minimum unless specified for longer period of time in relevant mechanical sections.
- .4 Prior to tests, isolate equipment and other parts which are not designed to withstand test pressure or media.
- .5 Conduct tests in presence of construction manager or project manager.
- .6 Pay costs for repairs or replacement, retesting, and making good. Consultant to determine whether repair or replacement is appropriate.
- .7 Insulate or conceal work only after approval and certification of tests by authorities.

3.13 Existing Systems

- .1 Connect into existing piping systems at times approved by Owner. Work to be carried out off hours after 5 p.m., weekends or holidays, or as indicated by Owner.
- .2 Request written approval by Owner, 10 days minimum, prior to commencement of work.
- .3 Be responsible for damage to existing plant by this work.

3.14 Cleaning

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

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 Materials and installation for meters, thermometers, and pressure gauges in piping systems.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted and coordinated with all other parts
- .2 Section 21 05 01 – Common Work Results for Mechanical
- .3 Section 25 09 01 –Control Systems

1.3 References

- .1 The latest revisions of the following standards shall apply
- .2 American Society of Mechanical Engineers (ASME).
 - .1 ASME B40.100 Pressure Gauges and Gauge Attachments.
 - .2 ASME B40.200 Thermometers, Direct Reading, and Remote Reading.
- .3 Canadian Standards Association
 - .1 CSA C22.2 No. 61010-1 Electrical Equipment for Measurement, Control and Laboratory Use; Part 1: General Requirements
 - .2 CAN/CSA-C22.2 No. 157 Intrinsically Safe and Non-incendive Equipment for Use in Hazardous (Classified) Locations.
 - .3 CSA C22.2 No. 213 Non-incendive Electrical Equipment for use in Class I, Div. 2 Hazardous Locations.

1.4 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and additionally the following:
- .2 Submit manufacturer's product data for following items:
 - .1 Flow Meters.
 - .2 Encoders, pulse heads and or data output modules
 - .3 Pressure gauges.
 - .4 Pressure gauge taps
 - .5 Thermometers.
 - .6 Wells.
 - .7 Test plugs
 - .8 Test thermometer

2. PRODUCTS

2.1 Acceptable Manufacturers

- .1 Refer to Section 23 05 01 – Acceptable Manufacturers

2.2 General

- .1 Select thermometers and pressure gauges so that their operating range falls in the middle half of the scale range.

2.3 Thermal Energy Flow Meters

- .1 Supplied by Division 25, installed by Division 23 Contractor.

2.4 Pressure Gauges

- .1 Case & Ring: 115 mm (4½”), cast aluminum, black steel, or stainless steel case with stainless steel or chrome plated face ring.
- .2 Lens: Shatter-proof acrylic.
- .3 Dial: Aluminum with white finish and black markings, both IP and metric graduations.
- .4 Pointer: Adjustable type, aluminum with black finish.
- .5 Movement: Rotary type bushed movement, silicone dampened to prevent pointer oscillation.
- .6 Pressure Element Assembly: Phosphor bronze bourdon tube.
- .7 Connection: Brass, 6 mm (1/4”) NPT, bottom-outlet.
- .8 Accuracy: Plus or minus one percent of entire range (ASME B40.1 Grade A).
- .9 Scale: Dual units, Kilopascal, and psig.
- .10 Listing:
 - .1 Registered with Provincial Boiler and Pressure Vessel Safety Branches with CRN number.
 - .2 ULC listed for use on fire protection systems.
- .11 Accessories:
 - .1 Install a needle valve ahead of each gauge.
 - .2 Install a pressure snubber ahead of each gauge.
 - .3 Install an anti-syphon loop (suitable for steam pressure) ahead of each gage on steam systems.

2.5 Differential Pressure Gauges

- .1 Magnehelic: 90 mm (3½”) diameter dial in case, diaphragm actuated, black figures on white background, front recalibration adjustment, (inclined type manometer and tubing, static pressure taps, and mounting assembly).

2.6 Pressure Gauge Taps

- .1 Needle Valve: Brass, 6mm (1/4”) NPT for minimum 2068 kPa (300 psi).
- .2 Ball Valve: Brass 6mm (1/4”) NPT for 1724 kPa (250 psi).
- .3 Pulsation Damper: Pressure snubber, brass with 6mm (1/4”) NPT connections

2.7 Thermometers – Duct/Panel Mounted

- .1 Type:
 - .1 Duct mounted dial type: solid liquid filled with remote capillary element.
 - .2 Panel mounted dial type (surface mount): vapour filled direct mounting.

- .3 Panel mounted dial type (flush mount): remote liquid filled capillary element.
- .2 Case & Ring: Dial-type, cast aluminum, black enamel steel, or stainless steel with stainless steel or chrome-plated face ring.
- .3 Size: 115 mm (4½”) diameter dial.
- .4 Lens: Clear Lexan.
- .5 Accuracy: plus or minus 2 percent of full scale.
- .6 Scale:
 - .1 White background with temperature range in black.
 - .2 Dual Celsius and Fahrenheit scale.

2.8 Thermometers – Piping

- .1 Case: cast aluminum alloy with anodized, powder coat or baked enamel finish.
- .2 Lens: Clear glass or heat resistant acrylic window.
- .3 Scale:
 - .1 225 mm (9 inch) scale length.
 - .2 White background with temperature range in black
 - .3 Dual Celsius and Fahrenheit scale.
- .4 Tube: non-toxic organic filled (non-mercury).
- .5 Adjustable Fitting: 180° adjustment in vertical plane and 360° adjustment in horizontal plane.
- .6 Connection: 30mm (1¼”) threaded brass coupling nut.
- .7 Stem: Aluminum, tapered to fit standard thermowells, packed with heat transfer paste to provide maximum temperature response.
- .8 Accuracy: plus or minus one percent of full scale.

2.9 Thermometer Wells

- .1 Material:
 - .1 Copper Pipe: Copper or bronze.
 - .2 Steel Pipe: Brass.
- .2 Size: 20 mm (¾”) NPT.
- .3 Brass separable sockets for thermometer stems with or without extensions, and with cap and chain. Provide extensions as required.
- .4 Registered with Provincial Boiler and Pressure Vessels Safety Branch with CRN number.

2.10 Test Plugs for Pressure / Temperature

- .1 6 mm (¼”) NPT solid brass test plug fitting and cap for receiving 3 mm (1/8”) O.D. pressure or temperature probe.
- .2 Dual seal core, Nordel EPDM, suitable for temperature of 177°C (350°F) and rated for zero leakage from vacuum to 6895 kPa (1000 psi).
- .3 Provide one (1) master test kit containing:
 - .1 One (1) gauge adaptor, 3 mm (1/8”) O.D. probe.
 - .2 Two (2) test pressure gauge of suitable range

- .3 Two (2) stem pocket testing thermometers of suitable range.

2.11 Test Thermometer

- .1 Hand over a test thermometer in protective case to the Owner during the Owner's Demonstration and Instruction Period. Provide the same make and type as the permanently installed thermometers suitable for use with pipe mounted wells. Range 0°C to 115°C. (30°F to 240°F).
- .2 Obtain two signed receipts from the Owner certifying that the test thermometer has been received. Hand one over to the Owner's Consultant.

3. EXECUTION

3.1 Application

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

3.2 Installation

- .1 Install thermometers and gauges so they can be easily read from floor or platform. If this cannot be accomplished, install remote reading units.
- .2 Install between equipment and first fitting or valve.
- .3 Install engraved lamacoid nameplates as specified in Section 23 05 53 – Identification for Mechanical Piping and Equipment, identifying medium.
- .4 Adjust gauges and thermometers to final angle, clean windows, and lenses, and calibrate to zero.

3.3 Flow Meters

- .1 Energy sub meters shall be supplied by Division 25 and installed under Division 22. Coordinate with Division 25.
- .2 The flow meter shall be sized and programmed by the manufacturer for each specific application and installed according to manufacturer's recommendations.
- .3 Pay special attention to straight pipe length requirements. Provide flow conditioners when required to meet the manufacturer's minimum upstream straight pipe run requirement.
- .4 Co-ordinate required output signals with the Division 25 Contractor.
- .5 For installations in non-metallic pipe, install grounding rings or probes as required.
- .6 Provide lateral and horizontal supports as required to minimize vibration at the meter location.
- .7 Final connection to the BAS shall be completed by Division 25 as per specifications. All wiring will be done in accordance with Canadian National Electric Code standards and regulations, and in conjunction with the local Electrical Safety Association office.

3.4 Pressure Gauges

- .1 Install pressure gauges with pulsation dampers for liquid service. Provide gauge cock or needle valve to isolate each gauge. Extend nipples to allow clearance from insulation.
- .2 Provide one compound pressure gauge per pump. Install taps on pump suction, pump discharge and before strainer. Pipe to gauge with needle valve on each tap.
- .3 Use extensions where pressure gauges are installed through insulation.

- .4 Provide air system static pressure gauges as indicated on the drawings and in the following locations:
 - .1 Medium and high pressure system.
 - .2 Supply fan discharge.

3.5 Differential Pressure Gauges

- .1 Provide filter differential pressure gauges as indicated on the drawings and at the following locations:
 - .1 Built-up filter banks.
 - .2 Unitary filter sections.
- .2 Provide air system static pressure taps as indicated on the drawings and at the following locations:
 - .1 Inlet and discharge of supply and return fans.
 - .2 Inlet and discharge of coils.
 - .3 Inlet and discharge of silencers.
 - .4 Inlet and discharge of mixing chambers.
 - .5 Inlet and discharge of humidifier section.
 - .6 Inlet and discharge of heat recovery sections.

3.6 Thermometers

- .1 Install in wells on piping. Provide heat conductive material inside well.
- .2 Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 65 mm (2½") for installation of thermometer sockets. Ensure sockets allow clearance from insulation.
- .3 Install thermometers in air duct systems on flanges.
- .4 Install thermometer sockets adjacent to control systems thermostat, transmitter, or sensor sockets.
- .5 Locate duct mounted thermometer minimum 3 metres (10 feet) downstream of mixing dampers, coils, or other devices causing air turbulence, whenever possible.
- .6 Coil and conceal excess capillary on remote element instruments.
- .7 Use extensions where thermometers are installed through insulation.
- .8 Provide stem type thermometers as indicated on the drawings and in the following locations:
 - .1 Headers to central equipment.
 - .2 Coil banks at inlet and outlet.
 - .3 Heat exchangers at inlet and outlet.
 - .4 Boilers at inlet and outlet.
 - .5 Chillers at inlet and outlet.
 - .6 Heat pumps at inlet and outlet.
 - .7 Cooling tower/fluid coolers at inlet and outlet.
 - .8 DHW tanks.
- .9 Provide dial type thermometers as indicated on the drawings and in the following locations:

- .1 After coils in air systems.
- .2 Each supply air zone.
- .3 Outside air intake.
- .4 Return air plenum.
- .5 Mixed air plenum.

3.7 Thermometer Wells

- .1 Install wells for balancing purposes.
- .2 Install wells where indicated for use with test thermometers.
- .3 Provide thermometer wells as indicated on the drawings and in the following locations:
 - .1 All lines to three way control valves.
 - .2 Individual return lines from heating and cooling coils.

3.8 Pressure / Temperature Ports

- .1 Install pressure/temperature ports into threaded pipe nipples welded to wall of pipe. Locate fittings in accessible spaces.
- .2 Provide one pressure / temperature port test kit.
- .3 Coordinate locations with the balancing agent to ensure all ports are provided as required for testing and balancing services.
- .4 Install pressure / temperature ports in the following locations:
 - .1 Both sides of two-way control valves.
 - .2 All lines to three-way control valves.
 - .3 Heating and cooling coils: At common inlet and outlet of each coil.
 - .4 Heat exchanger: At inlet and outlet.
 - .5 Chiller: At inlet and outlet of chilled water and condenser water.
 - .6 Finned tube elements: At inlet and outlet.
 - .7 Radiant heaters: At inlet and outlet.
 - .8 In-slab radiant heating zones: At inlet and outlet to manifolds.
 - .9 Reheat coils: At inlet and outlet.

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 Materials and installation for hangers and supports for mechanical and plumbing piping, ducting and equipment.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical
- .3 Section 23 05 48 – Vibration and Seismic Control for Mechanical.

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
- .2 American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME)
 - .1 ANSI/ASME B31.1 – Power Piping.
- .3 ASTM International
 - .1 ASTM A125 – Standard Specification for Steel Springs, Helical, Heat-Treated.
 - .2 ASTM A307 – Standard Specification for Carbon Steel Bolts, Studs and Threaded Rod, 60,000 PSI Tensile Strength.
 - .3 ASTM A563 – Standard Specification for Carbon and Alloy Steel Nuts.
- .4 [Factory Mutual (FM)]
- .5 Manufacturer's Standardization Society of the Valves and Fittings Industry (MSS)
 - .1 MSS SP58 – Pipe Hangers and Supports - Materials, Design and Manufacture.
- .6 Underwriter's Laboratories of Canada (ULC)
- .7 Canadian Standards Association
 - .1 CSA B149.1 – Natural Gas and Propane Code

1.4 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and additionally the following:
 - .1 Submit shop drawings for:
 - .1 Bases, hangers and supports.
 - .2 Connections to equipment and structure.
 - .3 Structural assemblies.
 - .2 Certificates:
 - .1 Submit certificates from the manufacturer certifying that materials comply with specified performance characteristics and physical properties of the listed Related Standards.
 - .3 Manufacturers' Instructions:
 - .1 Provide manufacturer's installation instructions.

1.5 General Requirements

- .1 Plumbing piping: to BC Plumbing Code
- .2 Fire protection: to applicable NFPA Standards.
- .3 Natural gas/propane piping: to CSA B149.1 Natural Gas and Propane Code
- .4 Construct pipe hangers and supports to manufacturer's recommendations utilizing manufacturer's regular production components, parts and assemblies.
- .5 Base maximum load ratings on allowable stresses prescribed by ASME B31.1 or MSS SP58.
- .6 Ensure that supports, guides, anchors do not transmit excessive quantities of heat to building structure.
- .7 Design hangers and supports to support systems under conditions of operation, allow free expansion and contraction, prevent excessive stresses from being introduced into pipework or connected equipment.
- .8 Provide for vertical adjustments after erection and during commissioning. Amount of adjustment in accordance with MSS SP58.
- .9 Provide hangers and supports to secure equipment in place, prevent vibration, protect against damage from earthquake, maintain grade, provide for expansion and contraction and accommodate insulation.
- .10 Support from (top of) structural members. Where structural bearings do not exist or inserts are not in suitable locations, suspend hangers from steel channels or angles. Provide supplementary structural members, as necessary.
- .11 Arrange and pay for the services of a BC registered professional engineer to provide all required engineering services necessary for the complete design, sizing and detailing of all anchors and anchor supports to structure required for the project.

2. PRODUCTS

2.1 Acceptable Manufacturers

- .1 Refer to Section 23 05 01 – Acceptable Manufacturers

2.2 General

- .1 Fabricate hangers, supports and sway braces in accordance with ANSI B31.1 and MSS SP58.
- .2 Use components for intended design purpose only. Do not use for rigging or erection purposes.
- .3 Toggle hangers and/or strap hangers shall not be used.
- .4 Power actuated fasteners and “drop-in” anchors shall not be used for tension load applications such as pipe and duct hangers.

2.3 Pipe Hangers

- .1 Finishes:
 - .1 Pipe hangers and supports: galvanized.
 - .2 Ensure steel hangers in contact with copper piping are copper plated, epoxy coated or have a non-metallic sleeve coupling between the dissimilar metals.
- .2 Upper attachment structural: suspension from lower flange of I-Beam:

- .1 Cold piping NPS 2 maximum: malleable iron C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip.
- .2 Cold piping NPS 2½ or greater, hot piping: malleable iron beam clamp, eye rod, jaws and extension with carbon steel retaining clip, tie rod, nuts and washers, UL listed, FM approved to MSS-SP58.
- .3 Upper attachment structural: suspension from upper flange of I-Beam:
 - .1 Cold piping NPS 2 maximum: ductile iron top-of-beam C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip, UL listed, FM approved.
 - .2 Cold piping NPS 2 ½ or greater, hot piping: malleable iron top-of-beam jaw-clamp with hooked rod, spring washer, plain washer and nut UL listed, FM approved.
- .4 Upper attachment to concrete:
 - .1 Ceiling: carbon steel welded eye rod, clevis plate, clevis pin and cotters with weldless forged steel eye nut. Ensure eye 6 mm (¼”) minimum greater than rod diameter.
 - .2 Concrete inserts: wedge shaped body with knockout protector plate UL listed, FM approved. Size inserts to suit threaded hanger rod diameter. Refer to “minimum rod diameter” table below.
- .5 Shop and field-fabricated assemblies:
 - .1 Trapeze hanger assemblies and steel brackets: to ASME B31.1 and MSS SP58.
 - .2 Sway braces for seismic restraint systems: to Section 23 05 48 - Vibration and Seismic Control for Mechanical.
- .6 Hanger rods: threaded rod material to MSS SP58:
 - .1 Minimum rod for fire suppression is 9 mm (¾”) UL listed or 13 mm (½ inch) for FM approved.
 - .2 Ensure that hanger rods are subject to tensile loading only.
 - .3 Provide linkages where lateral or axial movement of pipework is anticipated.

Maximum Pipe Size NPS	Minimum Rod Diameter mm (in)	Maximum Rod Length mm (in)
up to 2	9 (3/8)	n/a
2-1/2 to 3	12 (1/2)	635 (25)
4 to 5	16 (5/8)	785 (31)
6	20 (3/4)	940 (37)
8 to 12	22 (7/8)	1090 (43)
14	25 (1)	1270 (50)
16	30 (1-1/4)	1575 (62)

- .4 Provide reinforcing hanger angle for rod lengths in excess of maximum length as scheduled by the Seismic Engineer. Refer to Section 23 05 48 – Vibration and Seismic Control for Mechanical.
- .7 Pipe attachments: material to MSS SP58:
 - .1 Attachments for steel piping: carbon steel galvanized.
 - .2 Attachments for copper piping: copper plated black steel.
 - .3 Use insulation shields for cold pipework.

- .4 Oversize pipe hangers and supports to accommodate insulation thickness and maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
- .8 Adjustable clevis: material UL listed and FM approved, clevis bolt with nipple spacer and vertical adjustment nuts above and below clevis.
- .9 Yoke style pipe roll: carbon steel yoke, rod and nuts with cast iron roll.
- .10 U-bolts: carbon steel with 2 nuts at each end to ASTM A563.
 - .1 Finishes for steel pipework: galvanized.
 - .2 Finishes for copper, glass, brass or aluminum pipework: galvanized with formed portion plastic coated or epoxy coated.
- .11 Pipe rollers: cast iron roll and roll stand with carbon steel rod.

2.4 Riser Clamps

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

2.5 Insulation Protection Shields

- .1 Insulated cold piping:
 - .1 64 kg/m³ (4 lb/ft³) density insulation plus insulation protection shield, galvanized sheet carbon steel. Length designed for maximum 3 m (10 foot) span.
 - .2 Non-metallic support coupling, sized to suit standard and millimeter pipe O.D. UL listed, meeting 25/50 flame and smoke spread ratings. Supplied with hanger and/or strut mount as a complete support assembly.
- .2 Insulated hot piping:
 - .1 Curved plate 300 mm (12 inch) long, with edges turned up, welded-in centre plate for pipe sizes NPS 300 mm (12 inch) and over.
 - .2 For piping to 60°C (140°F) Non-metallic support coupling, sized to suit standard and millimeter pipe O.D. UL listed, meeting 25/50 flame and smoke spread ratings. Supplied with hanger and/or strut mount as a complete support assembly.

2.6 Constant Support Spring Hangers

- .1 Springs: alloy steel to ASTM A125, shot peened, magnetic particle inspected, with +/-5% spring rate tolerance, tested for free height, spring rate, loaded height and provided with Certified Mill Test Report (CMTR).
- .2 Load adjustability: 10 % minimum adjustability each side of calibrated load. Adjustment without special tools. Adjustments not to affect travel capabilities.
- .3 Provide upper and lower factory set travel stops.
- .4 Provide load adjustment scale for field adjustments.
- .5 Total travel to be actual travel + 20%. Difference between total travel and actual travel 25 mm (1") minimum.
- .6 Individually calibrated scales on each side of support calibrated prior to shipment, complete with calibration record.

2.7 Variable Support Spring Hangers

- .1 Vertical movement: 13 mm (½") minimum, 50 mm (2") maximum, use single spring pre-compressed variable spring hangers.
- .2 Vertical movement greater than 50 mm (2"): use double spring pre-compressed variable spring hanger with 2 springs in series in single casing.
- .3 Variable spring hanger complete with factory calibrated travel stops. Provide certificate of calibration for each hanger.
- .4 Steel alloy springs: to ASTM A125, shot peened, magnetic particle inspected, with +/-5 % spring rate tolerance, tested for free height, spring rate, loaded height and provided with CMTR

2.8 Equipment Supports

- .1 Fabricate equipment supports not provided by equipment manufacturer from structural grade steel meeting requirements of Division 5. Submit calculations with shop drawings.

2.9 Equipment Anchor Bolts and Templates

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

2.10 Other Equipment Supports

- .1 Fabricate equipment supports from structural grade steel meeting requirements of Division 5.
- .2 Submit structural calculations with shop drawings.

3. EXECUTION

3.1 Manufacturer's Instructions

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

3.2 Installation

- .1 Install in accordance with manufacturer's instructions and recommendations.
- .2 Vibration Control Devices:
 - .1 Install on piping systems at pumps, boilers, chillers, cooling towers, and as indicated.
- .3 Clamps on riser piping:
 - .1 Support independent of connected horizontal pipework using riser clamps and riser clamp lugs welded to riser.
 - .2 Bolt-tightening torques to industry standards.
 - .3 Steel pipes: install below coupling or shear lugs welded to pipe.
 - .4 Cast iron pipes: install below joint.
- .4 Clevis plates:
 - .1 Attach to concrete with 4 minimum concrete inserts, one at each corner.
- .5 Provide supplementary structural steelwork where structural bearings do not exist or where concrete inserts are not in correct locations.
- .6 Use approved constant support type hangers where:

- .1 Vertical movement of pipework is 13 mm (½”) or more,
- .2 Transfer of load to adjacent hangers or connected equipment is not permitted.
- .7 Use variable support spring hangers where:
 - .1 Transfer of load to adjacent piping or to connected equipment is not critical.
 - .2 Variation in supporting effect does not exceed 25 % of total load.

3.3 Hanger Spacing

- .1 Flexible joint roll groove pipe: in accordance with table below, but not less than one hanger at joints.
- .2 Within 300 mm (12”) of each elbow.

Maximum Pipe Size NPS	Maximum Spacing Steel m (ft)	Maximum Spacing Copper m (ft)	Minimum Rod Dia mm (in)
up to 1/2	1.8 (6)	1.5 (5)	9 (3/8)
3/4, 1, 1-1/4	2.4 (8)	1.8 (6)	9 (3/8)
1-1/2, 2	3.0 (10)	2.4 (8)	9 (3/8)
2-1/2, 3, 4	3.7 (12)	3.0 (10)	12 (1/2)
5, 6, 8	4.3 (14)		16 (5/8)
10, 12	4.9 (16)		

- .3 For other plastic piping, provide supports at intervals recommended by manufacturer.

3.4 Hanger Installation

- .1 Install hanger so that rod is vertical under operating conditions.
- .2 Adjust hangers to equalize load.
- .3 Support from structural members. Where structural bearing does not exist or inserts are not in suitable locations, provide supplementary structural steel members.
- .4 Do not support from metal deck.
- .5 Install hangers to provide minimum 13 mm (½”) space between finished covering and adjacent work.
- .6 Support vertical piping at every other floor.
- .7 Where several pipes can be installed in parallel and at the same elevation, provide multiple or trapeze hangers.
- .8 Support riser piping independently of connected horizontal piping.
- .9 Install plastic inserts between steel studs and piping.
- .10 Provide insulation protection saddles on all insulated piping.

3.5 Horizontal Movement

- .1 Angularity of rod hanger resulting from horizontal movement of pipework from cold to hot position not to exceed 4 degrees from vertical.
- .2 Where horizontal pipe movement is less than 13 mm (½”), offset pipe hanger and support so that rod hanger is vertical in the hot position.

3.6 Final Adjustment

- .1 Adjust hangers and supports:
 - .1 Ensure that rod is vertical under operating conditions.
 - .2 Equalize loads.
- .2 Adjustable clevis:
 - .1 Tighten hanger load nut securely to ensure proper hanger performance.
 - .2 Tighten upper nut after adjustment.
- .3 C-clamps:
 - .1 Follow manufacturer's recommended written instructions and torque values when tightening C-clamps to bottom flange of beam.
- .4 Beam clamps:
 - .1 Hammer jaw firmly against underside of beam.

3.7 Inserts

- .1 Install in accordance with manufacturer's recommendations.
- .2 Use inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams wherever practical.
- .3 Set inserts in position in advance of concrete work. Use grid system in equipment rooms.
- .4 Provide reinforcement rod in concrete for inserts carrying piping over 100 mm (4") or ducts over 1500 mm (60") wide.
- .5 Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 The work in this section includes, but is not limited to the following:
 - .1 Vibration isolation for piping, ductwork, and equipment.
 - .2 Equipment isolation bases.
 - .3 Flexible piping connections.
 - .4 Seismic restraints for isolated equipment.
 - .5 Seismic restraints for non-isolated equipment.
 - .6 Certification of seismic restraint designs and installation supervision.
 - .7 Certification of seismic attachment of housekeeping pads.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical.
- .3 Section 23 21 16 – Hydronic Piping Specialties.
- .4 Section 23 33 00 - Duct Accessories.

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
- .2 Applicable Building Code: Refer to Section 21 05 01 – Common Work Results for Mechanical.
- .3 National Fire Protection Association (NFPA):
 - .1 NFPA 13-[2013] – Standard for the Installation of Sprinkler Systems.
- .4 Sheet Metal and Air Conditioning Contractors National Association (SMACNA):
 - .1 SMACNA – Seismic Restraint Manual Guidelines for Mechanical Systems.
- .5 American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE):
 - .1 ASHRAE HVAC Applications Handbook (Seismic Design Chapter 54).
- .6 Federal Emergency Management Agency (FEMA):
 - .1 FEMA – Installing Seismic Restraints for Mechanical Equipment.
- .7 Vibration Isolation and Seismic Control Manufacturers Association (VISCMA):
 - .1 VISCMA – Installing Seismic Restraints for Mechanical Equipment.

1.4 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and additionally the following:
 - .1 Consultant Assurance of Professional Design and Commitment for Field Review by Supporting Registered Professional Schedule S-B and Assurance of Professional Field Review and Compliance by Supporting Registered Professional Schedule S-C for seismic engineering.

- .2 Shop drawings: submit drawings for vibration control stamped and signed by a Professional Engineer.
- .3 Shop drawings: submit drawings for seismic control stamped and signed by a Professional Engineer registered or licensed in Province of British Columbia.
- .4 Provide separate shop drawings for each isolated system complete with performance and product data.

1.5 General Requirements

- .1 All mechanical equipment, piping, and ductwork as noted on the equipment schedule or in the specification shall be mounted on vibration isolators to prevent the transmission of vibration and mechanically transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.
- .2 Provide seismic restraints for all required equipment, piping, and ductwork.
- .3 Responsibilities:
 - .1 The Contractor shall retain the services of a qualified professional seismic engineer (Seismic Engineer) registered in the Province of British Columbia. The Seismic Engineer shall design and review the installation of all seismic restraints as well as mechanical equipment and mechanical system supports. The restraints and supports shall be specifically designed to fasten to the structure indicated in the contract documents and installed in the field. The complete design for these systems shall comply with all applicable building code requirements.
 - .2 Seismic Engineer shall provide and submit to the Owner's Consultant Assurance of Professional Design and Commitment for Field Review by Supporting Registered Professional Schedule S-B and Assurance of Professional Field Review and Compliance by Supporting Registered Professional Schedule S-C for seismic engineering.
 - .3 Manufacturer of vibration isolation and seismic control equipment shall have the following responsibilities:
 - .1 Determine vibration isolation and seismic restraint sizes and locations.
 - .2 Provide vibration isolation and seismic restraints as scheduled or specified.
 - .3 Provide calculations and materials if required for restraint of non-isolated equipment.
 - .4 Provide installation instructions, drawings and trained field supervision to insure proper installation and performance.
- .4 All isolators and isolation materials shall be of the same manufacturer and shall be certified by the manufacturer.
- .5 It is the intent of the seismic portion of this specification to keep all mechanical and electrical building system components in place during a seismic event.
- .6 All such systems must be installed in strict accordance with seismic codes, component manufacturer's, and building construction standards. Whenever a conflict occurs between the standards, the most stringent shall apply.
- .7 Seismic restraints shall be designed in accordance with seismic force levels as indicated in the Building Code for the specific region of the project.
- .8 All elastomeric components in isolation pads, mounts, and seismic snubbers shall be bridge bearing neoprene, meeting CSA Standard CAN3-S6 Section 11.10.

- .9 Provide an acceptable means of corrosion protection for all equipment, attachments, and accessories supplied under this section, suitable for the conditions in which this equipment, etc. will be installed.
- .10 Bolt all equipment to the structure. Do not bridge isolation elements.
- .11 Use ductile materials in all vibration isolation equipment.
- .12 Motor Drive Equipment:
 - .1 Provide vibration isolation on all motor driven fans regardless of power rating and all other motor driven equipment over 0.35 kW (0.5 HP) (as indicated on the motor nameplate), and on piping and ductwork specified herein.
 - .2 For fans less than 0.35 kW (0.5 HP), provide isolation with neoprene grommets at the support points. Select isolators for a minimum static deflection of 3mm.
 - .3 Fire pumps and jockey pumps driven by electric motors are excluded.
 - .4 Provide horizontal limit springs on all fans (except vertical discharge) having a static pressure in excess of 1.0 kPa static pressure, and on hanger supported, horizontally mounted axial fans with more than 330 N thrust due to static pressure. The springs shall limit the movement of flexible duct connections to 25% of the fabric width under steady state conditions and to 40% at start-up.
- .13 Isolators:
 - .1 Provide neoprene isolators for deflections 6mm ($\frac{1}{4}$ ") and under.
 - .2 Provide either neoprene or steel spring isolators for deflections between 6mm and 12mm ($\frac{1}{2}$ ").
 - .3 Provide steel spring isolators for deflections of 12mm ($\frac{1}{2}$ ") and over.
 - .4 Provide adjustable limit stops for spring isolation mounts on equipment with operating weights substantially different from the installed weights.
 - .5 All spring isolators shall be "open spring" unless otherwise stated. Seismically rated housed spring isolators may be used in lieu provided that they meet this project's requirements for seismic restraint.
 - .6 Isolators and bases which are factory supplied with equipment shall meet the requirements of this section. Where internal isolation is provided, the isolation requirements specified in the minimum static deflection table apply to all separate vibration sources in the unit. Where internal vibration isolation is not provided, the unit frame shall be rigid enough such that the isolators can be attached directly without additional stiffening.
 - .7 Space isolators under equipment so that the minimum distance between adjacent corner isolators is at least equal to the height of the center of gravity of the equipment. Include height of center of gravity on shop drawings. Otherwise, provide suitable horizontal restraint isolators.
 - .8 Select isolators in accordance with equipment weight distribution to allow for an average deflection meeting or exceeding the specified deflection requirements and so that no isolator has a deflection less than 80% of the static deflection specified. A minimum of 4 isolators are required for each piece of equipment, unless specified otherwise. Number and colour code each isolator to show location. Mark code number and colour on shop drawings, on each isolator and on each base to ensure proper placement. Clearly tag all springs to show undeflected height and static deflection.
 - .9 Refer to the minimum static deflection table contained in this Section.
- .14 Bases:

- .1 Provide all concrete inertia bases where specified or required by equipment manufacturers. Bases to be located between the vibrating equipment and the vibration isolation elements. Provide concrete inertia bases for centrifugal fans with static pressure in excess of 0.875 kPa (3.5" SWG) and/or motors in excess of 30 kW (40 HP) and on base mounted pumps over 15 kW (20 HP), except slab on grade installations or unless otherwise specified. Provide concrete inertia bases on all plug fans that also require thrust restraints.
 - .2 Other than equipment requiring concrete inertia bases, provide structural steel bases for all vibration isolated equipment, unless the equipment manufacturer certifies direct attachment capabilities.
 - .3 Co-ordinate with Division 03 for the provision of housekeeping pads at least 100 mm (4") high under all isolated equipment. Provide at least 175 mm (7") clearance between drilled inserts and edge of housekeeping pads and follow structural consultant's instructions for drilled inserts.
- .15 Ducting:
- .1 Install flexible duct connectors on all ductwork connected to isolated equipment.
- .16 Piping Hangers:
- .1 Provide resilient hangers on all piping, etc., rigidly connected to vibration isolated equipment. Provide the hangers for a distance of 3.0m (9.75') for a 1 NPS pipe and 13.5m (44') for a 10 NPS pipe. Isolate other pipe sizes for a proportionate distance (both interpolation and extrapolation may be required). Select the three closest hangers to the vibration source for the lesser of 25mm (1") static deflection or the static deflection of the isolated equipment. Select the remaining isolators for the lesser of 25mm (1") static deflection or one-half the static deflection of the isolated equipment.
 - .2 Where resilient hangers cannot be provided for piping rigidly connected to vibration isolated equipment (such as a rigid fire-stop falling within the required isolation distance), provide flexible connectors. One end of each flexible connector shall be installed directly to a flange of the isolated equipment (between the equipment and isolation valves) unless otherwise indicated on the drawings.
- .17 Electrical Connections:
- .1 Coordinate with the Division 26 to ensure all electrical connections to vibration isolated equipment is made with flexible conduit or other flexible means and does not restrict the maximum anticipated movement.

1.6 Regulatory Requirements

- .1 Tested values must show that the seismic restraint hardware used in conjunction with the vibration isolation product is capable of withstanding the increased forces, as calculated for the specific project, using the formulae provided in the applicable building code.
- .2 Supply isolators and seismic restraints meeting the structural requirements of the building code, including Section 4.1.8.18 with respect to seismic snubbers, or provide equivalent requirements where integral seismic restraint is provided in isolators / bolting.

Referenced code section is correct for Include building code Section 6.2.1.6(2). Vibration isolator housings are considered a safety guard with respect to isolated equipment and any contained compressed springs. Include "Fail Safe" seismic restraint in all vibration isolation designed to hold mechanical equipment and springs in place.

2. PRODUCTS

2.1 General

- .1 Isolation, anchors, bolts, bases, restraints, etc., are to be designed to withstand without failure or yielding, the dynamic G load as specified in Code for the seismic zone in which building is located. Design loads are ultimate limit state loads (1.5 times working load) acting through the centre of gravity of the anchored or restrained equipment. "Fail Safe" designs are acceptable.
- .2 For both isolated and non-isolated floor mounted equipment, i.e. tanks, heat exchangers, boilers, etc., design and provide anchors and bolts to withstand, without failure or yielding, a dynamic ultimate limit state load as defined in Code, of the greater of 0.3 g or as required by Code, applied horizontally through the centre of gravity.
- .3 Where impact forces may be significant, use ductile materials.
- .4 Seismic restraining devices factory supplied with equipment are to meet requirements of this Section.

2.2 Acceptable Manufacturers

- .1 Refer to Section 23 05 01 – Acceptable Manufacturers.

2.3 Open Spring Mounts

- .1 Base mount free-standing assemblies, each complete with a stable colour coded steel spring welded in place, drilled mild steel mounting plate bonded to a ribbed rubber or neoprene acoustical pad, and an external 16 mm (5/8") diameter level adjustment bolt.

2.4 Closed Spring Mounts

- .1 Base mount free-standing enclosed assemblies, each complete with stable colour coded spring(s), 2 piece cast housing, non-binding rubber horizontal stabilizers, a ribbed rubber or neoprene acoustical pad bonded to base of the closed housing, and an external level adjustment bolt.

2.5 Totally Retained Spring Mounts

- .1 Base mount free-standing enclosed and retained assemblies to limit both vertical and lateral movement of mounted equipment, each complete with stable colour coded spring(s), drilled welded steel housing and top plate, ribbed rubber or neoprene acoustical pad bonded to bottom of housing, vertical limit adjusting hardware, and a level adjustment bolt.

2.6 Type 1 - Neoprene Pad Isolators

- .1 Neoprene or neoprene / steel / neoprene pad isolators.
- .2 Minimum static deflection 2.5 mm (0.1") or greater.
- .3 Use hold down bolts selected for seismic loads. Isolate bolts from base of unit using neoprene washer/bushing.
- .4 Size bolt and washer/bushing for minimum lateral clearance.

2.7 Type 2 - Rubber Floor Mounts

- .1 Bridge bearing neoprene mountings.
- .2 Minimum static deflection of 5mm (0.2") or greater and all directional seismic capability.

- .3 The mount shall consist of a ductile iron casting containing two separated and opposing molded neoprene elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock absorbing neoprene materials shall be compounded to bridge bearing specifications.

2.8 Type 3 - Spring Floor Mounts

- .1 Spring isolators shall be free standing, laterally stable and supplied complete with a lower molded neoprene acoustical cup or 1/4" (6mm) neoprene acoustical friction pad between the baseplate and the support.
- .2 All mountings shall have a leveling bolt that allows for rigid attachment to the equipment.
- .3 Spring diameters shall be no less than 0.8 of compressed height at rated load and have an additional travel to solid equal to 50% of rated deflection.
- .4 Nominal static deflection shall be 25 mm. No spring shall be loaded to less than 70% of its rated capacity nor exceed manufactures capacity.
- .5 Open springs may be used in conjunction with Type 5 or 5PD seismic snubbers or housed in a seismically rated housing. Where spring is housed to meet seismic requirements, the housing shall be of ductile iron or steel construction and allow for all directional seismic snubbing. The snubber shall be vertically adjustable and designed for a maximum of 6.4 mm travel in all directions. Potential impact areas to be protected by a minimum of a 3.2 mm neoprene bushing. Submittals to include spring diameter, rated deflection, spring constant, and free and operating height.

2.9 Type 3A - Spring Isolators for Variable Weight Equipment (Chillers, Cooling Towers)

- .1 Restrained spring mountings shall incorporate spring (Type 3), within a rigid steel housing that includes a minimum of two vertical limit stops to prevent spring extension when weight is removed. The housing shall serve as blocking during installation and steel spacers shall be removed after adjustment such that the installed and operating heights are the same.
- .2 An air gap of 3 mm in all directions, before contact is made between the rigid and resilient surfaces, shall be incorporated into the design. Limit stops shall be out of contact during normal operation.
- .3 Since housing may be bolted or welded into position, there must be an internal isolation pad under the springs. Housing shall be designed to resist seismic forces.

2.10 Type 5 - Seismic Snubbers

- .1 Omni-directional seismic snubbers consisting of interlocking steel members restrained by a one piece molded neoprene bushing of bridge bearing neoprene.
- .2 Bushing shall be replaceable and a minimum of 6mm (1/4") thick.
- .3 Rated loadings shall not exceed 6895 kPa (1000 psi).
- .4 A minimum air gap of 3mm (1/8") shall be incorporated in the snubber design in all directions before contact is made between the rigid and resilient surfaces. Snubber end caps shall be removable to allow inspection of internal clearances. Ensure neoprene bushing can easily be rotated by hand after installation ensure no short circuits exist before systems are activated.

2.11 Type 6N – Neoprene Isolation: Curb Mounted Rooftop Equipment

- .1 Internally isolated curb mounted equipment shall be externally isolated on 12 mm thick perimeter strips of closed cell neoprene sponge of appropriate density and width to ensure that deflection under load does not exceed 3 mm. Bridge bearing quality neoprene hemi-grommets or washers and cylinders must be used in conjunction with the neoprene sponge to ensure that the isolation is not compromised by the required anchor bolts.

2.12 Type 6S - Continuous Rail Type Isolation for Roof Mounted Equipment

- .1 Continuous rooftop isolation shipped completely assembled, consisting of:
 - .1 galvanized steel sections formed to fit roof curb and associated equipment with a flexible air and weather seal joining upper and lower rail sections;
 - .2 stable springs, cadmium plated and selected to provide minimum deflection with 50% additional travel to solid;
 - .3 neoprene cushioned and wind restraints allowing 6 mm (¼") movement before engaging and resisting wind loads in any lateral direction.

2.13 Type 7N – Neoprene Hangers

- .1 Double deflection neoprene hangers shall consist of a rigid steel frame containing a neoprene element with an upper embedded steel washer and an integral bottom flange, which will protrude, and friction fit into the lower circular opening of the hanger frame. The lower hole in the hanger box shall be of a large enough diameter to permit the threaded hanger rod to swing through a minimum 30° arc from side to side before contacting the neoprene flange. Nominal static deflection under load shall be 5mm. No hanger shall be loaded to less than 50% of this deflection nor exceed the manufacturers maximum recommended loading.

2.14 Type 7S – Spring Isolation Hangers

- .1 Spring isolation hangers shall consist of a rigid steel frame containing a steel spring (see Type 3) and shall be seated in a steel washer reinforced neoprene cup. This cup shall have a neoprene bushing projecting through the steel box. Spring diameters and hanger box lower hole diameters shall be large enough to permit the hanger rod to swing through a 30° arc from side to side before contacting the protruding neoprene bushing. Spring selection and submittal data similar to that for Type 3.

2.15 Type 7SN - Spring Hangers with Neoprene Elements

- .1 Hangers shall consist of rigid steel frames containing minimum 32mm (1 ¼") thick neoprene elements at the top and a steel spring seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box.
- .2 Provide a combination rubber and steel rebound washer as the seismic up stop for suspended piping, ductwork, and equipment. Rubber thickness shall be a minimum of 6mm (¼").
- .3 To maintain stability the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring.
- .4 Spring diameters and hanger box lower hole diameters shall be large enough to permit the hanger rod to swing through a 30° arc from side to side before contacting the protruding neoprene bushing.
- .5 Colour coded springs, rust resistant, painted box type hangers.

2.16 Type 8 - Neoprene Washer/Bushing

- .1 A one piece molded bridge bearing neoprene washer/bushing. The bushing shall surround the anchor bolt and have a flat washer face to avoid metal to metal contact.
- .2 Use washer/bushing only on light-weight equipment.

2.17 Type 9 – Horizontal Thrust Restraints

- .1 Spring isolated air handling equipment shall be fitted with horizontal thrust restraints design to keep movement due to thrust to $\pm 1/4"$ at equipment start and stop.

- .2 Restraints shall consist of a pair of Type 3 springs, complete with neoprene molded cups having the same deflection as those specified for the equipment. The restraints shall be attached at the centreline of the thrust and symmetrical on each side of the unit.

2.18 Type 10 – Acoustical Split Wall Seals

- .1 Split wall seals shall consist of two bolted pipe halves with a minimum 18 mm thick neoprene sponge bonded to the liner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping.
- .2 Concrete may be packed around the seal to make it integral with the floor, wall, or ceiling if the seal is not already in place around the pipe prior to the construction of the building member. Seals shall project a minimum 25 mm past both sides of the wall.
- .3 Where temperatures exceed 113°C 10# density fiberglass may be used in lieu of the sponge.

2.19 Type 11 - Pipe Riser Anchor

- .1 All directional acoustical pipe anchors shall consist of two sizes of steel tubing separated by a minimum 12 mm thick 60 durometer neoprene. Vertical restraint shall be provided by similar material arranged to prevent vertical travel in either direction. Allowable loads on the isolation material should not exceed 500 psi (0.35 kg/mm²) and be designed to balance for equal resistance in any direction.
- .2 Provide hot application isolators as required.

2.20 Type 12 – Pipe Riser Guides

- .1 Guides are to be used in conjunction with Type 3 spring isolators and shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum 12 mm thick 60 durometer neoprene. The height of the guides shall be preset with a shear pin to allow for vertical motion due to pipe expansion or contraction. Guides shall be capable of ±40 mm motion or to meet project requirements.

2.21 Type 13 - Flexible Piping Connections

- .1 Flexible piping connectors are to be supplied with seismic restraint materials.
- .2 Where flexible connections are not specified with piping in other Sections they are to be as specified herein.
- .3 Expansion joints shall be peroxide cured EPDM throughout with Kevlar® tire cord reinforcement. Substitutions must have certifiable equal or superior characteristics. The raised face rubber flanges must encase solid steel rings to prevent pull out. Flexible cable wire is not acceptable.
- .4 Sizes 3/4" through 2" (19mm through 50mm) may have one sphere, bolted threaded flange assemblies, and cable retention.
- .5 Sizes 1 1/2" through 14" (40mm through 350mm) shall have a ductile iron external ring between the two spheres. Sizes 16" through 24" (400mm to 600mm) may be single sphere.
- .6 Minimum ratings through 14" (350mm) shall be 250psi at 170°F and 215psi at 250°F. (1.72MPa at 77°C and 1.48MPa at 121°C), 16"(400mm) through 24"(600mm) 180psi at 170°F and 150psi at 250°F. (1.24MPa at 77°C and 1.03 MPa at 121°C). Higher published rated connectors may be used where required.
- .7 Safety factors shall be a minimum of 3/1. All expansion joints must be factory tested to 150% of maximum pressure for 12 minutes before shipment.

- .8 The piping gap shall be equal to the length of the expansion joint under pressure. Control rods passing through 1/2"(13mm) thick Neoprene washer bushings large enough to take the thrust at 1000psi (0.7 kg/mm²) of surface area may be used on unanchored piping where the manufacturer determines the condition exceeds the expansion joint rating without them.
- .9 Submittals shall include two test reports by independent consultants showing minimum reductions of 20 DB in vibration acceleration and 10 DB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer.
- .10 All expansion joints shall be installed on the equipment side of the shut off valves.

2.22 Type 14 - Flexible Duct Connectors

- .1 Flexible duct connectors of Durodyne with Durolon fabric or approved equal.
- .2 Provide 75 mm (3") flexible duct connectors and a 40 mm (1½") metal to metal gap. Centrifugal fans with 900 mm (36") diameter and larger fan wheels, use 150 mm (6") long flexible connection.
- .3 Do not install connectors on perchloric acid fume exhaust systems.
- .4 Provide stabilizing springs limiting movement at flexible connections to 25% of fabric width under steady state conditions and 40% at start up.

2.23 Bases – Type B1 - Concrete Inertia

- .1 Concrete inertia bases shall be formed in a structural steel perimeter base, reinforced as required to prevent flexure, misalignment of drive and driven unit or stress transferal into equipment. The base shall be complete with motor slide rails, pump base elbow supports, reinforcing, equipment bolting provisions and isolators.
- .2 Minimum thickness of the inertia base shall be according to the following tabulation:

Motor Size		Minimum Thickness	
HP	KW	mm	inches
5 to 15	4 to 11	150	6
20 to 50	15 to 37	200	8
60 to 75	45 to 55	250	10
100 to 250	75 to 190	300	12

- .3 Height saving brackets shall be employed in all mounting locations to provide a base clearance of 25mm (1").

2.24 Bases – Type B2 - Steel

- .1 Provide integral structural steel bases.
- .2 Rectangular bases are preferred for all equipment. Centrifugal refrigeration machines and pump bases may be T or L shaped where space is a problem.
- .3 Pump bases for split case pump shall include supports for suction and discharge elbows.
- .4 All perimeter members shall be steel beams with a minimum depth equal to 1/10 of the longest dimension of the base. Base depth need not exceed 14" (350mm) provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer.
- .5 Height saving brackets shall be employed in all mounting locations to provide a base clearance of 25mm (1").

2.25 Closed Cell Foam Gaskets

- .1 20 mm (3/4") thick continuous perimeter closed cell foam gasket to isolate base of package type equipment, air handler units, exhaust fans, etc. from concrete floors and roof curbs.
- .2 Do not use on NFPA96 installations.

2.26 Anchor Bolts

- .1 Equal to Mason Industries type SAB seismic anchor bolts.

2.27 Seismic Cable Restraints

- .1 Galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two and arranged to provide all-directional restraint.
- .2 Cables must be pre-stretched to achieve a certified minimum modulus of elasticity. Cable end connections shall be steel assemblies that swivel to final installation angle and utilize two clamping bolts to provide proper cable engagement.
- .3 Cables must not be allowed to bend across sharp edges.
- .4 Cable assemblies shall suit installation type:
 - .1 Ceiling and at the clevis bolt.
 - .2 Between the hanger rod nut and the clevis.
 - .3 Clamped to a beam.

3. EXECUTION

3.1 General

- .1 All vibration isolators and seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.
- .2 Brace in-line equipment independently of ducts and pipes.
- .3 Do not mix solid and cable bracing.
- .4 All runs to have a minimum of two transverse and one longitudinal brace. A run is defined as any change in direction except offsets.

3.2 Seismic Restraint Installation

- .1 The following Mechanical Components Restraint Guide is to be used as a general guide only to establish appropriate restraint methods, hardware, and attachments, however, due to differences in construction, size, weight, and configuration of different manufacturer's equipment and variety of ways and means that equipment and components can be installed, specific restraint methods are to be confirmed in the field. Seismic restraint materials and methods are to be reviewed and approved by Seismic Consultant.

3.3 Mechanical Component Restraint Guide

Item	Type Of Restraint	Minimum No. of Restraints	Notes
Pumps Non-Isolated	BTHP	4	Base mount type pump
Pumps Isolated	SNBR	4	Base mount type pump
Rooftop Air Units (all types)	BTRC		Vibration-isolated seismic curb
Piping	SCR	As required	As per Specification

Item	Type Of Restraint	Minimum No. of Restraints	Notes
	TSR		
Ductwork	SCR TSR	As required	As per Specification

LEGEND	
SCR	Slack cable restraint (bolted to structure)
SNBR	Seismic snubber (bolted to structure)
TSR	Threaded support rod (bolted or clamped to structure)
BTSLPR	Bolt to sleeper (sleeper bolted to structure)
BTHP	Bolt to concrete housekeeping pad (pad to be keyed to structure)
CSSB	Custom steel shoe base (bolted to structure)
BTRC	Bolt to roof curb (roof curb bolted to roof structure)

3.4 Seismic Piping Restraints

- .1 Seismic restrain all piping as follows:
 - .1 Seismically restrain all piping as follows:
 - .1 Fuel oil piping, gas piping, medical gas piping, and compressed air piping that is 1 NPS or larger.
 - .2 Piping located in boiler rooms, mechanical equipment rooms, and refrigeration equipment rooms that is 1 ¼ NPS and larger.
 - .3 All other piping 2 ½ NPS and larger.
 - .2 Provide transverse piping restraints at 12m (40') maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
 - .3 Provide longitudinal restraints shall be at 24m (80') maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
 - .4 For fuel oil and all gas piping transverse restraints must be at 6m (20') maximum and longitudinal restraints at 12m (40') maximum spacing.
 - .5 Where thermal expansion is a consideration, guides and anchors may be used as transverse and longitudinal restraints provided they have a capacity equal to or greater than the restraint loads in addition to the loads induced by expansion or contraction.
 - .6 Hold down clamps must be used to attach pipe to all trapeze members before applying restraints in a manner similar to clevis supports.

3.5 Seismic Ductwork Restraints

- .1 Seismically restrain all ductwork as follows:
 - .1 Restrain all ductwork and duct mounted equipment.
 - .2 Transverse restraints shall occur at 9m (30') intervals or at both ends of the duct run if less than the specified interval. Transverse restraints shall be installed at each duct turn and at each end of a duct run.
 - .3 Longitudinal restraints shall occur at 18m (60') intervals with at least one restraint per duct run.

- .4 The ductwork must be reinforced at the restraint locations. Reinforcement shall consist of an additional angle on top of the ductwork that is attached to the support hanger rods. Ductwork is to be attached to both upper angle and lower trapeze.
- .5 A group of ducts may be combined in a larger frame so that the combined weights and dimensions of the ducts are less than or equal to the maximum weight and dimensions of the duct for which bracing details are selected.
- .6 Walls, including gypsum board non-bearing partitions, which have ducts running through them, may replace a typical transverse brace. Provide channel framing around ducts and solid blocking between the duct and frame.

3.6 Seismic Cable Restraints

- .1 Cable restraints shall be installed slightly slack to avoid short circuiting the isolated suspended equipment, piping or conduit.
- .2 Cable assemblies are installed taut on non-isolated systems.
- .3 Where cable restraints are installed on support rods with spring isolators, the spring isolation hangers must be specification type.

3.7 Vibration Isolator Installation - General

- .1 Vibration isolation products as outlined in section 2 above are to be applied based on 4 basic project specific situations. The requirements for each of these is outlined below:
 - .1 Acoustical classification AAA - Hospitals, Recording Studios, Theatres, High end Hotels
 - .2 Acoustical classification AA - Office Towers, Multi Storey Condominiums
 - .3 Acoustical classification A - Commercial
 - .4 Acoustical classification W - Warehouse, Industrial
- .2 This project has an acoustical classification of A. See Vibration Isolation Application Schedule for vibration isolation application requirements.
- .3 Unless otherwise specified, vibration isolation products are to be product of one manufacturer.
- .4 Ensure vibration isolation manufacturer coordinates material selections with equipment provided in order to ensure adherence to performance criteria. Allow for expansion and contraction when material is selected and installed.
- .5 Use the lowest RPM scheduled for two-speed equipment in determining isolator deflection.
- .6 Before bolting isolators to the structure, start equipment and balance the systems so that the isolators can be adjusted to the correct operating position before installing (seismically rated) anchors.
- .7 Where hold down bolts for isolators or seismic restraint equipment penetrate roofing membranes, provide "gum cups" and sealing compound to maintain waterproof integrity of roof. Ensure sealing compound is compatible with isolator components such as neoprene.
- .8 Unless otherwise indicated, install isolation materials for base mounted equipment on concrete housekeeping pad bases which extend at least over the full base and isolated area of the isolated equipment. Additional requirements are as follows:
 - .1 Block and shim bases level so ductwork and piping connections can be made to a rigid system at proper operating level, before isolated adjustment is made, and ensure there is no physical contact between isolated equipment and building structure;
 - .2 Steel bases are to clear the sub-base by 25 mm (1");

- .3 Concrete bases are to clear the sub-base by 50 mm (2").
- .9 Where a pump intake pipe or similar pipe configuration requires a pedestal support, construct inertia or steel base large enough to accommodate pedestal.
- .10 Isolate piping larger than 25 mm (1") dia. directly connected to motorized and/or vibration isolated equipment with 25 mm (1") static deflection spring hangers at spacing intervals in accordance with following:
 - .1 For pipe less than or equal to 100 mm (4") dia. – first 3 points of support;
 - .2 For pipe 125 mm (5") to 200 mm (8") dia. – first 4 points of support;
 - .3 For pipe equal to or greater than 250 mm (10") dia. – first 6 points of support;
- .11 First point of isolated piping support is to have a static deflection of twice the deflection of the isolated equipment but maximum 50 mm (2").
- .12 Flexible pipe connectors (Type 13 isolator) shall be provided and installed per the Vibration Isolation Application Schedule.
- .13 Provide hot dipped galvanized housings and neoprene coated springs, or other acceptable weather protection, for all isolation equipment located outdoors or in areas of high moisture which may cause corrosion.
- .14 Provide a minimum clearance of 50mm (2") to other structures, piping, equipment, etc., for all equipment mounted on vibration isolators.
- .15 Before bolting isolators to the structure, start equipment and balance the systems so that the isolators can be adjusted to the correct operating position before installing drilled inserts.
- .16 When spring isolators are used for equipment with operating weights substantially different from installed weights, block the equipment with temporary shims to the final heights prior to making piping connections. When full load is applied, adjust the isolators to take up the load just enough to allow shim removal.
- .17 After installation and adjustment of isolators, verify deflection under load to ensure loading is within specified range.
- .18 Where hold-down bolts for isolators or attachments penetrate roofing membranes, co-ordinate with Division 7 and with roofing contractor.
- .19 For all pump installations, ensure that pumps are installed and aligned such that no piping loads are imposed on the pump. Pumps and piping should be independently supported and aligned prior to final connection.
- .20 Where isolated piping connected to noise generating equipment is routed from the mechanical room through plumbing chases or other openings, position isolated piping to avoid contact with the structure, framing, gypsum wallboard and other elements which may radiate noise. Submit proposed details to meet this requirement. On all AAA and AA projects, Type 10 acoustical seals shall be provided on piping entering or leaving mechanical rooms.
- .21 Ensure that the installed seismic restraints do not adversely affect the proper functioning of any vibration isolation products required by this section.
- .22 All fire protection piping shall be braced in accordance with NFPA 13 and 14.

- .23 For control wiring connections to vibration isolated equipment ensure flexible metallic conduit with 90° bend is used for conduit 25 mm (1") dia. and smaller, and for conduit larger than 25 mm (1") dia., use Crouse Hinds EC couplings. Connections are to be long enough so that conduit will remain intact if equipment moves 300 mm (12") laterally from its installed position, and flexible enough to transmit less vibration to structure than is transmitted through vibration isolation. Coordinate these requirements with mechanical trades involved. If electrical power connections are not made in a similar manner as part of the electrical work, report this fact to Consultant.

3.8 Type 2 - Rubber Floor Mounts

- .1 Mount in-line pumps on two (2) rubber floor mount isolators under each support foot, where scheduled.
- .2 For equipment mounted on a slab on grade, mount on rubber floor mount isolators unless otherwise specified.
- .3 Provide protection of the rubber element from contact with oil in the mechanical room.

3.9 Type 3 - Spring Floor Mounts

- .1 Isolate all floor or pier mounted equipment on spring floor mount isolators, unless otherwise specified.
- .2 Isolate air-cooled chillers on spring floor mount isolators and Neoprene pads under isolator base plates. Submit details of pipe supports on roof and wall/roof penetration.
- .3 Isolate air compressors on spring floor mount isolators and concrete inertia base unless scheduled otherwise.
- .4 Mount cooling towers on spring floor mount isolators and, if necessary, seismic snubbers to meet seismic requirements unless scheduled otherwise.

3.10 Type 5 - Seismic Snubbers

- .1 Neoprene bushings shall be rotated to insure no short circuits exist before systems are activated.

3.11 Type 6S Continuous Rail Type Isolation for Roof Mounted Equipment

- .1 Erect roof curb vibration isolation in accordance with instructions shipped with assembly. Match vibration isolation with associated roof top unit and orient isolation as identified by manufacturer to ensure proper loading and optimum performance.
- .2 Caulk top of roof curb with 2 beads of caulking provided and centre isolation assembly onto roof curb and, unless otherwise noted, screw in place with 50 mm (2") lag screws at 900 mm (36") O.C. Position gasket on top rail or alternatively, caulk with 2 beads of caulking provided and orient and lower roof top unit onto isolation rails and, unless otherwise noted, screw unit into top rail with 25 mm (1") lag screws at 900 mm (36") O.C.
- .3 After roof top unit is secured in place, but before damageable work is installed, spray each isolated equipment assembly with water and correct any water leaks.

3.12 Type 7S & 7SN - Spring Hangers

- .1 Locate isolation hangers as near to the overhead support structure as possible.
- .2 Installation shall permit hanger box or rod to move through a 30 degrees arc without metal to metal contact.
- .3 All discharge ductwork runs for a distance of 15m (50') from the connected equipment shall be isolated from the building structure by means of spring hangers. Spring deflection shall be a minimum of 19mm (0.75").

3.13 Type 8 - Neoprene Washer/Bushing

- .1 Isolate variable frequency drive controller using neoprene washer/bushing isolators or soft grommets such that structure borne noise transmission to occupied space is less than airborne noise transmission.

3.14 Type 13 - Flexible Piping Connectors

- .1 Supply flexible piping connectors for connections (including plumbing) to seismically restrained equipment. Hand connectors to appropriate piping trade at site for installation.

3.15 Type 14 - Flexible Duct Connectors

- .1 Install flexible duct connectors so that duct cross-section is not reduced by the deflection of the flexible connector.

3.16 Closed Cell Foam Gaskets

- .1 Select width for nominal 21kPa (3psi) loading under weight of equipment and allow for 25% compression 5mm (³/₁₆").
- .2 Increase width of curb using steel shim if necessary to accommodate gasket.
- .3 For light equipment such as exhaust fans, deflection should be a minimum of 1mm (0.05").

3.17 Minimum Static Deflection Schedule

Equipment	Equipment Supported By:	
	Slab on Grade	Elevated Slab
Heat Pumps (see Note 5)	9mm (³ / ₈ ")	38mm (1½")
Pumps:		
In-line under 1.5kW (2HP)	1mm (¹ / ₁₆ ")	3mm (¹ / ₈ ")
In-line 1.5kW (2 HP) to 11.5kW (15 HP)	3mm (¹ / ₈ ")	5mm (¹ / ₄ ")
In-line over 11.5kW (15 HP)	3mm (¹ / ₈ ")	9mm (³ / ₈ ")
Base mounted under 5.5kW (7.5 HP)	5mm (¹ / ₄ ")	19mm (³ / ₄ ")
Base mounted 5.5kW (7.5 HP) and greater	19mm (³ / ₄ ")	38mm (1½")
Fans, Blowers & Packaged H & V Units:		
Under 0.5 HP	1mm (¹ / ₁₆ ")	1mm (¹ / ₁₆ ")
0.5 HP to 7.5 HP	25mm (1")	25mm (1")
7.5 HP to 40 HP - up to 400 rpm	38mm (1½")	38mm (1½")
7.5 HP to 40 HP - over 400 rpm	25mm (1")	25mm (1")
Over 40 HP – up to 400 rpm	38mm (1½")	38mm (1½")
Over 30 KW (40 Hp) – over 400 rpm	25mm (1")	38mm (1½")

NOTES:

- .1 Table indicates required static deflection of isolators for all fans regardless of power rating and for all other motor driven equipment over 0.37kW (0.5 HP).
- .2 Advise consultant of equipment not contained in this table and obtain clarification as to the isolation performance requirements.

- .3 Steel spring isolators shall be used for all deflections 12mm (½”) and over.
- .4 Neoprene isolators shall be used for deflections 6mm (¼”) and under.
- .5 Use housed spring isolators for heat pump.
- .6 Concrete inertia bases required for pumps over 15kW (20HP), fans over 30kW (40HP).

3.18 Vibration Isolation Application Schedule

Equipment	AAA	AA	A	W
Pumps >1/2hp< 10hp Floor Mounted				
Upper Floor	3, B2 & 13	2, stanchions or B2 & 13	1, stanchions or B2 & 13	1
On Grade	2, stanchions or B2 & 13	2, stanchions or B2 & 13	1	-
Pumps <<1.2hp floor mounted	8	8	-	-
Piping				
Attached to Isolated Equipment	7SN - See 3.4.5	7SN - See 3.4.5	7SN - See 3.4.5	See 3.4.5
Through Mechanical Room Walls 1½”	10	10	-	-
Hot Water Risers - No Expansion Loops	11,12,13	11,12,13	-	-
Roof Mounted Packaged Air Handling Equipment				
Internally Isolated	6S & 14	6S & 14	6N & 14	-
Not Internally Isolated	6S & 14	6S & 14	6N & 14	6N & 14

Note:

- .1 Table indicates type of isolation required, base type (B) if required and any other sections of note.
- .2 Type 3 and 4 isolators may be used with Type 5 and 5PD and snubbers. Those pieces of equipment requiring seismic ‘post disaster’ protection must use 5PD snubbers with Type 3 and 4 isolators.

3.19 Field Quality Control

- .1 Seismic Engineer:
 - .1 The Seismic Engineer shall perform all field services as required to fulfil the Building Code obligation for the provision of the Assurance of Professional Field Review and Compliance by Supporting Registered Professional Schedule S-C for seismic engineering.
 - .2 Submit concise field reports to the Consultant within 3 days of each site review.
 - .3 Make adjustments and corrections in accordance with written report.
- .2 Manufacturer's Field Services:
 - .1 Arrange with manufacturer's representative to review work of this Section and submit written reports to verify compliance with Contract Documents.
 - .2 Manufacturer's Field Services: consisting of product use recommendations and periodic site visits to review installation, scheduled as follows:
 - .1 Twice during the installation, at [25] % and [60] % completion stages.
 - .2 Upon completion of installation.

- .3 Submit a concise manufacturer's report to the Consultant within 3 days of manufacturer representative's review.
- .4 Make adjustments and corrections in accordance with written report.

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 Materials and installation for the identification of all mechanical piping, ducting, equipment, and controls.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical.

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
- .2 Canadian Standards Association (CSA International):
 - .1 CAN/CSA B128.1 – Design and Installation of Non-potable Water Systems.
 - .2 CAN/CSA B128.2 – Maintenance and Field Testing of Non-potable Water Systems
 - .3 CAN/CSA Z305.1 – Non-flammable Medical Gas Piping.
 - .4 CAN/CSA Standard-Z7396.1-17 Medical Gas Pipeline Systems – Part 1
- .3 Canadian Gas Association (CGA):
 - .1 CSA/CGA B149.1 – Natural Gas and Propane Installation Code.
- .4 Canadian General Standards Board (CGSB):
 - .1 CAN/CGSB-1.60 – Interior Alkyd Gloss Enamel.
 - .2 CAN/CGSB-24.3 – Identification of Piping Systems.
- .5 National Fire Protection Association (NFPA):
 - .1 NFPA 13 – Standard for the Installation of Sprinkler Systems.
 - .2 NFPA 14 – Standard for the Installation of Standpipe and Hose Systems.

1.4 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and additionally the following:
 - .1 Submit data on all materials.

1.5 General Requirements

- .1 Comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.
- .2 Identify each system and system component according to the nomenclature used on the drawings and specifications. Identification to be consistent throughout the project.
- .3 When identifying systems and components in existing buildings, the new items shall be numbered sequentially with existing systems. Where possible include the zone or building area serviced by each system.
- .4 Submit list of system and component labels to be Consultant for review prior to engraving

2. PRODUCTS

2.1 Acceptable Manufacturers

- .1 Refer to Section 23 05 01 – Acceptable Manufacturers.

2.2 Piping Systems Governed by Codes

- .1 Any piping that is governed by CSA/NFPA or any other applicable code as addressed in contract documents, is to comply with those applicable codes concerning identification.

2.3 Manufacturer's Equipment Nameplates

- .1 Metal or plastic laminate nameplate mechanically fastened to each piece of equipment by manufacturer.
- .2 Lettering and numbers raised or recessed.
- .3 Information to include, as appropriate:
 - .1 Equipment: manufacturer's name, model, size, serial number, capacity.
 - .2 Motor: voltage, Hz, phase, power factor, duty, frame size.

2.4 System Equipment Nameplates

- .1 Each piece of equipment shall be identified with its equipment schedule identification, e.g. supply fan SF-1, cooling coil CC-1, pump P-1.
 - .1 Coordinate equipment with drawings and with owner's requirements
- .2 Colours:
 - .1 Hazardous: red letters, white background.
 - .2 Elsewhere: black letters, white background (except where required otherwise by applicable codes).
- .3 Construction:
 - .1 3 mm ($\frac{1}{8}$ ") thick laminated plastic or white anodized aluminum, matte finish, with square corners, letters accurately aligned and machine engraved into core.
- .4 Sizes:
 - .1 Conform to following table:

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

- .2 Use maximum of 25 letters/numbers per line.
- .5 Locations:
 - .1 Terminal cabinets, control panels: use size # 5.

- .2 Equipment in Mechanical Rooms: use size # 9.

2.5 Piping Systems Identification

- .1 Identify contents by background colour marking, pictogram (as necessary), legend; direction of flow by arrows. To CAN/CGSB 24.3 except where specified otherwise.
- .2 Medical Gas Pipeline Systems:
 - .1 All medical gas pipelines shall have a permanent label at intervals of 6.0 m [20 ft.], immediately before and after barriers, at each valve, and behind access doors and inlet and outlet points.
 - .2 Lettering colour, background colour, lettering height and gas or gas mixture symbol shall be in accordance with CAN/CSA Z7396.1 Medical Gas Pipeline Systems – Part 1.
- .3 Pictograms:
 - .1 Where required by Workplace Hazardous Materials Information System (WHMIS) regulations.
- .4 Letter Height:
 - .1 13 mm [1/2"] high - 1-1/4 NPS pipe & smaller.
 - .2 25 mm [1"] high - 1-1/2 NPS up to 2-1/2 NPS pipe.
 - .3 50 mm [2"] high - 3 NPS and larger pipe.
- .5 Arrows showing direction of flow:
 - .1 Outside diameter of pipe or insulation less than 75mm (3"): 100mm long x 50mm high (4" x 2").
 - .2 Outside diameter of pipe or insulation 75mm (3") and greater: 150mm long x 50mm high (6" x 2").
 - .3 Use double-headed arrows where flow is reversible.
- .6 Extent of background colour marking:
 - .1 To full circumference of pipe or insulation.
 - .2 Length to accommodate pictogram, full length of legend and arrows.
- .7 Materials for background colour marking, legend, arrows:
 - .1 Pipes and tubing 20mm (3/4") and smaller: waterproof and heat-resistant pressure sensitive plastic marker tags.
 - .2 Other pipes: pressure sensitive plastic-coated cloth or vinyl with protective overcoating, waterproof contact adhesive undercoating, suitable for ambient of 100% RH and continuous operating temperature of 150°C (302°F) and intermittent temperature of 200°C (392°F).
- .8 Colours and Legends:
 - .1 Where not listed, obtain direction from the Consultant.
 - .2 Colours for legends, arrows: to following table:

Background Colour	Legend, Arrows
Yellow	BLACK
Green	WHITE

Background Colour	Legend, Arrows
Red	WHITE
Blue	WHITE

.3 Background colour marking and legends for piping systems:

Contents	Background Colour Marking	Legend
Chilled Water Supply	Blue	CHILLED SUPPLY CHWS
Chilled Water Return	Blue	CHILLED RETURN, CHWR
Solar Water Supply	Yellow	SOLAR SUPPLY
Solar Water Return	Yellow	SOLAR RETURN
Heating Water	Yellow	HEATING SUPPLY, HWS
Heating Water	Yellow	HEATING RETURN, HWR
Make-Up Water	Yellow	MAKE-UP WTR
Domestic Hot Water Supply	Green	DOM. HW SUPPLY, DHW
Dom. HWS Recirculation	Green	DOM. HW CIRC, DHWR
Domestic Cold Water Supply	Green	DOM. CW SUPPLY, DCW
Storm Water	Green	STORM
Sanitary	Green	SAN
Compressed Air (Non-Medical)	Green	COMP. A.
Natural Gas	Refer to CGA code	
Gas Regulator Vents	Refer to CGA code	
Fire Protection Water	Red	FIRE PROT. WTR
Heat Pump Supply	Yellow	HT PUMP SUPPLY
Heat Pump Return	Yellow	HT PUMP RETURN
Radiant Floor Supply	Yellow	RAD FLR SUPPLY
Radiant Floor Return	Yellow	RAD FLR RETURN
Condensate Drain	Green	COND
Steam Condensate Supply	Orange	STM COND SUPPLY
Steam Condensate Return	Orange	STM COND RETURN
Irrigation Water	Per CSA B128.1	
Non Potable Water	Per CSA B128.1	
Grey Water	Per CSA B128.1	

.9 Labeling of Recycled Rainwater system (irrigation, crop irrigation systems) shall be as follows:

- .1 Identification labels for crop irrigation shall include the term ``crop irrigation`` in addition to the following:
- .2 The contractor shall install all piping and equipment associated with the rainwater collection storage filtration and recycled rainwater (non-potable) distribution system in accordance with:
 - .1 CAN/CSA Standard B128.1 Design and Installation of Non-potable Water Systems
 - .2 CAN/CSA Standard B128.2 Maintenance and Field Testing of Non-potable Water Systems.
- .3 Fixtures, fittings, and appurtenances connected to the recycled rainwater system shall be marked in accordance with the CSA Standard.

2.6 Valves, Controllers Identification

- .1 Provide valve identification and secure with non-ferrous chain or "S" hooks suitable for the system temperature.
- .2 Identification tags shall be of brass, aluminum, metalphoto, lamicoïd or fiberglass, stamped or engraved with 12mm (½") high identifier markings.
- .3 Tag the following valves as a minimum:
 - .1 Valves on main piping circuits.
 - .2 Valves on major branch lines.
 - .3 Valves on minor branch lines in horizontal or vertical service spaces and mechanical rooms.
 - .4 Drain valves and hose bibbs on systems containing glycol.
 - .5 Control valves.
- .4 Do not tag the following valves:
 - .1 Valves on control valve stations.
 - .2 Valves on steam trap stations.
 - .3 Plumbing fixture stops or hose bibbs.
 - .4 System drain valves.
- .5 Provide a valve tag schedule. Include in the identification of each tagged item, valve type, service, function, normal position and location of tagged item.
- .6 Provide a flow diagram for each system, reference applicable charts and schedules.

2.7 Ductwork Systems Identification

- .1 50mm (½") high stencilled letters and directional arrows 150mm long x 50mm high (6" x 2").
- .2 Colours: back, or co-ordinated with base colour to ensure strong contrast.

2.8 Ductwork Access Identification

- .1 Secure 50 mm (2") high, self-adhesive stick on-letters, on duct access panels to identify their usage, according to the following:
 - .1 Cleaning and service access, colour black, tag "C.A"
 - .2 Controls including sensors, colour black, tag "C"
 - .3 Backdraft dampers, balance dampers and control dampers, colour black, tag "D"

- .4 Fire dampers, colour red, tag “F.D.”
- .5 Smoke dampers and duct smoke detectors, colour red, tag “S.D.”

2.9 Controls Components Identification

- .1 Identify all systems, equipment, components, controls, sensors with system nameplates specified in this section. Include: sensors, transmitters, BMS controlled valve and damper actuators, end-devices, distributed control panels (DCP)'s, application specific controllers (ASC)'s and field panels.
- .2 Inscriptions to include function and (where appropriate) fail safe position.
- .3 Warning notices shall be provided at all equipment controlled by the BMS and at all associated motor starters. The warning notices shall state that the equipment is under the control of the BMS and may start or stop at any time without warning. Provide warning notices at minimum at all MCC's, at local disconnect switches, at AHU plenum doors, and electrical motors.
- .4 Provide warning notices on all Distributed Control Panel doors indicating that hand held radio transmitters are not to be keyed within 3 meters of the DCP.
- .5 All BMS wire and cable shall be identification tagged. Wire/cable shall be identification tagged at every termination location. Wire/cable and tubing terminating at distributed control panels (DCP) and application specific controllers (ASC) shall be tagged with the DCP/ASC controller termination number. Wire/cable and tubing terminating at field devices shall be tagged with both the DCP/ASC number and the DCP/ASC termination number. At any splices or terminal strips between the field device and DCP/ASC, the wiring shall be tagged on both sides of the termination point the same as for a field device termination.
- .6 In accordance with CSA B44-[07] [13] clause 2.7.9.2, provide signage indicating the allowable temperature and relative humidity range for the elevator machinery spaces, machine rooms, control spaces, and control rooms. Post in the machine room, control room, control space, or where specified by the elevator manufacturer, in the machinery space.

2.10 Ceiling Access Identification

- .1 Provide 6 mm (1/4") self adhesive coloured dots to the T-bar framing, adjacent to panel to be removed or to access doors in solid ceilings. Identify the location of equipment concealed above as follows:
 - .1 **Yellow** - Concealed equipment and cleaning access.
 - .2 **Black** - Control equipment, including control valves, dampers and sensors.
 - .3 **Red** - Fire and smoke dampers, fire protection equipment and fire system drains.
 - .4 **Green** – Heating water, chilled water, domestic cold water, domestic hot water isolation valves.

3. EXECUTION

3.1 General

- .1 Provide identification only after painting has been completed.
- .2 Perform work in accordance with CAN/CGSB-24.3 Identification of Piping Systems except as specified otherwise.
- .3 Provide ULC and/or CSA registration plates as required by respective agency.

3.2 Nameplates

- .1 Location shall be in conspicuous location to facilitate easy reading and identification from operating floor.
- .2 Provide standoffs for nameplates on hot and/or insulated surfaces.
- .3 Do not paint, insulate or cover nameplate data.

3.3 Location of Identification on Piping and Ductwork Systems

- .1 Provide on long straight runs in open areas in boiler rooms, equipment rooms, galleries, tunnels: at not more than 17m (55') intervals and more frequently if required to ensure that at least one is visible from any one viewpoint in operating areas and walking aisles.
- .2 Provide adjacent to each change in direction.
- .3 Provide at least once in each small room through which piping or ductwork passes.
- .4 Provide on both sides of visual obstruction or where run is difficult to follow.
- .5 Provide on both sides of separations such as walls, floors, partitions.
- .6 Provide where system is installed in pipe chases, ceiling spaces, galleries, confined spaces, at entry and exit points, and at access openings.
- .7 Provide at beginning and end points of each run and at each piece of equipment in run.
- .8 Provide at point immediately upstream of major manually operated or automatically controlled valves, and dampers. Where this is not possible, place identification as close as possible, preferably on upstream side.
- .9 Identification shall be easily and accurately readable from usual operating areas and from access points. Position the identification approximately at right angles to the most convenient line of sight, considering operating positions, lighting conditions, risk of physical damage or injury and reduced visibility over time due to dust and dirt.

3.4 Valves, Controllers Identification

- .1 Provide identification on valves and operating controllers, except at plumbing fixtures, radiation, or where in plain sight of equipment they serve.
- .2 Install one copy of flow diagrams, valve schedules mounted in frame behind non-glare glass located in the main mechanical room. Provide one copy in each operating and maintenance manual.
- .3 Number valves in each system consecutively.
 - .1 Identification coding is to start with a utility description followed by a maximum of three numerals:
 - .2 Domestic Water DW-1, DW-2, DW-3...
 - .3 Natural Gas G-1, G-2, G-3...
 - .4 Steam S-1, S-2, S-3...
 - .5 Heating Water HW-1, HW-2, HW-3...
 - .6 HVAC to be numbered H-1, H-2, H-3...
 - .7 Fire Protection to be numbered FP-1, FP-2, FP-3...

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 Test to verify proper and safe operation, determine actual point of performance, evaluate qualitative and quantitative performance of equipment, systems and controls at design, average and low loads using actual or simulated loads
- .2 Adjust and regulate equipment and systems to meet specified performance requirements and to achieve specified interaction with other related systems under normal and emergency loads and operating conditions.
- .3 Balance systems and equipment to regulate flow rates to match load requirements over full operating ranges and document results.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical.
- .3 Section 23 08 00 – Commissioning of Mechanical Systems.

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
- .2 Associated Air Balance Council (AABC)
 - .1 National Standards for Total System Balance, MN-1.
- .3 National Environmental Balancing Bureau (NEBB)
 - .1 Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.
- .4 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
 - .1 HVAC Systems – Testing, Adjusting, and Balancing.
- .5 American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)
 - .1 ASHRAE 62.1 – Ventilation for Acceptable Indoor Air Quality.
 - .2 ASHRAE 62.2 – Ventilation for Acceptable Indoor Air Quality in Low Rise Residential Buildings.

1.4 General Requirements

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

1.5 Approved TAB Agencies

- .1 Refer to Section 23 05 01 – Acceptable Manufacturers.

1.6 Qualifications of TAB Personnel

- .1 Employ an approved independent testing and balancing agency to test and balance the following systems.

- .2 Submit names of personnel to perform TAB to the Owner's Consultant within 90 days of award of contract. Provide documentation confirming qualifications, years of direct field testing and balancing experience and successful experience. Provide a list of a minimum of ten comparable projects successfully completed by all key members of the balancing team and the Standard under which the projects were completed.
- .3 TAB shall be performed in accordance with the requirements of the standard under which the TAB Firm's qualifications are approved:
 - .1 AABC – National Standards for Total System Balance, MN-1
 - .2 NEBB – Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems
 - .3 SMACNA -HVAC Systems – Testing, Adjusting and Balancing
- .4 Recommendations and suggested practices contained in the TAB Standard are mandatory.
- .5 Use TAB Standard provisions, including checklists, and report forms to satisfy the Contract requirements.
- .6 Where the instrument manufacturer's calibration recommendations are more stringent than those listed in TAB Standard, use manufacturer's recommendations.
- .7 TAB Standard quality assurance provisions such as performance guarantees form part of this contract.
 - .1 For systems or system components not covered in TAB Standard, use TAB procedures developed by the TAB Specialist.
 - .2 Where new procedures, and requirements, are applicable to the Contract requirements, procedures shall have been published or adopted by the body responsible for the TAB Standard used (AABC, NEBB, or TABB), requirements, and recommendations contained in these procedures and requirements are mandatory.

1.7 Exceptions

- .1 TAB of systems and equipment regulated by codes, standards to satisfaction of authority having jurisdiction.

1.8 Submittals

- .1 Comply with Section 21 05 01 – Common Work Results for Mechanical, Submittals, and the following:
- .2 Preliminary TAB Report
 - .1 Submit for checking and approval of the Owner's Consultant, prior to submission of formal TAB report, sample of rough TAB sheets. Include:
 - .1 Details of instruments used.
 - .2 Details of TAB procedures employed.
 - .3 Calculations procedures.
 - .4 List of air and liquid systems to be TAB
 - .5 Summaries.
- .3 TAB Report
 - .1 Format in accordance with referenced standards.
 - .2 TAB report to show results in SI units and to include:
 - .1 Project record drawings.

- .2 System schematics.
 - .3 Date of test, Name, and address of building and balancing technician's name.
 - .4 Range of outdoor air temperature during the balancing period.
 - .5 Main branch duct traverses. Maximum and minimum outdoor air quantities.
 - .6 Static pressure across each component in an air handling system at full flow.
 - .7 Static pressure across each fan.
 - .8 Pumps: Tag, service, location, manufacturer, model, and size. Specified and actual flow and head pressure. Motor size, speed, amps, and voltage.
 - .9 Heating/Cooling Coils: Tag, service and location. Specified and actual capacity, flow, fluid pressure drop, liquid entering and leaving temperatures, air-side entering and leaving temperatures, and air flow.
 - .10 Flow measuring devices: Flow rates.
 - .11 Terminal heating/cooling elements: Entering and leaving liquid temperatures, and flow rates.
 - .12 Provide fan performance curve for each new air handling system and pump performance curve for each new pump system.
 - .13 Fire damper drop test confirmation.
- .3 Submit copies of TAB Report to the Owner's Consultant for verification and approval.

1.9 Co-ordination

- .1 Schedule time required for TAB (including repairs, re-testing) into project construction and completion schedule to ensure completion before acceptance of project.
- .2 Do TAB of each system independently and subsequently, where interlocked with other systems, in unison with those systems.

1.10 Pre-TAB Review

- .1 During construction, co-ordinate location and installation of TAB devices, equipment, accessories, measurement ports and fittings.
- .2 Ensure devices are accessible and maintainable. Advise the installing Contractor of omissions or conflicts affecting the scope of this section.
- .3 Review contract documents before project construction is started and confirm in writing to Consultant the adequacy of provisions for TAB and that other aspects of design and installation are pertinent to the success of TAB.
- .4 Review specified standards and report to Consultant in writing describing any proposed procedures which vary from the standard.

1.11 Start-up

- .1 Follow start-up procedures as recommended by equipment manufacturer unless specified otherwise.
- .2 Follow special start-up procedures specified elsewhere in Divisions 21, 22, 23 and 25.

2. PRODUCTS

2.1 Instruments

- .1 Prior to TAB, submit to the Owner's Consultant a list of instruments used together with serial numbers.
- .2 Calibrate in accordance with requirements of most stringent of referenced standards for applicable system.
- .3 Calibration shall be within 6 months of TAB. Provide certificate of calibration to the Owner's Consultant.

3. EXECUTION

3.1 Start of TAB

- .1 Notify the Consultant 7 days prior to start of TAB.
- .2 Start TAB when building is essentially completed, including:
 - .1 Installation of ceilings, doors, windows, other construction affecting TAB.
 - .2 Application of weather-stripping, sealing, and caulking.
 - .3 Pressure, leakage, other tests specified elsewhere Division 23.
 - .4 Provisions for TAB installed and operational.
- .3 Start-up, verification for proper, normal, and safe operation of mechanical and associated electrical and control systems affecting TAB including but not limited to:
 - .1 Proper thermal overload protection in place for electrical equipment.
 - .2 Air systems:
 - .1 Filters in place, clean.
 - .2 Duct systems clean.
 - .3 Ducts, air shafts, ceiling plenums are airtight to within specified tolerances.
 - .4 Correct fan rotation.
 - .5 Fire, volume control dampers installed and open.
 - .6 Coil fins combed, clean.
 - .7 Access doors, installed, closed.
 - .8 Outlets installed, volume control dampers open.
 - .3 Fluid systems:
 - .1 Flushed, filled, vented.
 - .2 Correct pump rotation.
 - .3 Strainers in place, baskets clean.
 - .4 Isolating and balancing valves installed, open.
 - .5 Calibrated balancing valves installed, at factory settings.
 - .6 Chemical treatment systems complete, operational.

3.2 Tolerances

- .1 Application Tolerances:

- .1 Do TAB to following tolerances of design values:
 - .1 Laboratory/Healthcare HVAC systems: plus 10%, minus 0%.
 - .2 General HVAC systems: plus or minus 5%.
 - .3 Hydronic systems: plus or minus 10%.
- .2 Accuracy Tolerances:
 - .1 Measured values accurate to within plus or minus 2% of actual values.
- .3 Site Tolerances:
 - .1 System leakage tolerances specified are stated as percentage of total flow rate handled by system. Pro-rate specified system leakage tolerances. Leakage for sections of duct systems: not to exceed total allowable leakage.
 - .2 Leakage tests on following systems not to exceed specified leakage rates.
 - .3 Small duct systems up to 250Pa (1"WC): leakage 2%.
 - .4 Large low pressure duct systems up to 500Pa (2"WC): leakage 2%.
 - .5 Evaluation of test results to use surface area of duct and pressure in duct as basic parameters.

3.3 Testing

- .1 Test ducts and piping before installation of insulation or other forms of concealment. Do not externally insulate or conceal work until tested and approved.
- .2 Test after seals have cured.
- .3 Test when ambient temperature will not affect effectiveness of seals, and gaskets.
- .4 Conduct tests in presence of the Owner's Consultant or Owner's representative.
- .5 Bear costs including retesting and making good.
- .6 Refer to Piping Sections for specific test requirements.
- .7 Prior to tests, isolate all equipment or other parts which are not designed to withstand test pressures.

3.4 Air System Procedure

- .1 Perform balancing, adjusting and testing with building doors and windows in their normal operation position.
- .2 Perform drop test on all fire dampers and reset to open position.
- .3 The following procedure shall be adopted for central systems:
 - .1 Ensure dampers or volume control devices are in fully open position.
 - .2 Balance central apparatus to $\pm 10\%$ air flow.
 - .3 Balance branches, mains to $\pm 10\%$ air flow.
 - .4 Recheck central apparatus.
 - .5 Balance all terminal air outlets to $\pm 10\%$.
 - .6 Rebalance central apparatus to $\pm 5\%$.
 - .7 Recheck all air outlets.
 - .8 Perform acoustical measurements.

- .9 Perform building pressurization tests and measurements at minimum and maximum outdoor air damper positions of the main air unit(s).
- .4 When balancing air outlets:
 - .1 Rough balance furthest outlets and then balance sequentially back to source.
 - .2 Fine balance furthest outlet back to source.
- .5 Take static pressure readings and air supply temperature readings at 10 points on each air system.
- .6 Make air quantity measurements in ducts by "Pitot Tube" traverse of entire cross sectional area. If readings are inconsistent across duct, relocate to two duct *diameters *widths and re-do traverse.
- .7 Use volume control devices to regulate air quantities only to extent that adjustments do not create objectionable air motion or sound levels. Effect volume control only by duct internal devices such as dampers and splitters.
- .8 Vary total system air quantities by adjustment of fan speeds. Vary branch air quantities by damper regulation.
- .9 Where modulating dampers are provided, take measurements, and balance at extreme conditions. (Balance variable volume systems at maximum air flow rate - full cooling, and at minimum air flow rate - full heating).
- .10 The final balanced condition of each area shall include testing and adjusting of pressure conditions. Test and record building pressurization levels in the aquatic space throughout full range of fan delivery rates, under both clean & dirty filter conditions. Document abnormal building leakage conditions noted.
- .11 Complete balancing to achieve positive building pressure with respect to lobby. A positive pressure relative to outside of 10 Pa minimum and 20 Pa maximum shall be achieved, measured with negligible outside wind velocity.
- .12 Adjust building zones to achieve the following pressure differentials:
 - .1 Aquatic space to be negative to lobby.
 - .2 Aquatic to be neutral to change rooms.

3.5 Balancing of Hydronic Systems

- .1 Open all (except pressure bypass must be closed) valves to fully open position including balancing valves, isolation valves, and control valves.
- .2 Execute air balance prior to initiating hydronic balance (if coils are provided).
- .3 Set pumps to deliver 10% excess flow if possible.
- .4 Adjust flows through each boiler or chiller to ensure equal flow.
- .5 Check and adjust flows and temperatures at inlet side of coils.
- .6 Position and mark all automatic valves, hand valves and balancing cocks for design flow through all coils, connectors and all items in system requiring circulation of chilled water, hot water or glycol.
- .7 Upon completion of flow readings and coil adjustments, mark setting and record data.
- .8 Coordinate shaving of impellor to operating condition on pumps larger than 1.5 kW. (2 Hp).
- .9 Ensure all bypass valves are tightly closed.
- .10 After making all terminal unit adjustments, re-check settings at pumps. Re-adjust as required.
- .11 Calibrate all pressure and temperature gauges.

- .12 Install pressure gauges on each coil then read pressure drop through coil and set flow rate on call for full flow through coil. Set pressure drop across bypass valve to match coil full flow pressure drop.
- .13 For all parallel pumping systems, check all flows through boiler, chiller, heat exchanger, and pumps under the following situations.
 - .1 With two pumps operating.
 - .2 With one pump operating - repeat for each pump.
 - .3 With controls demanding no heating or cooling.
- .14 For each pump, plot maximum and minimum flows on curve.

3.6 Verification

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

3.7 Settings

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

3.8 Completion of TAB

- .1 TAB is considered complete when final TAB Report received and all results are accepted by the Owner's Consultant.

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 Internal and external thermal duct insulation, accessories, sealers, and finishes.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical.

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
- .2 Applicable Building Code – Refer to Section 21 05 01 – Common Work Results for Mechanical
- .3 Applicable energy code or standard – Refer to Section 21 05 01 – Common Work Results for Mechanical.
- .4 Thermal Insulation Association of Canada (TIAC) – National Insulation Standards.
- .5 British Columbia Insulation Contractors Association (BCICA) – Quality Standard for Mechanical Insulation Manual.
- .6 CAN/ULC S102-M88 – Method of Test for Surface Burning Characteristics of Building Materials and Assemblies
- .7 CGSB 51-GP-52MA – Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation
- .8 ASTM C612 – Standard Specification for Mineral Fiber Block and Board Thermal Insulation
- .9 ASTM C534 Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
- .10 ASTM C553 – Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
- .11 ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining.
- .12 ASTM C1290 – Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.

1.4 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:
 - .1 Certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - .2 Manufacturer's installation instructions.

1.5 General Requirements

- .1 The Installation firm shall be a current member of one of the following:
 - .1 Thermal Insulation Association of Canada (TIAC).
 - .2 British Columbia Insulation Contractors Association (BCICA).
 - .3 Thermal Insulation Association of Alberta (TIAA).

- .2 Only Journeyman insulation applicators, with 3 years minimum successful experience in this size and type of project, shall perform the work.
- .3 Definitions:
 - .1 "CONCEALED" insulated mechanical services in trenches, chases, furred spaces, shafts and hung ceilings (services in tunnels are not considered to be concealed.)
 - .2 "EXPOSED" will mean not concealed.
 - .3 "K" value means Thermal Conductivity
 - .4 "UNCONDITIONED SPACE" referred to in the duct thickness tables are crawlspaces (vented or not vented), parkades, warehouse space, shipping and receiving areas and other areas noted on the drawings.
 - .5 "EXTERIOR SPACE" referred to in the duct thickness tables are all spaces outside the building insulation envelope, including attic spaces, unless noted otherwise.
 - .6 UL GREENGUARD: Provides independent third-party, Indoor Air Quality (IAQ) certification of products for emissions of respirable particles and Volatile Organic Compounds (VOC's), including formaldehyde and other specific product-related pollutants. Certification is based upon criteria used by Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA) and World Health Organization (WHO).
 - .7 ASJ: All Service Jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper
 - .8 SSL: Self-Sealing Lap.
 - .9 FSK: Foil Scrim Kraft; jacketing.
 - .10 PSK: Poly Scrim Kraft; jacketing.
 - .11 PVC: PolyVinyl Chloride.
- .4 Unless otherwise specified, insulation system materials inside building must have a fire hazard rating of not more than 25 for flame spread and 50 for smoke developed when tested in accordance with ULC S102, Surface Burning Characteristics of Building Materials, and Assemblies.
- .5 Provide thermal insulation on all HVAC ductwork and as follows:
 - .1 Heating only duct and plenum – service temperature 20°C to 65°C (68°F to 149°F)
 - .2 Cooling only or combined cooling and heating duct and plenum - service temperature 5°C to 65°C (41°F to 149°F)
 - .3 Outside air duct and plenum - -40°C (-40°F) to ambient
 - .4 All exhaust air ductwork from outside wall or roof to damper but a minimum of 3 m (10 ft.) inside building.
 - .5 Supply and return ductwork exposed in the space being served does not require insulation unless noted otherwise.
 - .6 Where an internal duct liner is used in lieu of external insulation, the internal thickness shall match that of the "Rigid Exterior Duct Insulation" table.
- .6 Provide acoustic internal insulation on ductwork as follows:
 - .1 All ductwork indicated on drawings with cross hatching.
 - .2 Where internal insulation is required, external insulation may be reduced or omitted by an equivalent thickness.

- .7 If the Contractor, during renovations, should discover asbestos (or material suspected to be asbestos) on piping, ductwork, etc., he shall immediately cease all work in that area and contact Owner's representative.
- .8 Make good all existing insulation disturbed or removed to facilitate alterations and additions to existing piping.

2. PRODUCTS

2.1 Acceptable Manufacturers

- .1 Refer to Section 23 05 01 – Acceptable Manufacturers

2.2 General

- .1 Products shall not contain asbestos, lead, mercury, mercury compounds or Polybrominated diphenyl ethers (PBDE).
- .2 Mineral fibre specified includes glass wool and rock wool.
- .3 The RSI value shall not be reduced from the specified values when tested in accordance with ASTM C1290.
- .4 Insulation and jacketing materials shall not exceed 25 flame spread, 50 smoke developed rating when tested in accordance with CAN/ULC S102-M88.
- .5 Elastomeric insulation shall comply with NFPA 90A, 90B and ASTM C1534
- .6 Foam insulation products shall not use CFC or HCFC blowing agents in the manufacturing process and be formaldehyde free.
- .7 Glass mineral wool products shall have a recycled content of a minimum of 50 percent recycled glass content.
- .8 Low Emitting Materials: For all thermal and acoustical applications of glass mineral wool insulation, insulation shall be UL GREENGUARD Certified.

2.3 Intermediate Temperature Range Insulation

- .1 External rigid Insulation (TIAC C-1):
 - .1 Service temperature 5°C to 232°C (41°F to 450°F)
 - .2 Glass mineral wool board for low and medium temperature applications.
 - .3 Complying with ASTM C1071 and CGSB 51-GP-52MA
 - .4 All service aluminum foil-scrim kraft (FSK) jacket with glass fibre reinforcement, factory applied.
 - .5 Density 36kg/m³ (2.25 PCF)
 - .6 Minimum RSI 0.76/25mm (R 4.3/in)
- .2 External flexible duct wrap insulation (TIAC C-2):
 - .1 Service temperature 5°C to 121°C (41°F to 250°F)
 - .2 For service temperatures above 121°C refer to 2.4 High Temperature Insulation
 - .3 Glass mineral wool flexible blanket for low and medium temperature applications.
 - .4 Complying with CGSB 51-GP-52MA, ASTM C1071 and ASTM C553.
 - .5 All service aluminum foil-scrim kraft (FSK) jacket with glass fibre reinforcement, factory applied.
 - .6 Density 12kg/m³ (0.75PCF),

- .7 Minimum RSI 0.49/25mm (R 2.8/in) (installed)
- .3 Internal rigid duct liner:
 - .1 Rigid glass mineral wool board, for low and medium temperature acoustical applications.
 - .2 Complying with ASTM C1071 and CGSB 51-GP-52MA
 - .3 Airstream surface faced with a black mat bonded to the glass mineral wool substrate.
 - .4 Air velocity rating 25.4 m/s (5,000 ft/min)
 - .5 Density 48kg/m³ (3 PCF),
 - .6 Minimum RSI 0.76/25mm (R 4.3/in)
 - .7 Sound absorption coefficients (type 'A' mounting):

Thickness		Frequency (Hz.)						
mm	inches	125	250	500	1000	2000	4000	NRC
25	1	0.13	0.24	0.56	0.83	0.92	0.98	0.65
40	1.5	0.19	0.41	0.89	1.02	1.03	1.04	0.85
50	2	0.33	0.67	1.07	1.07	1.03	1.06	0.95

- .4 Internal flexible duct liner:
 - .1 Flexible glass mineral wool blanket, for low and medium temperature acoustical applications.
 - .2 Complying with CGSB 51-GP-52MA, ASTM C1071 and ASTM C553.
 - .3 Airstream surface faced with non-woven fiberglass mat bonded to the glass mineral wool substrate.
 - .4 Air velocity rating 25.4 m/s (5,000 ft/min)
 - .5 Density 24kg/m³ (1.5 PCF)
 - .6 Minimum RSI 0.74/25mm (R 4.2/in)
 - .7 Sound absorption coefficients (type 'A' mounting):

Thickness		Frequency (Hz.)						
mm	inches	125	250	500	1000	2000	4000	NRC
25	1	0.18	0.36	0.59	0.86	0.95	0.9	0.7
40	1.5	0.35	0.51	0.83	0.93	0.97	0.96	0.8
50	2	0.34	0.64	0.96	1.03	1	1.03	0.9

2.4 Fastenings, Adhesives and Coatings

- .1 Insulation Fastenings:
 - .1 Min. 1.6 mm thick (16 ga) galvanized wire , 0.6 mm thick aluminium wire, 0.6 mm thick type 304 stainless steel wire or 1.6 mm thick copper wire.
 - .2 Mechanical fasteners, welded fasteners or adhesive fasteners to meet SMACNA HVAC Duct Construction Standard for mechanical fasteners.
- .2 Corner Beads: Galvanized steel or aluminum 38 mm x 38 mm x 0.37 mm thick.
- .3 Jacket Fastenings:

- .1 Thermocanvas and All Service Jacket: Staples (flare type), compatible jacket finishing tape, contact adhesives recommended by the jacket manufacturer.
- .2 Metal Jackets: Sheet metal screws, pop rivets.
- .4 Adhesives:
 - .1 Fabric adhesive to insulation covering, water based, ultra white, washable, anti-microbial.
 - .2 Internal elastomeric insulation adhesive shall be as per manufacturer's recommendations.
- .5 Coatings: Vapour barrier coating on reinforcing membrane.

2.5 Finish Jackets

- .1 Thermocanvas Jacket: fire rated, 170g (6 oz) fire retardant canvas jacket for covering mechanical insulation indoors, 25/50 fire class, plain wave cotton, no dyes.
- .2 Aluminum Jacket: 51 mil (22 ga.) thick stucco aluminum jacketing with longitudinal slip joints and 50mm (2") end laps with factory applied protective liner on interior surface.
- .3 Bitumen Membrane: 55 mil composite membrane consisting of a multiply embossed UV-resistant aluminum foil/polymer laminate over a layer of rubberized asphalt specially formulated for use on insulated duct and piping applications.

3. EXECUTION

3.1 General

- .1 Installation shall be to Thermal Insulation Association of Canada (TIAC): National Insulation Standards and the following:

3.2 Rigid Insulation External Application

- .1 Heating only Duct and Plenum – Service Temperature 20° to 65°C (CER/1)
 - .1 Fix mechanical fasteners to both horizontal and vertical surfaces at approximately 300 mm centers, each direction.
 - .2 Provide insulation without integral vapor retarder with horizontal surfaces overlapping vertical surfaces and edges tightly butted together. Secure insulation by impaling on mechanical fasteners.
 - .3 In areas of limited space wire fastenings, insulation adhesive, or other suitable methods of attachment may be substituted.
- .2 Cooling only or Combined Cooling and Heating Duct and Plenum - Service Temperature 5°C to 65°C (CER/2)
 - .1 Fix mechanical fasteners to both horizontal and vertical surfaces at approximately 300 mm centers, each direction.
 - .2 Install vapor retarder toward the ambient atmosphere with horizontal surfaces overlapping vertical surfaces tightly butted together. Secure insulation by impaling on mechanical fasteners.
 - .3 Where mechanical fasteners penetrate vapor retarder, and at all corners and joints, apply self adhesive vapor retarder tape or vapor retarder strips adhered with vapor retarder adhesive. Where raised seams are encountered, add a strip of insulation above seam termination on each side of the seam, secure to the seams an overlapping strip of insulating material of equal thickness to the one required to provide a continuous vapor retarder. Seal all joints and edges with self adhesive vapor retarder tape.

- .4 In areas of limited space wire fastenings, insulation adhesive, or other suitable methods of attachment may be substituted.
- .3 Outside Air Duct and Plenum - -40°C to Ambient (CER/3)
 - .1 As per CER/2 application but firstly apply a layer of rigid insulation without vapor retarder before applying layer of rigid insulation with vapor retarder. All joints shall be staggered.

3.3 Flexible Insulation External Application

- .1 Heating only Duct and Plenum – Service Temperature 20°C to 65°C (CEF/1)
 - .1 On rectangular ducts ≥ 600mm in width, apply mechanical fasteners to the bottom surface at approximately 300 mm centres.
 - .2 Apply insulation without integral vapour retarder with 50 mm overlap at each joint. Secure insulation with wire fastening on approximately 300 mm centres, or by stapling laps.
- .2 Cooling only or Combined Cooling and Heating Duct and Plenum – Service Temperature 5°C to 65°C (CEF/2)
 - .1 On rectangular ducts ≥ 600 mm in width, apply to bottom surface mechanical fasteners at approximately 300 mm centers.
 - .2 Apply insulation with vapor retarder to the outside.
 - .3 Where mechanical fasteners or staples penetrate the vapor retarder and at all joints apply vapor retarder tape or vapor retarder strips adhered with vapor retarder adhesive.
 - .4 All joints shall be overlapped a minimum of 50 mm and stapled on approximately 100 mm centers.
 - .5 Secure insulation with wire fastening on approximately 300 mm centers.
- .3 Heating only Duct and Plenum Fire Barrier – ambient to 538°C (1000°F)
 - .1 As per manufacturers installation instructions

3.4 Duct Insulation Minimum Thickness Table (Climatic Zone 5)

Rigid Exterior Duct Insulation				
Duty	Plenum-Concealed (4)	Duct Location		
		Interior		Exterior
		Conditioned Space	Unconditioned Space	
Minimum Insulation Thickness in mm (in.)				
Cooling Only Air Supply	25 (1")	25 (1")	25 (1")	125 (5")
Heating or H/C Air Supply	38 (1-1/2")	38 (1-1/2")	38 (1-1/2")	125 (5")
Outdoor Air Supply	38 (1-1/2")	38 (1-1/2")	38 (1-1/2")	0
Combustion Air	38 (1-1/2")	38 (1-1/2")	38 (1-1/2")	0
Return Air	25 (1")	0	25 (1")	125 (5")
Exhaust Air (1)(2)	25 (1")	0	25 (1")	25 (1")
Grease Hood Exhaust (5)	N/A	38 (1-1/2")	38 (1-1/2")	0
Tempered Air Supply or Makeup Air	0	0	25 (1")	125 (5")
Mixed Air (3)	25 (1")	25 (1")	25 (1")	125 (5")

See note (6) for factory installed duct and plenums				
Flexible Exterior Duct Insulation				
Duty	Plenum-Concealed (4)	Duct Location		
		Interior		Exterior
		Conditioned Space	Unconditioned Space	
Minimum Insulation Thickness mm (in.)				
Cooling Only Air Supply	38 (1-1/2")	38 (1-1/2")	38 (1-1/2")	188 (7-1/2")
Heating or H/C Air Supply	50 (2")	50 (2")	50 (2")	188 (7-1/2")
Outdoor Air Supply	50 (2")	50 (2")	50 (2")	0
Combustion Air	50 (2")	50 (2")	50 (2")	0
Return Air	38 (1-1/2")	0	38 (1-1/2")	188 (7-1/2")
Exhaust Air (1)(2)	38 (1-1/2")	0	38 (1-1/2")	38 (1-1/2")
Grease Hood Exhaust (5)	N/A	38 (1-1/2")	38 (1-1/2")	0
Tempered Air Supply or Makeup Air	0	0	38 (1-1/2")	188 (7-1/2")
Mixed Air (3)	38 (1-1/2")	38 (1-1/2")	38 (1-1/2")	188 (7-1/2")
See note (6) for factory installed duct and plenums				

Note (1): Air temperatures 15°C to 49°C (60°F to 120°F)

Note (2): Provide 38mm (1-1/2") flexible duct insulation on all exhaust air ductwork from outside wall or roof to damper but a minimum of 1.5 m (5 ft.) inside building.

Note (3): Mixed Air includes tempered air downstream of heat recovery units

Note (4): Plenums located outside the building shall be insulated to the values listed in the exterior column.

Note (5): Provides 1 hour fire rating. Thickness shall be doubled for 2 hour applications

Note (6): Factory installed ductwork and plenums provided with equipment need not comply with this table provided they meet the requirements of the relevant CSA Standard for that equipment and is insulated to RSI 0.58 (R3.3) or greater. Refer to NECB article 5.2.12.1 for relevant CSA Standards.

3.5 Liner Internal Application

- .1 General
 - .1 Where an interior duct liner is used, external insulation shall not be applied unless noted otherwise.
 - .2 Where an interior duct liner is used, the thickness shall be selected to match the thickness specified for external rigid insulation. Where no external insulation is required internal acoustic duct liner shall be a minimum 25mm (1").
- .2 Rigid Duct Liner (CIR/1)
 - .1 Fix mechanical fasteners to both horizontal and vertical surfaces at approximately 300 mm centers each direction.
 - .2 Apply insulation with surfaces overlapping vertical surfaces and with edges tightly butted together.
 - .3 Insulation shall be applied to the ductwork with a minimum 90% coverage of adhesive and mechanical fasteners.

- .4 Where mechanical fasteners penetrate factory finish and at all joints, apply a heavy layer of seal coating.
- .5 On high velocity duct systems 20 m/s to 30 m/s (4000 fpm -6000 fpm) apply reinforcing membrane over the entire insulation joint surface.
- .6 Seal off leading edge of insulation to duct surface on low velocity ductwork with reinforced seal coating or metal nosing. On high velocity duct systems, (over 20 m/s (4000 fpm) use metal nosing.

3.6 Finishes

- .1 General
 - .1 Insulation on concealed ductwork shall be left with factory finish. No further finish is required.
 - .2 The following finishes apply to exposed ductwork and plenums only.
- .2 Canvas Jacket – Indoor (CRF/1) (CRD/1)
 - .1 Use over rigid insulation for rectangular ductwork and flexible insulation for round ductwork, all with an integral vapor retarder. Apply continuous metal corner bead to all corners. Adhere vapor retarder tape over all joints and breaks in vapor retarder, and at all corners.
 - .2 Secure canvas jacket over insulation using fire resistive lagging coating and adhesive, and finish with one (1) coat of fire resistive lagging coating adhesive.
- .3 Utility Finish – Indoor (CRF/2) (CRD/2)
 - .1 Use over rigid insulation for rectangular ductwork and flexible insulation for round ductwork, all with an integral vapor retarder. Apply continuous metal corner bead to all corners. Adhere vapor retarder tape over all joints and breaks in vapor retarder, and at all corners.
- .4 Aluminum Jacket – Outdoor (CRF/3) (CRD/3)
 - .1 Adhere vapour retarder tape over all joints and breaks in vapor retarder and at all corners on cold or dual temp ductwork.
 - .2 Apply over the insulation surface a stucco embossed aluminum jacket secured with pop rivets or stainless steel self tapping screws. All joints sealed or flashed to prevent water infiltration.
- .5 Bitumen Membrane – Outdoor (CRF/5) (CRD/4)
 - .1 Install a modified bitumen membrane on rectangular ductwork and an aluminized modified bitumen membrane on round ductwork.
 - .2 Install in accordance to manufacturer’s instructions.

3.7 Duct Finishes Table

- .1 Conform to the following:

Duty	Rectangular Duct		Round Duct	
	Type	TIAC Code	Type	TIAC Code
Indoor Concealed	None	None	None	None
Indoor Exposed in Mechanical Room & Elsewhere except Utility Areas	Canvas Jacket	CRF/1	Canvas Jacket	CRD/1

Duty	Rectangular Duct		Round Duct	
	Type	TIAC Code	Type	TIAC Code
Indoor Exposed in Utility Areas, Parkade, Etc.	Utility Finish	CRF/2	Utility Finish	CRD/2
Outdoor Exposed to Precipitation	Aluminum Jacket	CRF/3	Aluminum Jacket	CRD/3
Outdoor Elsewhere	Bitumen Membrane	CRF/5	Bitumen Membrane	CRD/4

END OF SECTION

1. GENERAL

1.1 Section Scope

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
- .2 Applicable Building Code - Refer to Section 21 05 01 – Common Work Results for Mechanical
- .3 Thermal Insulation Association of Canada (TIAC): National Insulation Standards.
- .4 British Columbia Insulation Contractors Association (BCICA) – Quality Standard for Mechanical Insulation Manual.
- .5 CAN/ULC S102-M88 – Method of Test for Surface Burning Characteristics of Building Materials and Assemblies
- .6 CGSB 51-GP-52MA – Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation
- .7 ASTM C553 – Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
- .8 ASTM C612 – Specifications for Mineral Fiber Block and Board Insulation

1.4 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:
 - .1 Certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - .2 Manufacturer's installation instructions.

1.5 General Requirements

- .1 The Installation firm shall be a current member of one of the following:
 - .1 Thermal Insulation Association of Canada (TIAC).
 - .2 British Columbia Insulation Contractors Association (BCICA)
 - .3 Thermal Insulation Association of Alberta (TIAA)
- .2 Only Journeyman insulation applicators, with 3 years minimum successful experience in this size and type of project, shall perform the work.
- .3 Definitions:
 - .1 "CONCEALED" insulated mechanical services in trenches, chases, furred spaces, shafts and hung ceilings (services in tunnels are not considered to be concealed.)
 - .2 "EXPOSED" will mean not concealed.
 - .3 "K" value means Thermal Conductivity

- .4 UL GREENGUARD: Provides independent third-party, Indoor Air Quality (IAQ) certification of products for emissions of respirable particles and Volatile Organic Compounds (VOC's), including formaldehyde and other specific product-related pollutants. Certification is based upon criteria used by Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA) and World Health Organization (WHO).
- .4 Provide thermal insulation on mechanical equipment and the following:
 - .1 Chillers
 - .2 Converters/Heat Exchangers
 - .3 Pumps (chilled/hot)
 - .4 Expansion Tanks
 - .5 Air Eliminators
 - .6 Engine silencer and exhaust
 - .7 Breechings/Flues
 - .8 Flash Tanks
 - .9 Condensate Receivers, Deaerator and Feed Water Tanks
 - .10 Domestic Hot Water Storage Tanks
 - .11 Buffer Tanks (chilled/hot)

2. PRODUCTS

2.1 Acceptable Manufacturers

- .1 Refer to Section 23 05 01 – Acceptable Manufacturers

2.2 General

- .1 Products shall not contain asbestos, lead, mercury, mercury compounds or Polybrominated diphenyl ethers (PBDE).
- .2 Mineral fibre specified includes glass wool and rock wool.
- .3 The RSI value shall not be reduced from the specified values when tested in accordance with ASTM C553.
- .4 Insulation and jacketing materials shall not exceed 25 flame spread, 50 smoke developed rating when tested in accordance with CAN/ULC S102-M88.
- .5 Elastomeric insulation shall comply with NFPA 90A, 90B and ASTM C1534
- .6 Foam insulation products shall not use CFC or HCFC blowing agents in the manufacturing process and be formaldehyde free.
- .7 Glass mineral wool products shall have a recycled content of a minimum of 50 percent recycled glass content.
- .8 Low Emitting Materials: For all thermal and acoustical applications of glass mineral wool insulation, insulation shall be UL GREENGUARD Certified.

2.3 Low Temperature Range (-40°C to 5°C)

- .1 Flexible Elastomeric (TIACA-6)
 - .1 Sheet and roll flexible foamed elastomeric insulation. Plain and self-adhering as required:

- .1 Maximum “K” value at 24°C (75°F) = 0.039 W/m.°C (0.27 Btu.in/hr.ft2.°F)
- .2 Complying with ASTM C534.

2.4 Low to Intermediate Temperature Range (55°C TO 315°C)

- .1 Rigid (TIAC C-1):
 - .1 Service temperature 5°C to 315°C (41°F to 599°F)
 - .2 Glass mineral wool board for low and medium temperature applications.
 - .3 Plain or Aluminum foil-scrim kraft (FSK) jacket reinforced with glass fibre reinforcement or all service jacket (ASJ) consisting of a white kraft bonded to aluminum foil, reinforced with glass fibre reinforcement. Type as required. All jackets factory applied.
 - .4 Minimum density 36kg/m3 (2.25 PCF)
 - .5 Maximum “K” value at 24°C (75°F) = 0.035 W/m.°C (0.24 Btu.in/hr.ft2.°F)
 - .6 Complying with ASTM C612 – Specifications for Mineral Fiber Block and Board Insulation
- .2 Flexible (TIAC C-2):
 - .1 Service temperature 5°C to 315°C (41°F to 599°F)
 - .2 Glass mineral wool flexible blanket for low and medium temperature applications.
 - .3 Plain or Aluminum foil-scrim kraft (FSK) jacket reinforced with glass fibre reinforcement or all purpose (AP) jacket consisting of a white kraft bonded to aluminum foil, reinforced with glass fibre reinforcement. Type as required. All jackets factory applied.
 - .4 Minimum density 40kg/m3 (2.5PCF),
 - .5 Maximum “K” value at 24°C (75°F) = 0.035 W/m.°C (0.24 Btu.in/hr.ft2.°F)
 - .6 Complying with ASTM C553 Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications

2.5 Fastenings, Adhesives and Coatings

- .1 Insulation Fastenings: min. 1.6 mm thick [16 ga.] galvanized wire, 0.6 mm thick aluminum wire, 0.6 mm thick type 304 stainless steel wire or 1.6 mm thick copper wire as commercially available. Jacket Fastenings:
 - .1 Thermocanvas and All Service Jacket:
 - .1 Staples (flare type), compatible jacket finishing tape, contact adhesives recommended by the jacket manufacturer.
 - .2 Metal Jackets:
 - .1 Sheet metal screws, pop rivets, stainless steel bands.
 - .3 PVC Jacket and Fitting Covers:
 - .1 PVC self-adhesive tape, plastic pop rivets, bonding cement.
- .2 Adhesives:
 - .1 Fabric adhesive to insulation pipe covering, water based, ultra white, washable, anti-microbial
- .3 Coatings:
 - .1 Vapour barrier coating on reinforcing membrane or on insulating cement:

2.6 Finish Jackets

- .1 Jackets:
 - .1 Thermocanvas Jacket: fire rated, 170g (6 oz) fire retardant canvas jacket for covering mechanical insulation indoors, 25/50 fire class, plain wave cotton, no dyes.
 - .2 PVC Finishing Jacket: white, UV resistant, for indoor or outdoor applications, 25/50 fire class, minimum 0.50 mm (0.02") thick.
 - .3 Aluminum Jacket: 0.51 mm (22 ga.) thick stucco or smooth aluminum jacketing with longitudinal slip joints and 50mm (2") end laps with factory applied protective liner on interior surface.

3. EXECUTION

3.1 General

- .1 Install in accordance with Thermal Insulation Association of Canada (TIAC) National Standards.
- .2 Comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.
- .3 Pressure testing of piping systems and adjacent equipment to be complete, witnessed and certified prior to insulation installation.
- .4 Use two layers of preformed insulation with staggered joints when the required nominal wall thickness exceeds 75 mm.
- .5 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
- .6 Locate insulation or cover seams in least visible locations.

3.2 Removable, Pre-Fabricated, Insulation and Enclosures

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

3.3 Hot Tanks, Breechings and Equipment (TIAC 1503-H)

- .1 Apply insulation block, board segments, or pipe and tank insulation and secure firmly with mechanical fastenings, wire, or banding. Insulation shall be fitted neatly to all contours without voids.

3.4 Finish Jackets

- .1 Aluminum Jacket - Indoor/Outdoor (CEF/1)
 - .1 Apply over the insulation surface an aluminum jacket secured with pop rivets or stainless steel self tapping screws. All joints sealed or flashed to prevent water infiltration.
- .2 Canvas/PVC Jacket – Indoor (CEF/2)
 - .1 Secure canvas jacket using fire resistive lagging coating and adhesive. Finish with one (1) coat of fire resistive lagging coating. Alternatively, finish with a layer of PVC jacket with all joints and seams sealed.

3.5 Insulation Minimum Thickness Schedule

- .1 Factory insulated equipment need not comply with the minimum thickness table below provided they are insulated to a thermal resistance not less than RSI 0.58 (R3.3).

.2 Thermally insulate equipment to the following:

Duty	Thickness		TIAC Insulation Type	Application
	mm	inches		
Expansion Joints ①	**	**	C-2	TIAC 1503-H
Heat Exchanger(s)	50	2	C-1 or C-2	TIAC 1503-H
① Removable insulated cover type application **thickness to match adjacent pipe insulation R-value				

3.6 Equipment Finishes Schedule

- .1 On all externally insulated equipment, provide the following finish material:
- .1 Low temperature equipment in mechanical rooms: PVC jacket to TIAC standard CEF/2
 - .2 Intermediate temperature equipment in mechanical room's canvas jacket to TIAC standard CEF/2.
 - .3 High temperature equipment in mechanical room's aluminum jacket to TIAC standard CEF/1.
 - .4 Indoor equipment elsewhere canvas/PVC jacket to TIAC standard CEF/2.
 - .5 Outdoor equipment aluminum jacket to TIAC standard CEF/1.

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 Thermal insulation and jacketing for HVAC piping and HVAC piping accessories.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical.

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
- .2 Applicable Building Code – Refer to Section 21 05 01 – Common Work Results for Mechanical.
- .3 Applicable energy code or standard – Refer to Section 21 05 01 – Common Work Results for Mechanical.
- .4 Thermal Insulation Association of Canada (TIAC) – National Insulation Standards.
- .5 British Columbia Insulation Contractors Association (BCICA) – Quality Standard for Mechanical Insulation Manual.
- .6 CAN/ULC S102-M88 – Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.
- .7 ASTM C534 Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
- .8 ASTM C547 – Standard Specification for Mineral Fibre Pipe Insulation.
- .9 ASTM C553 – Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.

1.4 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:
 - .1 Certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - .2 Manufacturer's installation instructions.

1.5 General Requirements

- .1 The Installation firm shall be a current member of one of the following:
 - .1 Thermal Insulation Association of Canada (TIAC).
 - .2 British Columbia Insulation Contractors Association (BCICA)
- .2 Only Journeyman insulation applicators, with 3 years minimum successful experience in this size and type of project, shall perform the work.
- .3 Definitions:
 - .1 "CONCEALED" insulated mechanical services in trenches, chases, furred spaces, shafts and hung ceilings (services in tunnels are not considered to be concealed.)
 - .2 "EXPOSED" will mean not concealed.

- .3 "K" value means Thermal Conductivity.
- .4 UL GREENGUARD: Provides independent third-party, Indoor Air Quality (IAQ) certification of products for emissions of respirable particles and Volatile Organic Compounds (VOC's), including formaldehyde and other specific product-related pollutants. Certification is based upon criteria used by Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA) and World Health Organization (WHO).
- .5 ASJ: All Service Jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper
- .6 SSL: Self-Sealing Lap.
- .7 FSK: Foil Scrim Kraft; jacketing.
- .8 PSK: Poly Scrim Kraft; jacketing.
- .9 PVC: PolyVinyl Chloride.
- .4 Provide thermal insulation on all HVAC piping, valves and fittings and as follows:
 - .1 Hot water heating supply and return piping.
 - .2 Condensate piping.
 - .3 Glycol heating supply and return piping.
 - .4 Condenser water piping, outside building.
 - .5 Heat pump water piping, outside building.
- .5 Insulate the following valves and fittings if the pipe is insulated:
 - .1 Elbows, tees, reducers.
 - .2 Valve bodies on valves and check valves, over 2½ NPS
 - .3 Flanges.
 - .4 Strainers.
- .6 Where insulation is not specified, coat exposed hot pumps, pipe and fittings, operating at or above 60°C (140°F) with a Therma-Lite liquid insulation product to prevent skin burns. This includes:
 - .1 Valves, 2½ NPS and smaller.
 - .2 Valve bonnets.
 - .3 Unions.
 - .4 Drip legs.
 - .5 Flexible connections.
 - .6 Expansion joints.
 - .7 Check valve covers.
- .7 Insulate and vapour seal the following fittings, if the pipe is insulated:
 - .1 Elbows, tees, reducers.
 - .2 Valves, (bodies and bonnets) except check valve covers.
 - .3 Strainers.
 - .4 Flanges.
 - .5 Unions.

- .8 DO NOT insulate the following, unless otherwise noted:
 - .1 Drain lines for sumps 15°C (60°F) and over.
- .9 If the Contractor, during renovations, should discover asbestos (or material suspected to be asbestos) on piping, ductwork, etc., he shall immediately cease all work in that area and contact Owner's representative.
- .10 Make good all existing insulation disturbed or removed to facilitate alterations and additions to existing piping

2. PRODUCTS

2.1 Acceptable Manufacturers

- .1 Refer to Section 23 05 01 – Acceptable Manufacturers

2.2 General

- .1 Products shall not contain asbestos, lead, mercury, mercury compounds or Polybrominated diphenyl ethers (PBDE).
- .2 Mineral fibre specified includes glass fibre and rock wool.
- .3 Thermal conductivity ("k" factor) not to exceed specified values when tested in accordance with ASTM C547
- .4 Insulation and jacketing materials shall not exceed 25 flame spread, 50 smoke developed rating when tested in accordance with CAN/ULC S102-M88 and NFPA 90A
- .5 Foam insulation products shall not use CFC or HCFC blowing agents in the manufacturing process and be formaldehyde free.
- .6 Glass mineral wool products shall have a recycled content of a minimum of 50 percent recycled glass content.
- .7 Low Emitting Materials: For all thermal and acoustical applications of glass mineral wool insulation, insulation shall be UL GREENGUARD Certified.

2.3 Preformed Pipe Covering

- .1 Low Temperature Thermal Insulation
 - .1 Piping service temperature -40°C to 5°C (-40°F to 41°F)
 - .2 Complying with ASTM C534
 - .3 Preformed and pre-slit flexible foamed elastomeric insulation with self-adhesive self seal or lap seal joints:
 - .1 Maximum "K" value at 24°C (75°F) = 0.039 W/m.°C (0.27 Btu.in/hr.ft2.°F)
 - .4 Preformed flexible closed cell insulation:
 - .1 Maximum "K" value at 24°C (75°F) = 0.036 W/m.°C (0.24 Btu.in/hr.ft2.°F)
 - .5 Phenolic closed cell preformed rigid insulation with all service jacket vapour retarder (ASJ). ASJ shall be re-enforced with glass fibre, factory applied with pressure sensitive lap closure.
 - .1 Maximum "K" value at 24°C (75°F) = 0.019 W/m.°C (0.13 Btu.in/hr.ft2.°F)
- .2 Low to Intermediate Temperature Thermal Insulation
 - .1 Piping service temperature 5°C to 315°C (41°F to 599°F)

- .2 Preformed insulation, mineral glass wool pipe insulation with all service jacket vapour retarder (ASJ). ASJ shall be re-enforced with glass fibre, factory applied with pressure sensitive lap closure.
- .3 Complying with ASTM C547.
- .4 ASJ vapour transmission rate 0.02 perms maximum
- .5 Maximum “K” value at 38°C (100°F) = 0.035 W/m.°C (0.24 Btu.in/hr.ft².°F)

2.4 Fastenings, Adhesives and Coatings

- .1 Insulation Fastenings: min. 1.6 mm thick [16 ga.] galvanized wire, 0.6 mm thick aluminium wire, 0.6 mm thick type 304 stainless steel wire or 1.6 mm thick copper wire as commercially available.
- .2 Jacket Fastenings:
 - .1 Thermocanvas and All Service Jacket:
 - .1 Staples (flare type), compatible jacket finishing tape, contact adhesives recommended by the jacket manufacturer.
 - .2 Metal Jackets:
 - .1 Sheet metal screws, pop rivets, stainless steel bands.
 - .3 PVC Jacket and Fitting Covers:
 - .1 PVC self-adhesive tape, plastic pop rivets, bonding cement.
- .3 Adhesives:
 - .1 Fabric adhesive to insulation pipe covering, water based, ultra white, washable, anti-microbial.
- .4 Coatings:
 - .1 Vapour barrier coating on reinforcing membrane or on insulating cement.

2.5 Finish Jackets

- .1 Jackets:
 - .1 Thermocanvas Jacket: fire rated, 170g (6 oz) fire retardant canvas jacket for covering mechanical insulation indoors, 25/50 fire class, plain wave cotton, no dyes.
 - .2 All Service Jacket: high puncture and tear resistance with 0.03 mm [0.0019"] minimum thick foil. Water vapour permeance of 0.02 perms maximum. Self-adhesive material, flame spread/smoke development rating not to exceed 25/50.
 - .3 PVC Finishing Jacket: white, UV resistant, for indoor or outdoor applications, 25/50 fire class, minimum 0.50 mm (0.02") thick.
 - .4 Aluminum Jacket: 0.51 mm (22 ga.) thick stucco or smooth aluminum jacketing with longitudinal slip joints and 50mm (2") end laps with factory applied protective liner on interior surface.
 - .5 Stainless Steel: 0.25m thick [304][316] [smooth] [corrugated] [stucco embossed] longitudinal slip and circumferential slip joints with 0mm lasp, 19mm wide metal banding, 0.5mm thick, 300mm spacing.
- .2 Preformed Fitting Covers:
 - .1 PVC Fitting Covers pre-moulded one piece covers, white, UV resistant, for indoor or outdoor applications, 25/50 fire class, minimum 0.50 mm (0.02") thick.

- .2 Aluminum Fitting Covers: Die shaped components with factory applied protective liner on interior surface, 0.51 mm (22 ga.) thick.

3. EXECUTION

3.1 General

- .1 Install in accordance with Thermal Insulation Association of Canada (TIAC) National Standards.
- .2 Comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.
- .3 Pressure testing of piping systems and adjacent equipment to be complete, witnessed and certified prior to insulation installation.
- .4 Use two layers of preformed insulation with staggered joints when the required nominal wall thickness exceeds 75 mm.
- .5 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
- .6 Install hangers, supports outside vapour retarder jacket.
- .7 Apply high compressive strength insulation, suitable for service, at oversized saddles and shoes where insulation saddles have not been provided.
- .8 Ensure insulation is continuous through inside walls. Pack around pipes with fire proof self-supporting insulation material, properly sealed.
- .9 Insulate piping, fittings, and valves.
- .10 Locate insulation or cover seams in least visible locations. Locate seams on piping in ceiling spaces on the underside of the pipe.
- .11 Terminate insulation 75 mm (3") back from all uninsulated fittings to provide working clearance. Terminate insulation at 90°, finish with reinforced scrim cloth, and vapour barrier mastic system or use vapour barrier mastic and pre-formed fitting cover over.
- .12 On vertical pipes over 3 NPS, provide insulation supports welded or bolted to pipe, directly above the lowest pipe fitting. Provide supports on 4.5 m (15') centres.
- .13 Where insulation is not specified:
 - .1 Hot Piping: Coat exposed hot pumps, pipe and fittings with Therma-Lite liquid insulation product to prevent skin burns

3.2 Installation Hot Application - Intermediate Temperature (15°C - 315°C) TIAC 1501-H

- .1 Piping: Pipe covering without integral jacket shall be held in place with insulation fastening at not less than 300 mm centres. Pipe insulation with integral jacket shall be held in place by stapling the flap on 75 mm centres. Pipe insulation with integral self-sealing jacket will not require additional fastening.
- .2 Screwed or welded fittings: Insulate fittings with sections of the pipe insulation mitered to fit tightly, or with tightly placed flexible insulation covered with reinforcing membrane stapled in place. Alternately, insulate fittings with tightly placed flexible insulation and apply PVC fitting covers.
- .3 Valves, Strainers: Insulate valve bodies and strainers with fitted pipe insulation segments, or mitered blocks all to thickness of the adjacent pipe insulation. Drains, blow off plugs and caps shall be left uncovered. Alternately, insulate with tightly placed flexible insulation and apply PVC fitting covers.

- .4 Flanged and grooved fittings: Insulate with oversized pipe covering or mitered blocks to the thickness of the adjacent pipe covering. Alternately, insulate with tightly placed flexible insulation and apply PVC fitting covers.
- .5 Insulation Termination Points: Terminate insulation 75mm from fittings to provide working clearance and bevel insulation at 45° angle.

3.3 Finishes

- .1 Concealed piping shall be left as factory finished, TIAC standard CPF/2.
- .2 Exposed Piping Indoor (Canvas) CPF/1
 - .1 The factory applied integral all service jacket shall be neatly applied to receive the fabric jacket. Apply a jacket with a fire resistive lagging coating. Apply a finishing coat of fire resistive lagging coating
- .3 Exposed Piping Indoor (PVC Jacket) CPF/4:
 - .1 Apply PVC jacketing using necessary fastenings on approximately 300mm centers, or bond using an adhesive recommended by the manufacturer to provide continuous seal. Overlap each section a minimum 75mm (3"). Cover longitudinal and circumferential joints with finishing tape neatly applied. On hot piping tacks may be used to secure jacket laps. Tacks are to be applied on 100mm (4") centres.
 - .2 Over insulated fittings, valve bodies, valve bonnets, strainers, and flanges apply PVC jacket or preformed PVC fitting covers to provide a complete jacket system. Secure with appropriate fastenings and jacket finishing tape.
- .4 Exposed Piping Outdoor Aluminum Jacket CPF/3
 - .1 Apply aluminum jacketing with a 60mm overlap at 3 o'clock using necessary fastenings on approximately 150mm centers.
 - .2 Over insulated fittings, valve bodies, valve bonnets, strainers and flanges apply aluminum jacket or preformed metal fitting covers to provide a complete jacket system. Secure with necessary fastenings.

3.4 Application Design Operating Temperatures

- .1 Heat Recovery (Glycol) 10°C (50°F)
- .2 Heat Pump Water (Exterior) 32°C Use 41°C (106°F)

3.5 Piping Insulation Minimum Thickness Schedule

Type Of System	Design Operating Temperature Range °C (°F)	Thermal Conductivity of Insulation		Nominal Pipe Diameter NPS				
		Conductivity Range W/m.°C	Mean Rating Temperature °C (°F)	< 1	1 to 1½	1½ to 3	4 to 6	≥ 8
				Minimum Thickness of Piping Insulation (mm)				
Heating Systems (Steam, Condensate, and Hot Water)	>177 (350)	0.046-0.049	121 (250)	115	125	125	125	125
	122-177 (251-350)	0.042-0.046	93 (199)	75	100	115	115	115
	94-121 (201-250)	0.039-0.043	65 (149)	65	65	65	75	75
	61-93 (142-200)	0.036-0.042	52 (126)	40	40	50	50	50
	41-60 (105-141)	0.032-0.040	38 (100)	25	25	40	40	40

Cooling Systems (Chilled Water, Refrigeration)	5-16 (41-61)	0.030-0.039	24 (75)	25	25	25	25	25
	<5 (41)	0.029-0.037	10 (50)	25	25	25	25	40

Note: For all heating piping located exterior to the building envelope (incl. unheated areas of the building i.e. parkade) the insulation thickness shall match that of the >177°C (350°F) operating temperature range (i.e. 82°C HWS would move from 61-93°C range to the >177°C range).

Note: Where the thermal conductivity of a proposed insulation is greater than the range specified above, the thickness will be increased by the ratio of $U2/U1$.

$U2$ = proposed insulation “k” value at the table mean rating temperature.

$U1$ = upper range limit “k” value from the table above.

Note: Where thermal conductivity of proposed insulation is less than the range specified above, the thickness may be decreased by the ratio of $U2/U1$.

$U2$ = proposed insulation “k” value at the table mean rating temperature.

$U1$ = lower range limit “k” value from the table above.

3.6 Piping Finish Schedule

.1 Conform to the following:

Duty	Type	TIAC Code
Indoors, Concealed	Factory	CPF/2
Indoors, Exposed in Mechanical Room and Utility Areas	Canvas Jacket	CPF/1
Indoors, Exposed in Parkade and Elsewhere	PVC Jacket	CPF/4
Outdoors	Aluminum Jacket	CPF/3

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 Section includes commissioning process requirements for HVAC&R, plumbing and fire suppression systems, assemblies, and equipment.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical.

1.3 References

- .1 Commissioning Agency (CxA)
- .2 The latest revisions of the following standards shall apply unless noted otherwise.
 - .1 Applicable Building Code - Refer to Section 21 05 01.

1.4 Submittals

- .1 Comply with Division 1 – Submission and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:
 - .1 Certificates of readiness.
 - .2 Certificates of completion of installation, prestart, and start-up activities.

1.5 Contractor's Responsibilities

- .1 Perform commissioning tests.
- .2 Attend construction phase controls coordination meeting.
- .3 Attend testing, adjusting, and balancing review and coordination meeting.
- .4 Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection.
- .5 Provide information requested by the CxA for the final commissioning documentation.
- .6 Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.6 CxA's Responsibilities

- .1 Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC&R, plumbing and fire suppression systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.
- .2 Verify and participate in commissioning testing.
- .3 Verify testing, adjusting, and balancing of work are complete.
- .4 Prepare Cx Plan.
- .5 Review construction documents (drawing/specs).

1.7 Commissioning Documentation

- .1 Provide the following information to the CxA for the inclusion in the commissioning plan:

- .1 Plan for delivery and review of submittals, systems manuals, and other documents and reports.
- .2 Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
- .3 Process and schedule for completing construction checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
- .4 Certificate of completion certifying that installation, start-up checks, and start-up procedures have been completed.
- .5 Certificate of readiness, certifying that HVAC&R, plumbing and fire suppression systems, subsystems, equipment, and associated controls are ready for testing.
- .6 Test and inspection reports, and certificates.
- .7 Corrective action documents.
- .8 Documented verification of testing, adjusting, and balancing reports.

2. PRODUCTS (NOT USED)

3. EXECUTION

3.1 Testing Preparation

- .1 Certify that HVAC&R, plumbing and fire suppression systems, subsystems, and equipment, have been installed, calibrated, and started and are operating according to the Contract Documents.
- .2 Construction documents review:
 - .1 Provide full set of Div 21, 22, 23, 25, 26 drawings and specifications for preliminary design review, as applicable.
- .3 Certify that HVAC&R, instrumentation, and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- .4 Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.
- .5 Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- .6 Inspect and verify the position of each device and interlock identified on checklists.
- .7 Check safety cut-outs, alarms, and interlocks with life-safety systems during each mode of operation.
- .8 Testing instrumentation: Install measuring instruments and logging devices to record test data.

3.2 Testing and Balancing Verification

- .1 Prior to performance of testing and balancing (TAB) work, provide copies of TAB procedures, reports, sample forms, checklists, and certificates to the CxA.
- .2 Notify the CxA at least 10 working days in advance of testing and balancing work, and provide access for the CxA to witness testing and balancing work.

- .3 Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems.
 - .1 The CxA will notify testing and balancing Contractor 10 working days in advance of the date of field certification. Notice will not include data points to be verified.
 - .2 The testing and balancing Contractor shall use the same instruments (by model and serial number) that were used when original data were collected.
 - .3 Failure of an item includes, other than for sound measurements, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3dB shall result in rejection of final testing.
 - .4 Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.3 General Testing Requirements

- .1 Scope of HVAC&R testing includes entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditions space. Testing shall include measuring capacities and effectiveness of operational and control functions.
- .2 Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- .3 The CxA along with the HVAC&R Contractors, testing and balancing Contractor, and the HVAC&R Instrumentation and Control Contractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.
- .4 Tests will be performed using design conditions whenever possible.
- .5 Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Calibrate testing instruments before simulating conditions. Provide equipment to simulate loads. Set simulated conditions and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- .6 Alter sensor values with a signal generator when design or simulating conditions and altering set points are not practical.
- .7 Alter sensor values with a signal generator when design or simulating conditions and altering set points are not practical.
- .8 If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- .9 If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.4 HVAC&R Systems, Subsystems, and Equipment Testing Procedures

- .1 Heating plant.
- .2 HVAC&R instrumentation and control system testing: Field testing plans and testing requirements are specified in Section 25 08 00 Commissioning of Integrated Automation and Section 25 90 00 Integrated Automation Control Sequences.

- .3 Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in Section 23 21 13 Hydronic Piping and 23 25 00 HVAC Water Treatment. HVAC Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:
 - .1 Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
 - .2 Description of equipment for flushing operations.
 - .3 Minimum flushing water velocity.
 - .4 Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.
- .4 HVAC&R Distribution System and Testing: Provide technicians, instrumentation, tools, and equipment, to test performance of air and hydronic distribution systems including HVAC&R terminal equipment and unitary equipment.
- .5 Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

3.5 Procedures for Space Pressurization Measurements and Adjustments

- .1 Before testing for space pressurization, observe the space to verify the integrity of the space boundaries. Verify that windows and doors are closed and applicable gaskets, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.
- .2 Measure, adjust, and record the pressurization of each room, each zone, and each building by adjusting the supply, return, and exhaust airflows to achieve the indicated conditions.
- .3 Measure space pressure differential where pressure is used as the design criteria and measure airflow differential where differential airflow is used as the design criteria for space pressurization.
 - .1 For pressure measurements, measure and record the pressure difference between the intended spaces at the door with all doors in the space closed. Record the high-pressure side, low-pressure side, and pressure difference between each adjacent space.
 - .2 For applications with cascading levels of space pressurization, being in the most critical space and work to the least critical space.
 - .3 Test room pressurization first, then zones, and finish with building pressurization.
- .4 To achieve indicated pressurization, set the supply airflow to the indicated conditions and adjust the exhaust and return airflow to achieve the indicated pressure or airflow difference.
- .5 For spaces with pressurization being monitored and controlled automatically, observe and adjust the controls to achieve the indicated pressure or airflow difference.
 - .1 Compare the values of the measurements taken to the measured values of the control system instruments and report findings.
 - .2 Check the repeatability of the controls by the successive tests designed to temporarily alter the ability to achieve space pressurization. Test over pressurization and under pressurization, and observe and report on the system's ability to revert to the set point.

- .3 For spaces served by variable-air-volume supply and exhaust systems, measure space pressurization at indicated airflow and minimum airflow conditions.
- .6 In spaces that employ multiple modes of operation, such as normal mode and emergency mode or occupied mode and unoccupied mode, measure, adjust, and record data for each operating mode.
- .7 Record indicated conditions and corresponding initial and final measurements. Report deficiencies.

END OF SECTION

1. GENERAL

1.1 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical
- .3 Section 23 05 15 – Common Installation Requirements for HVAC Pipework
- .4 Section 23 05 93 - Testing, Adjusting and Balancing for HVAC
- .5 Section 23 21 13 – Hydronic Piping
- .6 Section 23 57 00 - Heat Exchangers for HVAC

1.2 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
 - .1 Applicable Building Code - Refer to Section 21 05 01
- .2 American Society for Testing and Materials International (ASTM)
 - .1 ASTM E202-18, Standard Test Methods for Analysis of Ethylene Glycols and Propylene Glycols.

1.3 Cleaning and Start-Up of Mechanical Piping Systems

- .1 In accordance with Section 23 21 13 - Hydronic Piping and Section 23 25 00 HVAC Water Treatment.

1.4 Hydronic Systems - Performance Verification (PV)

- .1 Perform hydronic systems performance verification after cleaning is completed and system is in full operation.
- .2 When systems are operational, perform following tests:
 - .1 Conduct full scale tests at maximum design flow rates, temperatures and pressures for continuous consecutive period of 48 hours to demonstrate compliance with design criteria.
 - .2 Verify performance of hydronic system circulating pumps as specified, recording system pressures, temperatures, fluctuations by simulating maximum design conditions and varying.
 - .1 Pump operation.
 - .2 Boiler operation.
 - .3 Maximum heating demand.
 - .4 Minimum heating demand.
 - .5 Boiler failure.
 - .6 Outdoor reset. Re-check system operation and output supply temperature at 100% and 50% reset, maximum water temperature.

1.5 Hydronic System Capacity Test

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

- .2 Verification of operating, limit, safety controls.
- .3 Verification of primary and secondary pump flow rates.
- .4 Verification of accuracy of temperature and pressure sensors and gauges.
- .2 Calculate system capacity at test conditions.
- .3 Using manufacturer's published data and calculated capacity at test conditions, extrapolate system capacity at design conditions.
- .4 When capacity test is completed, return controls and equipment status to normal operating conditions.
- .5 Submit sample of system water to approved testing agency to determine if chemical treatment is correct. Include cost.
- .6 Heating system capacity test:
 - .1 Perform capacity test when ambient temperature is within 10% of design conditions. Simulate design conditions by:
 - .1 Increasing OA flow rates through heating coils (in this case, monitor heating coil discharge temperatures to ensure that coils are not subjected to freezing conditions) or
 - .2 Reducing space temperature by turning of heating system for sufficient period of time before starting testing.
 - .2 Test procedures:
 - .1 Open fully heat exchanger, heating coil and radiation control valves.
 - .2 With boilers on full firing and hot water heating supply temperature stabilized, record flow rates and supply and return temperatures simultaneously.
 - .3 Conduct flue gas analysis test on boilers at full load and at low fire conditions.

1.6 Glycol Systems

- .1 Test to prove concentration will prevent freezing to minus 40 degrees C. Test inhibitor strength and include in procedural report. Refer to ASTM E202.

1.7 Reports

- .1 In accordance with Section 23 08 00 – Commissioning of Mechanical Systems, Supplemented as specified herein.

1.8 Training

- .1 In accordance with Section 21 05 01 – Common Work Results for Mechanical: Instructions to Owner, supplemented as specified herein.

2. PRODUCTS

2.1 Not Used

3. EXECUTION

3.1 Not Used

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 The provision of hydronic piping, pipe fittings, and valves for heating water service.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical
- .3 Section 23 05 16 – Expansion Fittings and Loops for Mechanical Piping.
- .4 Section 23 05 29 – Hangers and Supports for Mechanical Piping and Equipment
- .5 Section 23 05 48 – Vibration and Seismic Control for Mechanical
- .6 Section 23 05 53 – Identification for Mechanical Piping and Equipment.
- .7 Section 23 07 19 – HVAC Piping Insulation.
- .8 Section 23 25 00 – HVAC Water Treatment.

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
- .2 American National Standards Institute (ANSI)/American Welding Society (AWS).
 - .1 ANSI/AWS A5.8/A5.8M, Specification Filler Metals for Brazing and Bronze Welding.
- .3 American Society of Mechanical Engineers (ASME).
 - .1 ASME Boiler and Pressure Vessel Code (BPVC), Section V, Non-Destructive Examination.
 - .2 ASME B1.20.1, Pipe Threads, General Purpose.
 - .3 ASME B16.1, Cast Iron Pipe Flanges, and Flanged Fittings.
 - .4 ASME B16.3, Malleable Iron Threaded Fittings.
 - .5 ANSI/ASME B16.4, Gray-Iron Threaded Fittings.
 - .6 ASME B16.5, Pipe Flanges, and Flanged Fittings.
 - .7 ASME B16.9, Factory-Made Wrought Butt welding Fittings.
 - .8 ANSI/ASME B16.15, Cast Bronze Threaded Fittings.
 - .9 ANSI/ASME B16.18, Cast Copper Alloy, Solder Joint Pressure Fittings.
 - .10 ANSI/ASME B16.22, Wrought Copper and Copper-Alloy Solder Joint Pressure Fittings.
 - .11 ASME B18.2.1, Square and Hex Bolts and Screws
 - .12 ASME B18.2.2, Square and Hex Nuts.
 - .13 ASME B31.1, Power Piping.
 - .14 ASME B31.9, Building Services Piping.
- .4 American Society for Testing and Materials International, (ASTM).
 - .1 ASTM A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless.

- .2 ASTM A234, Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
- .3 ASTM A536, Standard Specification for Ductile Iron Castings.
- .4 ASTM B32, Standard Specification for Solder Metal.
- .5 ASTM B62, Standard Specification for Composition Bronze, or Ounce Metal Castings.
- .6 ASTM B88M, Seamless Copper Water Tube.
- .7 ASTM B283, Standard Specification for Copper and Copper-Alloy Die Forgings (Hot-Pressed).
- .8 ASTM D 1248, Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.
- .9 ASTM F876 – Standard Specification for Crosslinked Polyethylene (PEX) Tubing
- .10 ASTM F1960 - Standard Specification for Cold Expansion Fittings with PEX Reinforcing Rings for Use with Cross-Linked Polyethylene (PEX) Tubing
- .11 ASTM F2389, Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems
- .5 American Water Works Association (AWWA).
 - .1 AWWA C111, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
- .6 Canadian Standards Association (CSA International).
 - .1 CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code.
 - .2 CSA B214, Installation Code for Hydronic Heating Systems.
 - .3 CSA B137.5, Crosslinked Polyethylene (PEX) Tubing Systems for Pressure Applications.
 - .4 CSA B137.11, Polypropylene (PP-R) Pipe and Fittings for Pressure Applications
 - .5 CSA B242, Groove and Shoulder Type Mechanical Pipe Couplings.
 - .6 CSA W47.1, Certification of Companies for Fusion Welding of Steel.
 - .7 CSA W117.2, Safety in Welding, Cutting, and Allied Processes.
 - .8 CSA W178.2 Certification of Welding Inspectors
- .7 Manufacturer's Standardization of the Valve and Fittings Industry (MSS).
 - .1 MSS-SP-67, Butterfly Valves.
 - .2 MSS-SP-70, Cast Iron Gate Valves, Flanged and Threaded Ends.
 - .3 MSS-SP-71, Cast Iron Swing Check Valves Flanged and Threaded Ends.
 - .4 MSS-SP-80, Bronze Gate, Globe, Angle, and Check Valves.
 - .5 MSS SP-82, Valve Pressure Testing Methods.
 - .6 MSS-SP-85, Cast Iron Globe and Angle Valves, Flanged and Threaded Ends.
 - .7 MSP-SP-110, Ball Valves, Threaded, Socket-Welding, Solder Joint, Grooved, and Flared Ends.
 - .8 MSS SP 125:2010, Gray Iron and Ductile Iron In-Line, Spring-Loaded, Center-Guided Check Valves
- .8 Standards Council of Canada (CAN/ULC)

- .1 CAN/ULC S102.2 Standard Method of Test for Surface Burning Characteristics of building Materials and Assemblies
- .2 CAN/ULC-S115 Standard Method of Fire Tests of Firestop Systems.

1.4 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:
 - .1 Submit detailed shop drawings of valves. Shop drawings shall clearly indicate valve make, model, location, type, size and pressure rating, Cv rating and Provincial CRN number for each valve type.
 - .2 Grooved joint couplings and fittings shall be shown on drawings and product submittals, and shall be specifically identified with the applicable style or series designation.

1.5 Quality Assurance

- .1 All components, products, and fabrication techniques shall be provided in compliance with the Regulations and Requirements of the Province of British Columbia.
- .2 Grooved Piping
 - .1 All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer and are to match the existing piping system installed at the boiler loop during the recent boiler upgrade work. (Combining products of multiple manufacturers is not permitted.) Grooving tools shall be of the same manufacturer as the grooved components.
 - .2 The manufacturer shall be ISO 9001 certified.
 - .3 All coupling, fitting, and valve (body and component) castings shall be date stamped for quality assurance and traceability.
 - .4 Gaskets shall be molded and produced by the coupling manufacturer.
 - .1 EPDM elastomer materials shall be developed, manufactured, and tested in the coupling manufacturer's facility. The EPDM shall be a proprietary blend that exceeds industry standards for performance over the long term.
 - .2 The coupling manufacturer's gasket development and production shall be periodically audited by quality and polymer industry professionals.
 - .3 The Victaulic proprietary blend is the only EHP that is considered acceptable for hot water heating systems to 120°C (250°F).
 - .5 All grooved joint products shall comply with CSA B242.

1.6 Regulatory Requirements

- .1 Comply with ASME B31.3 or B31.9, Building Service Piping; CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code; and CSA B214, Installation Code for Hydronic Heating Systems, for material, products, and installation.

1.7 System Pressure Ratings

- .1 Pipe Fittings:
 - .1 Piping systems 860 kPa (125 psig) or less operating pressure - 860 kPa (125 psig) rating.
 - .2 Piping systems 870 kPa (126 psig) to 1730 kPa (250 psig) operating pressure – 1730 kPa (250 psig) rating.

- .2 Valves: Suitable for maximum system operating temperature and pressure.

1.8 Maintenance

- .1 Extra Materials. Provide the following spare parts:
 - .1 Valve seats: one for every ten valves, each size. Minimum one.
 - .2 Discs: one for every ten valves, each size. Minimum one.
 - .3 Stem packing: one for every ten valves, each size. Minimum one.
 - .4 Valve handles: two of each size.
 - .5 Gaskets for flanges: one for every ten flanges.

1.9 Valves

- .1 Wherever possible all valves shall be of one manufacturer.
- .2 Grooved valves shall be of the same manufacturer as the adjoining couplings.
- .3 Provide valves with manufacturer's name and pressure rating clearly marked on outside of body. All valves must be suitable in all respects for service used.
- .4 All valves shall have a Provincial CRN number, which is current.
- .5 Include lock shield handles where shown or noted.
- .6 Where lockshield valves are specified, provide three (3) keys of each size: malleable iron cadmium plated.
- .7 Use non-rising stem valves where there is insufficient clearance for stem to rise.
- .8 Where butterfly valves are installed to permit removal of equipment, they shall be of the threaded full lug type or grooved if grooved system is used. They may however, be of the wafer type if an additional pair of flanges (not those installed to contain the valve) are installed.
- .9 All valves shall be inspected and pressured tested in accordance with MSS SP-82.

2. PRODUCTS

2.1 Acceptable Manufacturers

- .1 Refer to Section 23 05 01 – Acceptable Manufacturers

2.2 Pipe Hangers and Supports

- .1 Comply with Section 23 05 29 – Hangers and Supports for Mechanical Piping and Equipment

2.3 Copper Pipe and Fittings

- .1 2 NPS and smaller
- .2 Tubing
 - .1 Type K hard drawn copper tubing complying with ASTM B88M.
 - .1 Applications: Pressure drains, heating water, chilled water, chemical feed, relief valve vents.
 - .2 Type K soft drawn copper tubing complying with ASTM B88M.
 - .1 Applications: Air vent overflow where concealed.
 - .2 Relief valve vents.

- .3 Fittings:
 - .1 Wrought copper and copper alloy solder joint pressure fittings: to ANSI/ASME B16.22.
 - .2 Cast copper alloy solder joint pressure fittings: to ANSI B16.18.
 - .3 Pressure coupled joint with Smart Connect feature" system copper fittings with EDPM seals, and pressure type crimped joints made by use of manufacturer recommended tool.
- .4 Flanges:
 - .1 Brass or bronze.
 - .2 Orifice flanges: slip-on, raised face, 2100 kPa (300 psi).
- .5 Joints:
 - .1 Solder, tin-antimony, 95:5: to ASTM B32.
 - .2 Silver solder BCUP: to ANSI/AWS A5.8.
 - .3 Brazing: as indicated.

2.4 Steel Pipe and Fittings

- .1 Steel Pipe:
 - .2 6 NPS and smaller: Schedule 40, complying with ASTM A53, Grade B.
 - .1 Applications: Heating water, chilled water, chemical feed, relief valve vents.
 - .3 8 NPS and over: Schedule 40, complying with ASTM A53, Grade B.
 - .1 Applications: Heating water, chilled water.
- .4 Fittings:
 - .1 NPS 2 and under: Screwed fittings, except where otherwise noted, with PTFE tape or lead-free pipe dope.
 - .1 Screwed fittings: malleable iron, to ASME B16.3, Class 150.
 - .2 Unions: malleable iron, to ASME B16.3.
 - .2 NPS 2-1/2 and over: welded fittings and flanges to CSA W47.1.
 - .1 Butt-welding fittings: steel, to ASME B16.9.
 - .3 NPS 2 to 12: Fittings for roll grooved piping to CSA B242.
 - .1 Housings shall be cast with offsetting angle-pattern bolt pads to provide rigidity and system support and hanging in accordance with ANSI B31.1 and B31.9.
 - .2 Rigid Type Coupling: Installation-Ready, for direct stab installation without field disassembly, with grade EHP gasket rated to 121°C (250°F).
 - .1 Victaulic Style 107 or Victaulic Zero-Flex Style 07.
 - .3 Flexible Type Coupling: Installation-Ready, for direct stab installation without field disassembly, with grade EHP gasket rated to 121°C (250°F). For use in locations where vibration attenuation and stress relief are required.
 - .1 Victaulic Style 77 or 177
 - .4 NPS 14 to 24: Fittings for roll grooved piping to CSA B242.
 - .1 Victaulic AGS series with lead-in chamfer on housing key and wide width FlushSeal gasket.

- .2 Rigid Type Coupling: Housing key shall fill the wedge shaped AGS groove and provide rigidity and system support and hanging in accordance with ANSI B31.1 and B31.9.
 - .1 Victaulic Style W07.
- .3 Flexible Type Coupling: Housing key shall fit into the wedge shaped AGS groove and allow for linear and angular pipe movement.
 - .1 Victaulic Style W77.
- .5 Roll Groove Fittings
 - .1 Roll grooved fitting gaskets: Grade “EHP” gasket for temperature range -34°C (-30°F) to 121°C (250°F) or “EPDM” gasket for temperature range -34°C (-30°F) to 110°C (230°F).
 - .2 Roll groove couplings shall consist of two ductile iron housing segments, pressure responsive gasket, and zinc electroplated steel bolts and nuts conforming to ASTM A536 Grade 65-45-12. (Multiple segment type couplings are not permitted.)
 - .3 Fittings for roll grooved piping: -Ductile iron to ASTM A 536; wrought steel to ASTM A234; or where cast or wrought pattern is not available factory fabricated and tested to ASTM A53.
 - .5 Fittings shall be of the same manufacturer as the adjoining couplings.
 - .6 Grooving tools shall be of the same Manufacturer as the grooved components.
 - .7 All castings used for coupling housings, fittings, valve bodies, etc., shall be dated stamped for quality assurance and traceability.
- .5 Small Diameter Installation-Ready Fittings for Carbon Steel Pipe
 - .1 Installation-ready fittings for Schedule 10 through Schedule 80 plain end carbon steel piping in HVAC and mechanical applications sizes NPS ½” thru 2” (DN15 thru DN50). System rated for a working pressure of 2065 kPa (300 psi). Fittings shall consist of a ductile iron housing conforming to ASTM A536, Grade 65-45-12, with installation-ready ends orange enamel coated or zinc coated. Fittings complete with gasket liner, zinc-electroplated steel bolts and nuts as per the mechanical properties of ASTM A449, and 300 series stainless steel retainer.
 - .2 Small diameter installation-ready fittings for carbon steel pipe shall be Victaulic Style/Number P07, P08, P10, P11, P20, P25, P27, P50, P60 (or equivalent for pipe type), designed for installation onto plain end pipe without prior disassembly of the fitting.
 - .3 Tools: Cut and mark tool, designed to cut and mark the insertion depth of the pipe simultaneously to ensure proper coupling and fittings installation. Victaulic PC3110 or equivalent for pipe type.
- .6 Flanges:
 - .1 Cast iron: to ASME B16.1, class 125 or 150 to match system pressure class.
 - .2 Steel: to ASME B16.5. Class 125 or 150 to match system pressure class.
 - .3 Roll Groove: Flange Adapter, flat face, ductile iron housings with elastomer pressure responsive gasket, for direct connection to ANSI Class 125, or 150 flanged components.
 - .1 Victaulic Style 741 / W741.
 - .4 Flange Bolts and Nuts, carbon steel: to ANSI B18.2.1 and ANSI B18.2.2.
 - .5 Gaskets to AWWA C111

- .1 Up to 860 kPa (125 psig) system pressure - non-asbestos gaskets for mating surfaces.

2.5 Isolation Valves

- .1 Gate Valve (for shut-off and isolation)
 - .1 NPS 1 and smaller, soldered:
 - .1 W.O.G. non-shock 1380 kPa (200 psi)
 - .2 Bronze body, solid wedge disc, bronze, or stainless steel trim, rising stem, union or screwed bonnet, complying with MSS SP 80.
 - .2 NPS 2 and smaller, threaded:
 - .1 ANSI Class 125 (860 kPa)
 - .2 Bronze body, solid wedge disc, bronze, or stainless steel trim, rising stem, union or screwed bonnet, complying with MSS SP 80.
 - .3 NPS 2½ and over, flanged:
 - .1 ANSI Class 125 (860 kPa)
 - .2 Cast iron body, solid wedge disc, bronze or stainless steel trim, bolted bonnet, rising stem, outside screw and yoke complying with MSS SP 70
- .2 Ball Valve (in lieu of gate valves or as specified)
 - .1 Ball valves for isolation service shall have a large/full port.
 - .2 Ball valves for balancing service shall have a reduced port and valve handle shall have a memory stop.
 - .3 In compliance with MSS-SP-110
 - .4 NPS 1 and smaller, soldered:
 - .1 W.O.G. non-shock 4140 kPa (600 psi)
 - .2 Brass two piece body, blow-out proof stem, PTFE seats, brass chrome plate ball, lever handle operator rating complying with ASTM B283.
 - .5 NPS 2 and smaller, threaded:
 - .1 W.O.G. non-shock 4140 kPa (600 psi)
 - .2 Brass two piece body, blow-out proof stem, PTFE seats, brass chrome plate ball, lever handle operator, complying with ASTM B283.
- .3 Ball Valve (Installation ready)
 - .1 Dezincification resistant brass body, stainless-steel ball and stem, full port, blow-out-proof stem with double EPDM O-ring, PTFE seats, zinc-plated carbon steel handle with orange vinyl grip, and plain ends for use with the small diameter installation-ready system in sizes ½" through 2" (DN15 through DN50). Rated for services to 2065 kPa (300 psi). Victaulic Series P89 or equivalent to match pipe system.
- .4 Globe Valves
 - .1 NPS 1 and under, soldered:
 - .1 W.O.G. non-shock 2070 kPa (300 psi)
 - .2 Bronze body, rising stem, bronze disc, screwed bonnet, PTFE disc, complying with MSS-SP-80
 - .2 NPS 2 and under, threaded:

- .1 ANSI Class 150 (1035 kPa)
- .2 W.O.G. non-shock 2070 kPa (300 psi)
- .3 Bronze body, rising stem, bronze disc, screwed bonnet, PTFE disc, complying with MSS-SP-80
- .3 NPS 2 1/2 to NPS 10
 - .1 Working pressure 860 kPa (125 PSI) steam, W.O.G. non shock 1400 kPa (200 PSI)
 - .2 Outside stem and yoke with bolted bonnet, bronze disc to ASTM B62, fully guided from bottom, renewable and regrindable seat, bronze stem. Hand wheel operated.
 - .3 Complies with MSS-SP-70
- .5 Butterfly Valves
 - .1 NPS 2-1/2 and over:
 - .1 ANSI Class 150 (1035 kPa)
 - .2 Ductile iron body with bronze disc, stainless steel stems and extended neck to clear minimum of 50 mm (2") thick insulation, EPT or EPDM, complying with MSS-SP-67.
 - .3 Threaded full lug type or wafer type (with or without integral flanges).
 - .4 Resilient EPT or EPDM seat.
 - .5 Operators (unless otherwise specified in the Controls Section):
 - .1 NPS 8 and under - lever handle with minimum 10 position ratchet and disc position indicator.
 - .2 NPS 10 and over - worm gear operator.
 - .2 NPS 2-1/2 to 14 – steel roll grooved piping:
 - .1 W.O.G. non-shock 2070 kPa (300 psi)
 - .2 Ductile iron body, blow-out proof stainless steel stem, electroless nickel coated ductile iron, aluminum bronze or stainless steel disc, grooved ends.
 - .3 EPDM seat
 - .4 Operators, unless noted otherwise in the Controls Section:
 - .1 NPS 2-1/2 through NPS 8: lever handle with minimum 10 position ratchet and disc position indicator.
 - .2 NPS 10 and over: worm gear operator.

2.6 Circuit Balancing Valves

- .1 NPS 2 and under:
 - .1 Maximum operating pressure 2065 kPa (300 psi).
 - .2 Operating temperature -20°C to 150°C (-4 to 300°F)
 - .3 Lead free brass or copper alloy body, double regulating valve, 'Y' pattern globe, threaded ends with test points, memory stop and hand wheel providing flow measurement, flow balancing and drip-tight shut-off. 90° 'circuit-setter' style ball valves are not acceptable.
- .2 NPS 2-1/2 and over:

- .1 Maximum operating pressure 863 kPa (125 psi).
- .2 Operating temperature to 110°C (230°F)
- .3 Cast iron body with flanged connections or ductile iron with grooved ends, double regulating valve, 'Y' pattern globe, with test points, memory stop and hand wheel providing flow measurement, flow balancing and drip-tight shut-off. 90° 'circuit-setter' style ball valves are not acceptable.
- .3 Calibration charts and adjustment tools to be included.
- .4 Provide one (1) differential pressure meter kit suitable for direct readout c/w connection hoses suitable for the system pressure.

2.7 Swing Check Valves

- .1 In compliance with MSS-SP-71
- .2 NPS 1 and under, soldered:
 - .1 W.O.G. non-shock 1380 kPa (200 psi)
 - .2 Bronze body, bronze swing disc, screw in cap, re-grindable seat.
- .3 NPS 2 and under, threaded:
 - .1 W.O.G. non-shock 1380 kPa (200 psi)
 - .2 Bronze body, bronze swing disc, screw in cap, re-grindable seat.
- .4 NPS 2-1/2 and over, grooved:
 - .1 W.O.G. non-shock 2065 kPa (300 psi)
 - .2 Ductile iron body, EPDM seat, stainless steel swing disc, coupled cap.
- .5 NPS 2-1/2 and over, flanged:
 - .1 ANSI Class 125 (860 kPa)
 - .2 Cast iron body, renewable or re-grindable seat, bronze swing disc, bolted cap.

2.8 Silent Check Valves (Spring Type)

- .1 NPS 2 and under, threaded:
 - .1 ANSI Class 125 (860 kPa)
 - .2 Bronze body, bronze trim, stainless steel spring, (heavy duty spring in vertical down flow application)
- .2 NPS 2-1/2 and over, flanged:
 - .1 ANSI Class 125 (860 kPa)
 - .2 Cast steel, wafer style, renewable bronze trim, stainless steel spring (heavy duty spring in vertical down flow application). Complying with MSS-SP-125
- .3 NPS 2-1/2 through 12, grooved ends
 - .1 W.O.G. non-shock 2065 kPa (300 psi)
 - .2 Ductile iron body, electroless nickel plated seat, EPDM coated disc and seals, stainless steel spring and shaft.
- .4 NPS 14 through 24, grooved ends
 - .1 W.O.G. non-shock 1575 kPa (230 psig)
 - .2 Ductile iron body, stainless steel dual disc(s), EPDM seat. Stainless steel spring and shaft.

2.9 Combination Balance/Check Valves

- .1 Combination Balance/Check Valves are not acceptable.

2.10 Drain Valves

- .1 Minimum 2070 kPa (300 psi) WOG rated, 20 mm ($\frac{3}{4}$ ") diameter straight pattern bronze ball valves, each complete with a threaded outlet suitable for coupling connection of 20 mm ($\frac{3}{4}$ ") diameter hose, and a cap and chain.

2.11 Pressure Relief Valves

- .1 ASME tested, rated, and certified, bronze or cast iron bronze fitted, 1725 kPa (250 psi) rated pressure relief valves, each capable of relieving full output of equipment it is associated with, and each factory set at 415 kPa (60 psi) unless otherwise specified.

2.12 Air Vents

- .1 Manual Air Vents
 - .1 Equal to Conbraco 27 Series, 3.2 mm ($\frac{1}{8}$ ") diameter with a key handle.
- .2 Automatic Air Vents
 - .1 Float actuated air vents, each complete with a semi-steel body and cap, a stainless steel float assembly and seat, and a neoprene head.

2.13 Strainers

- .1 Cast iron wye shaped strainers, minimum 890 kPa (125 psi) rated and complete with a removable type 304 stainless steel screen with perforations sized to suit the application, and, for strainers 50 mm (2") diameter and larger, a blowdown pipe connection tapping

2.14 Coil Piping Packages:

- .1 Coil-Hook-up Connections: Victaulic Koil-Kits Series 799 or 79V may be used at coil connections. The kit shall include a Series 786/787/78K circuit balancing valve, Series 78Y Strainer-Ball, Series 78U Union-Port fitting, or Series 78T union / ball valve and required coil hoses.
- .2 A Style 793 and/or 794 differential pressure controller shall be provided as required. A meter shall be provided by the valve manufacturer that shall remain with the building owner after commissioning.

3. EXECUTION

3.1 General

- .1 Installation shall meet or exceed all applicable Federal, Provincial and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- .2 Install in accordance with manufacturer's instructions.
- .3 Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Section 21 05 01 Common Work Results for Mechanical.
- .4 Avoid installation of service components (such as valves, air vents, strainers, etc.) in secure areas.

3.2 Clearances

- .1 Provide clearance around systems, equipment, valves, fittings and components for observation or operation, inspection, servicing, maintenance and as recommended by the manufacturer. Maintain a minimum of 25 mm (1") space between adjacent flanges or pipe insulation, whichever has the larger diameter.
- .2 Provide space for disassembly, removal of equipment and components as recommended by the manufacturer or as indicated, whichever is greater, without interrupting operation of other systems, equipment and components.
- .3 Provide adequate clearance for installation of insulation.

3.3 Routing and Grading

- .1 Route piping in an orderly manner and maintain proper grades. Install to conserve headroom and interfere as little as possible with use of space. Run exposed piping parallel to walls. Group piping wherever practical at common elevations. Install concealed pipes close to the building structure to keep furring to a minimum.
- .2 Install piping free of sags and bends.
- .3 Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and services areas.
- .4 Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- .5 Avoid piping in exterior walls unless otherwise directed. If required, install this piping protected from the outside by the building insulation and vapour barrier.
- .6 Avoid locating water and drain piping over electrical equipment. Where this is unavoidable, provide galvanized drip pans under such pipe, and weld piping and fittings. Provide drain and piping from drip pans to satisfactory floor drain.
- .7 Slope water piping at 0.2% and arrange to drain at low points.
- .8 Make reductions in water pipe sizes with eccentric reducers to provide drainage and venting.

3.4 Piping

- .1 Ream pipe ends. Clean scale and dirt, inside and outside before and after assembly. Remove welding slag or other foreign material from piping.
- .2 During construction, protect all openings in piping and equipment, by capping or plugging to prevent entry of dirt.
- .3 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, unions, and couplings for servicing are consistently provided.
- .4 Select system components with pressure rating equal to or greater than rated pressure of system piping.
- .5 Screw, or weld, fittings (unless otherwise specified) for all piping systems up to NPS 2.
- .6 Weld or Victaulic groove (unless otherwise specified) all piping systems NPS 2-1/2 and over.
- .7 Make screwed joints with full cut standard taper pipe threads with approved non-toxic compound applied to male threads only.
- .8 Saddle type branch fittings are not acceptable.

- .9 Saddle type branch fittings may be used on mains, if branch line is half size or smaller than main. Hole saw or drill and ream main to maintain full inside diameter of branch line prior to welding saddle. Victaulic Style 920/920N mechanical tees.
- .10 Use long radius elbows. Victaulic #10 or W10 standard radius elbows may be used in lieu of long radius elbows in grooved piping systems in equipment rooms and where space considerations must be made.
- .11 Install all thermometer wells and immersion sensor wells specified under the Controls Section. Where wells will restrict flow in small diameter pipes (NPS 1-1/2 and smaller) install a section of oversized pipe at least NPS 2.
- .12 Remake leaking joints using new materials, do not caulk, or cement leaking threaded joints.
- .13 Use eccentric reducers at pipe size changes, flush on top side, to permit positive venting and drainage.
- .14 Do not use thread protection couplings, close nipples, running nipples or street elbows.
- .15 Bull head tees shall not be used for converging flows.
- .16 Make connections to equipment and branch mains with unions.
- .17 All run-outs shall be installed with swing joints to allow for movement due to expansion and contraction of the main.
- .18 Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
- .19 Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting.
- .20 Install temperature probe ports and pressure probe ports upstream and downstream of all heating systems components including but not limited to the following items: heat exchangers, all hydronic coils, finned tube elements, radiant heaters, in-floor heating zones, pumps, boilers, chillers, and cogeneration units. The contractor shall coordinate these items with the balancing contractor to ensure that all ports are installed as required by the balancer.

3.5 Soldering and Brazing

- .1 Pressure fluid systems - with chemical treatment (heating, chilled and condenser water) braze with silver base brazing alloy, 538°C (1000°F) melting point.
- .2 Pressure fluid systems - without chemical treatment, (heat recovery, domestic water) solder with 95/5 tin-antimony to ASTM B32.
- .3 Non-pressure systems, (drains) solder with 50/50 tin lead.
- .4 Piping connections to radiant ceiling panels, solder with 95/5 tin-antimony.

3.6 Roll Groove Piping

- .1 Use lubricant supplied by Manufacturer and coat gasket. Lubricate gaskets in accordance with manufacturer's recommendation with lubricant supplied by the coupling manufacturer that is suitable for the gasket elastomer and system media.

3.7 Grooved Joint Piping

- .1 Grooved joints shall be installed in accordance with the manufacturer's latest published installation instructions.
- .2 Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove.
- .3 Gaskets shall be of an elastomer grade suitable for the intended service, and shall be molded and produced by the coupling manufacturer.

- .4 The grooved coupling manufacturer's factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools and installation of grooved joint products.
- .5 The representative shall periodically visit the jobsite and review contractor is following best recommended practices in grooved product installation and report their findings to the Consultant. (A distributor's representative is not considered qualified to conduct the training or jobsite visit(s).)

3.8 Connections to Equipment

- .1 Connect to equipment in accordance with manufacturer's instruction unless otherwise noted.
- .2 Provide line sized isolation valves at each piece of equipment.
- .3 Install unions, flanges, or grooved couplings downstream of isolation valves and at equipment or apparatus connection. Do not use direct welded or threaded connections to valves, equipment, or other apparatus.
- .4 Install removable sections of pipe or 300 mm (12") spool pieces on the suction side of end suction pumps and where required for ease of maintenance.
- .5 Arrange piping connections to allow ease of access and for removal of equipment.
- .6 Align and independently support piping connections adjacent to equipment to prevent piping stresses being transferred.
- .7 Do not reduce equipment connection sizes by bushing.
- .8 Use double swing joints when equipment mounted on vibration isolation and when piping is subject to movement.

3.9 Drain Connections

- .1 Make connections to all equipment drains, drain pans, ductwork drains, discharge from all liquid relief valves, liquid safety valves, high capacity air vents, steam drip pan elbows, equipment blowdowns, water columns, and overflows. Pipe to nearest floor drain or approved connection. Install a brass, bronze or copper receiving funnel on the drain where shown. Where item being drained is under pressure, provide a deep seal trap.
- .2 If a gravity drained connection cannot be made because of invert elevations, provide a packaged condensate pump with integral float control to be wired by this contractor to the unit power connection. The condensate drain line shall be insulated with continuous 25 mm (1") thick insulation from the point of connection to the indirect waste connection.
- .3 Drains from drain pans shall be DWV copper NPS 1-1/4 minimum size.
- .4 Drain and vent piping shall be of the same material as the piping system to which it is connected, except where otherwise specified.

3.10 Expansion of Piping

- .1 Install all piping systems with due regard and provision for expansion avoiding strain or damage to equipment and building. Pay particular attention to piping running horizontal across building expansion joints and provide adequate expansion and contraction for all such piping.
- .2 It is the contractor's responsibility to retain the services of a qualified professional engineer to design the thermal pipe expansion system for the actual installed layout of all piping systems covered by this specification section.

- .3 The contractor is also required to review the architectural, structural, and mechanical documents for the identification of any seismic joints or seismic separations within the building structure that affects the installation of any mechanical systems. At each of these locations, allow for the design, supply, and installation of applicable mechanical system flexible connections along with support of these systems on each side of the seismic joint or separation. Refer to Section 23 05 16 Expansion Fittings and Loops for Mechanical Piping.
- .4 Install flexible piping connections to all equipment that contains rotating components including but not limited to: hydronic coils within fan powered terminal units, isolated boilers, entrance heaters that are externally isolated, air handling units that are externally isolated, isolated pumps, isolated pump packages, cooling towers, chillers, heat pumps, and all compressorized equipment. Refer to Section 23 05 48 Vibration and Seismic Control for Mechanical.
- .5 Install at least three (3) elbows in all branch connections. Where space does not permit 3 elbows, install braided flexible pipe connectors in accordance with manufacturer's recommendations. Three (3) elbow branch connections shall have sufficient developed length to ensure that excessive stresses are not generated in the piping and in no case less than 900 mm (36").
- .6 Engage manufacturer of plastic piping to provide piping system design services to accommodate thermal movement, seismic movement, and for the settlement of the existing piping system on the roof, or to confirm it is not required. The service includes required grooved piping components detailed in CAD on an overlay of the mechanical contract drawing(s), including anchor load calculations and placement of anchors. A calculation report showing thermal movement and accommodation shall also be provided. A design stamped by a qualified professional engineer from the jurisdiction in which the grooved piping products manufacturer is located or where the project is being constructed is required. Include cost in the tender price.
- .7 Where applicable, the manufacturer of the anchors shall be the same as the grooved component(s) manufacturer.

3.11 Valves

- .1 General
 - .1 Install all valves in accordance with manufacturer's recommendations.
 - .2 Install valves in accessible locations with stems upright or angled 45° above horizontal unless approved otherwise. Valves must be accessible without removing adjacent piping.
 - .3 Provide valves suitable to connect to adjoining piping as specified for pipe joints. Use line sized valves unless specifically noted otherwise.
 - .4 Remove interior parts before soldering.
 - .5 Provide stem extensions on all insulated valves.
 - .6 Provide ball valves in piping NPS 2 and smaller and butterfly valves in piping NPS 2-1/2 and larger for shut-off, equipment isolation, throttling, bypass or manual flow control services.
 - .7 Throttling valves are not to be used for shut-off; additional valves shall be installed for isolation purposes.
- .2 Isolation valves:
 - .1 Provide isolation valves at branch take-offs, to isolate each piece of equipment, upstream of all meters, gauges, automatic air vents, and as indicated.

- .2 Provide isolation valves in all systems such that floor by floor for horizontal systems, all risers in vertical systems and zone areas on a large horizontal system can be isolated.
- .3 All pressure service cap-offs for future shall be provided with isolation valves.
- .4 Ball valves used for shut-off / isolation shall be full port.
- .3 Check valves:
 - .1 Use swing or soft seated spring loaded check valves in horizontal and vertical upflow pipes and on the discharge of pumps. Spring loaded water check valves shall be located eight (8) pipe diameters downstream of pumps or elbows.
 - .2 Use silent check valves on discharge of pumps and in vertical pipes with downward flow, and as indicated.
- .4 Balancing valves:
 - .1 Use circuit setting globe valves complete with lockshield to control flow in circuits, except where balancing cocks are specifically specified.
 - .2 Install balancing valves in return piping connections to each terminal heating and cooling unit – e.g. radiators, unit heaters, fan coil units, heating and cooling coils, and radiant panels.
 - .3 Coordinate with the balancing subcontractor regarding the appropriate sizing of all balancing valves and calibrated balancing valves. The balancing subcontractor shall provide direction to the mechanical contractor for the appropriate size for each balancing valve within each system that is to be balanced. The valves shall be selected to provide appropriate throttling range without imposing a pressure drop of more than 2.5 psi. The balancer is to determine each valves respective flow rate (even if heat transfer and temperature differential calculations are required to determine flow rates). If full line sized valve meets these requirements, then a full line installation of appropriate fittings to transition from the pipe size indicated on the drawings to the recommended valve size.
 - .4 Install circuit balance valves at least five pipe diameters downstream from any fitting, and at least ten pipe diameters downstream from any pump. Two pipe diameters downstream from the circuit balance valve should be free of any fittings. When installed, easy and unobstructed access to the valve handwheel and metering ports for adjustment and measurement are to be provided. Valve orientation shall prevent sediment build-up in metering ports.
 - .5 Install globe valves in by-pass around control valves as indicated.
 - .6 Do not install balancing or throttling valve on discharge of pumps equipped with VFD unless noted otherwise on the drawings. Install pressure ports for flow measurement.
 - .7 Install radiator valves in the supply connections to each convection heating element.
- .5 Control Valves:
 - .1 Install control valves provided by controls contractor.
 - .2 Install control valves with their stems upright unless approved otherwise and with adequate clearance for removal of actuators.
- .6 Drain Valves and Hose Bibbs
 - .1 Install drains, consisting of a tee fittings, NPS 3/4 ball valve, and short NPS 3/4 threaded connection with cap and chain at low points in piping system mains, bases of vertical risers, at equipment, as noted on drawings, and elsewhere as required for system drainage.

- .2 Provide main piping system drain valves at a low point and pipe to drain. Drain valves shall be two (2) pipe sizes smaller than largest mains but not less than NPS 1.
- .3 Provide drain valve and hose connections off the bottom of all strainers.
- .4 Install NPS 3/4 hose bibbs at all downfed terminal heating and cooling units.

3.12 Air Vents

- .1 Provide manual air vents at high points on lines and equipment connections in exposed piping system and pipe air vent discharge to the nearest drain complete with air gap.
- .2 Provide automatic air vents at all high points, as indicated on the drawings, and as required for proper operation of the system. Install an isolating valve upstream of each air vent. Pipe air vent discharge to approved location using NPS ¼ diameter hard drawn copper pipe and terminate where discharge is visible.
- .3 Provide access to all air vents.

3.13 Dielectric Couplings

- .1 Provide dielectric couplings, of suitable pressure rating for the system, where dissimilar metals are joined.
- .2 NPS 2 and under: provide isolating unions or bronze valves.
- .3 NPS 2-1/2 and larger: provide isolating flanges.
- .4 Dielectric waterway fittings may be used in lieu of unions or flanged connections. Waterways shall be grooved and/or threaded end(s), with inert thermoplastic lining.

3.14 Sleeves

- .1 Provide Schedule 40 black steel pipe sleeves or factory fabricated, flanged, high density polyethylene sleeves with reinforced nail bosses where pipes pass through masonry, concrete structures, fire rated assemblies, and elsewhere as indicated.
- .2 Construction:
 - .1 Foundation walls and where sleeves extend above finished floors to have annular fins continuously welded on at mid-point.
- .3 Size:
 - .1 Minimum 6 mm (1/4") clearance between sleeve and un-insulated pipe or between sleeve and insulation for insulated pipe.
- .4 Installation:
 - .1 Terminate flush with finished surface at concrete, masonry walls, and concrete floors on grade.
 - .2 Terminate 25 mm (1") above finished floor for all other floors.
 - .3 Paint exposed exterior surfaces with heavy application of zinc-rich paint before installation.
- .5 Sealing:
 - .1 Foundation walls and below grade floors: Fire retardant, waterproof non-hardening mastic.
 - .2 Elsewhere: Provide space for fire stopping. Maintain fire rating integrity.
 - .3 Sleeves installed for future use: Fill with lime plaster or other easily removable filler.
 - .4 Ensure not contact between copper pipe or tube and sleeve.

3.15 Escutcheons

- .1 Install on pipes passing through walls, partitions, floors, and ceilings in finished areas.
- .2 Construction: One piece type with set screws. Chrome or nickel plated brass or type 302 stainless steel.

3.16 Piping Tests

- .1 Notify the Consultant and the Inspection Authority having jurisdiction, 48 hours in advance of intended test dates.
- .2 Before testing piping, isolate all equipment, which cannot withstand the test pressure.
- .3 Leave joints, including welds, un-insulated and exposed for examination during test.
- .4 Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
- .5 Do not insulate, backfill or conceal until tests have been completed and approved by the inspection authorities.
- .6 Examine all systems under test for leaks.
- .7 Joints shall remain dry during the test. A general sweating around a weld shall be reason for rejection.
- .8 Remake all leaking connections and joints.
- .9 Tests shall be limited to new piping only.
- .10 New connections to existing piping shall be warranted.
- .11 Initial Hydrostatic test: 150% of working pressure, but not less than 860 kPa (125 psig) for 1 working day. For PP-R piping, do not exceed 1034 kPa (150 psi). For PEX piping, do not exceed 690 kPa (100 psi).
- .12 Final Hydrostatic test: 150% of working pressure (For PP-R piping do not exceed 1034 kPa (150 psi)) (For PEX piping do not exceed 690 kPa (100 psi)), after piping connections to all equipment are complete, maintain until all parts of piping systems have been inspected.
- .13 Notify Consultant when pipe tests are being performed. Consultant may review as timing permits. Otherwise, have all pipe pressure tests signed off by the Contractors' Site Foreman Manager.
- .14 Prepare written report of testing and certificate and submit copies to Consultant.

3.17 Flushing and Cleaning

- .1 Flushing and cleaning shall commence only after all piping tests have been completed. Refer to section 23 25 00 HVAC Water Treatment.
- .2 Install temporary bypass connections around all heat pump units before commencing chemical cleaning.
- .3 Chemically clean the following piping systems as recommended by an approved professional chemical cleaning and treatment agency who shall supervise the work:
 - .1 Heating hot water system(s).
 - .2 Glycol system(s).
- .4 Flush out all traces of chemicals with clean water after chemical cleaning is complete.
- .5 Install final connections to heat pump units after flushing is complete.
- .6 Remove, clean and reinstall all strainer baskets.

- .7 Submit a report signed by a principal of the Agency, which certifies that the cleaning has been satisfactorily completed.

3.18 Filling of System

- .1 Refill system with clean water adding water treatment as specified.

3.19 Chemical Treatment

- .1 Chemically treat water systems in accordance with Section 23 25 00 HVAC Water Treatment.

3.20 Start-Up of Hydronic Systems

- .1 After cleaning is completed and system is filled:
 - .1 Establish circulation and expansion tank level, set pressure controls.
 - .2 Ensure air is removed.
 - .3 Check pumps to be free from air, debris, possibility of cavitation when system is at design temperature.
 - .4 Dismantle system pumps used for cleaning, inspect, replace worn parts, install new gaskets and new set of seals.
 - .5 Clean out strainers repeatedly until system is clean.
 - .6 Commission water treatment systems as specified in Section 23 25 00 - HVAC Water Treatment.
 - .7 Check water level in expansion tank with cold water with circulating pumps OFF and again with pumps ON.
 - .8 Repeat with water at design temperature.
 - .9 Check pressurization to ensure proper operation and to prevent water hammer, flashing, cavitation. Eliminate water hammer and other noises.
 - .10 Bring system up to design temperature and pressure slowly over a 48 hour period].
 - .11 Perform TAB as specified in Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.
 - .12 Adjust pipe supports, hangers, springs as necessary.
 - .13 Monitor pipe movement, performance of expansion joints, loops, guides, anchors.
 - .14 If expansion fittings or components do not operate correctly, shut down system, re-align, repeat start-up procedures.
 - .15 Re-tighten bolts using torque wrench, to compensate for heat-caused relaxation. Repeat several times during commissioning.
 - .16 Check operation of drain valves.
 - .17 Adjust valve stem packings as systems settle down.
 - .18 Fully open balancing valves (except those that are factory-set).
 - .19 Check operation of over-temperature protection devices on circulating pumps.
 - .20 Adjust alignment of piping at pumps to ensure flexibility, adequacy of pipe movement, absence of noise or vibration transmission.

3.21 Testing and Balancing

- .1 Balance all piping systems in accordance with Section 23 05 93 Testing, Adjusting, and Balancing for HVAC.

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 The provision of:
 - .1 Expansion tanks
 - .2 Air vents
 - .3 Air separators
 - .4 Pipe line strainers
 - .5 Suction guides,
 - .6 Relief valves
 - .7 Flexible hoses.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical
- .3 Section 23 21 13 – Hydronic Piping

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
 - .1 Applicable Building Code - Refer to Section 21 05 01.
 - .2 American Society of Mechanical Engineers (ASME)
 - .1 ANSI/ASME B31 Standards of Pressure Piping
 - .2 ANSI/ASME Boiler and Pressure Vessel Code (BPVC), Section IV Heating Boilers.
 - .3 ANSI/ASME Boiler and Pressure Vessel Code (BPVC), Section VIII Pressure Vessels
 - .3 American Society for Testing and Materials International (ASTM)
 - .1 ASTM B62 Standard Specification for Composition Bronze or Ounce Metal Castings
 - .2 ASTM A278M Standard Specification for Gray Iron Castings for Pressure Containing Parts for Temperatures Up to 650°F (350°C)
 - .3 ASTM A536 Standard Specification for Ductile Iron Castings
 - .4 Canadian Standards Association (CSA International).
 - .1 CSA B51 Boiler, Pressure Vessel, and Pressure Piping Code.
 - .2 CSA B214 Installation Code for Hydronic Heating Systems.

1.4 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:
 - .1 Shop drawing data for:

- .1 Expansion tanks
- .2 Air vents
- .3 Air separators
- .4 Suction guides
- .5 Relief valves
- .6 Flexible hoses

2. PRODUCTS

2.1 Acceptable Manufacturers

- .1 Refer to Section 23 05 01 – Acceptable Manufacturers.

2.2 Diaphragm Type Expansion Tank – Non ASME

- .1 Provide non-ASME rated expansion tanks for systems with a working pressure up to 207 kPa (30 psig) and less than 610 mm (24") in diameter.
 - .1 Construction: Steel
 - .2 Finish: Urethane or baked enamel
 - .3 Diaphragm: Heavy Duty Butyl/EPDM
 - .4 Air Valve: Projection Welded
 - .5 Factory Pre-charge: 82 kPa (12 PSIG)
 - .6 Maximum Operating Temperature 240°F (115°C)
 - .7 Maximum Working Pressure 690 kPa (100 PSIG)
 - .8 Saddles for horizontal installation or base mount for vertical installation.
 - .9 Factory seismic restraint ring or factory welded anchor points
 - .10 Warranty: 1 Year

2.3 Automatic Air Vent

- .1 Provide automatic float-type valves:
 - .1 Brass body, polypropylene float, nitrile disc
 - .2 NPS 1/8 or 1/2 connection
 - .3 Maximum Operating Temperature: 99°C (210°F)
 - .4 Maximum Working Pressure: 861 kPa (125 PS)

2.4 Manual Air Vents

- .1 Provide manual air vents with NPS 1 or line diameter pipe, whichever is greater, to form air collection chamber 150 mm high.
- .2 Provide a NPS ½ globe valve, bronze body union bonnet, threaded ends, stainless steel trim, plug type disc.

2.5 Air Separators

- .1 Provide vertical, line size vortex type separator as scheduled on the drawings.
- .2 NPS 3 and smaller screwed ends.

- .3 NPS 4 and larger flanged.
- .4 Welded steel vessel to ASME Section VIII, Division 1.
- .5 Separator to include brass conical shaped air venting chamber, stainless steel strainer, automatic air vent at top of unit and bottom blowdown valve.
- .6 Maximum working pressure: 860 kPa (125 PSIG).
- .7 Maximum operating temperature: 115 °C (240 °F).

2.6 Pipe Line Strainer

- .1 NPS 2 and smaller:
 - .1 Bronze body to ASTM B62.
 - .2 Screwed connections.
 - .3 Y pattern.
- .2 NPS 2 ½ and larger:
 - .1 Cast ductile iron body to ASTM A536, Grade 65-45-12, grooved ends.
 - .2 Cast steel body to ASTM A278M, Class 30, flanged connections.
- .3 Blowdown connection: NPS 1.
- .4 Screen: stainless steel with 1.19 mm thru 3.2 mm perforations.
- .5 Maximum working pressure: 2065 kPa (300psig).

2.7 Suction Guides

- .1 Provide suction guides on the pump suction as scheduled on the drawings.
- .2 NPS 1-1/2 and larger:
 - .1 Cast Iron body with ANSI 125 flanged ports.
 - .2 For 300 psig flanged pipe system: Ductile Iron body and ANSI 250 flanged ports.
 - .3 For grooved pipe system: Ductile Iron body with Grooved inlet and ANSI 125 flanged outlet connections.
- .3 Outlet flow stabilizing guide vanes.
- .4 Removable Stainless Steel Strainer and Fine Mesh Start-up Strainer.
- .5 NPS 1 blowdown connection.
- .6 Pressure gauge tapings.
- .7 Adjustable support leg or base support boss.

2.8 Combination Valve (Triple Duty Valve)

- .1 Alternatively, to individual components provide a single combination valve on the discharge of vertical inline and base mounted pumps.
- .2 The combination valve shall include:
 - .1 Isolation valve.
 - .2 Spring closure type silent non slam check valve.
 - .3 Flow control and flow measurement device.
- .3 NPS 2-1/2 to 12
 - .1 Cast Iron body with ANSI 125 flanged ports.

- .2 For 300 psig flanged pipe system: Ductile Iron body and ANSI 250 flanged ports.
 - .3 For grooved pipe system: Ductile Iron body with grooved inlet and outlet connections.
 - .4 The body shall have brass pressure and temperature metering ports, with Nordel check valves and gasketed caps and two other connections to be supplied with brass drain plugs.
 - .5 Metering ports are to be interchangeable with drain ports to allow for measurement flexibility when installed in tight locations.
 - .6 The valve disc shall be bronze plug & disc type with high impact resin seat.
 - .7 Stainless steel valve stem.
- .4 Each valve shall be furnished with a pre-formed removable PVC insulation jacket to meet a flame spread rating of 25 and a smoke development rating of 50. Insulation shall meet ASHRAE 90.1

2.9 Pressure Relief Valves

- .1 NPS ¾ to NPS 2
 - .1 Provide an ASME Section IV certified pressure relief valve as indicated in the contract drawings.
 - .2 Raised seat and non-mechanical disc alignment.
 - .3 Spring loaded, lever operated, non adjustable, factory set.
 - .4 Bronze or iron body with expanded outlets.

2.10 Flexible Hose Assemblies

- .1 Provide flexible hose connections for connecting to air valve reheat coils, fan coil units etc.
- .2 EPDM rubber inner core, stainless steel exterior braid, steel crimp ferrules and brass or bi-chromate steel threaded ends.
- .3 Fixed male NPT one end and swivel male NPT other end.
- .4 Minimum length: 600mm (24")
- .5 Maximum operating temperature 110°C (230°F).
- .6 Maximum operating temperature: 115°C (240 °F).

3. EXECUTION

3.1 General

- .1 Comply with manufacturers written recommendations, including product technical bulletins, catalogue installation instructions and product carton installation instructions.
- .2 Ensure adequate clearances are maintained for service and maintenance.

3.2 Diaphragm Type Expansion Tank – Non ASME

- .1 Bolt floor mounted units to concrete housekeeping pads. Install seismic slack cables to suspended tanks.
- .2 Install the expansion tank on the supply side of the boiler, on the suction-side of the heating circulator(s).
- .3 With tank empty of water, adjust air pre-charge to match system fill pressure.

- .4 Restart the boiler system and check for relief valve discharge. If the relief valve drips, the tank may be improperly charged or undersized.

3.3 Automatic Air Vent

- .1 Install automatic air vents at each high point in the piping systems and where shown on the drawings.
- .2 Install on tees and not on horizontal pipe runs or elbows.
- .3 Install a minimum NPS 1/2 isolation valve ahead of each air vent, unless air vent has an integral shut-off valve.
- .4 Fit all vents on top of an air-collecting chamber.
- .5 Pipe all air vent discharge connections, (except for glycol) separately, to the nearest building drain, using NPS 1/4 hard drawn copper tube. Label ends with permanent labels.
- .6 Pipe all air vent discharge connections from the glycol circuit, separately back to the glycol mixing tank, using NPS 1/4 hard drawn copper tube.

3.4 Manual Air Vents

- .1 Install manual air vents at high points in the piping systems and where shown on the drawings.
- .2 Install on tees and not on horizontal pipe runs or elbows.
- .3 Install an isolation valve ahead of each air vent.

3.5 Air Separators

- .1 Provide air separators on the suction-side of the heating circulator(s).
- .2 Make direct connection to suspended expansion tanks. Connection to floor mounted expansion tanks shall be made to the piping directly downstream of the air separator.
- .3 Maintain a minimum of five (5) pipe diameters of straight run piping to the inlet and outlet connections of the air separator.

3.6 Pipe Line Strainer

- .1 Provide isolation valves on either side of the strainer to facilitate cleaning without system drain down.
- .2 Provide blow down connections as follows:
 - .1 Cold services: all sizes, plug
 - .2 Hot services: NPS 2 and under, nipple and cap
 - .3 Hot services: NPS 2-1/2 and larger, nipple, globe valve and nipple.

3.7 Suction Guides

- .1 Provide suction guides on all pumps with an inlet size NPS 2-1/2 and larger.
- .2 Maintain service space for strainer removal.
- .3 Provide a blow-down globe valve.
- .4 Remove the fine mesh start-up strainer after a short running period. (24 hours maximum).

3.8 Relief Valves

- .1 Provide relief valves on pressure tanks, low pressure side of reducing valves, heating convertors, expansion tanks, boilers and where indicated elsewhere in the contract documents.
- .2 Pipe all relief valve discharge connections, (except for glycol) separately, to the nearest building drain.
- .3 Pipe all relief valve discharge connections from the glycol circuit, separately back to the glycol mixing tank or collection tank. Do not drain waste glycol to floor drains.
- .4 System relief valve capacity shall equal make-up pressure reducing valve capacity.
- .5 Equipment relief valve capacity shall exceed input rating of connected equipment.
- .6 Equipment relief valve pressure rating shall be below the equipment maximum operating pressure rating.
- .7 Where one vent serves several relief valves, the cross sectional areas shall exceed the sum of the individual vent areas.

3.9 Flexible Hose Assemblies

- .1 Provide flexible hose assemblies for connections to air valve reheat coils, fan coil units, misaligned connections and where indicated elsewhere in the contract documents.

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 The provision of heating water circulation pumps.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical.
- .3 Section 23 05 14 – Variable Frequency Drives.
- .4 Section 23 05 29 – Hangers and Supports for Mechanical Piping and Equipment.
- .5 Section 23 05 48 – Vibration and Seismic Control for Mechanical.
- .6 Section 23 21 16 – Hydronic Piping Specialties.
- .7 Division 26 – Electrical.

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
 - .1 Applicable Building Code - Refer to Section 21 05 01.
 - .2 Applicable energy code or standard - Refer to Section 21 05 01.
 - .3 CAN/CSA-B214, Installation Code for Hydronic Heating Systems.
 - .4 Electrical Equipment Manufacturers Association of Canada (EEMAC).
 - .5 National Electrical Manufacturers' Association (NEMA) MG 1, Motors and Generators.

1.4 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:
 - .1 Manufacturer's Catalog Data, including specific model, type, and size for all pumps including:
 - .2 Pump connections, piping and fittings, valves, strainers, triple duty valves, suction guides, control assemblies, and ancillaries, identifying factory and field assembled.
 - .3 Wiring as assembled and schematics.
 - .4 Dimensions, construction details, recommended installation and support, mounting bolt hole sizes and locations and point loads.
 - .2 Operator's manual and service manual.
 - .3 Exploded parts list.
 - .4 List indicating manufacturer recommend service tasks and intervals.

1.5 General Requirements

- .1 Provide pumps as specified in the project's equipment schedules.
- .2 Pump motors and guards shall comply with the motor and guard requirements specified under Section 21 05 01 Common Work Results for Mechanical.

- .3 Variable Frequency Drives shall comply with the requirements specified under Section 23 05 14 Variable Frequency Drives.
- .4 Provide correctly sized load and line reactors. Reactors shall be shipped with each drive for all supply voltages, (No exceptions).

2. PRODUCTS

2.1 Acceptable Manufacturers

- .1 Refer to Section 23 05 01 – Acceptable Manufacturers.

2.2 Close Coupled Vertical In-Line Pump (Up to 5 hp)

- .1 Volute: cast iron, radially split, with tapped openings for venting, draining, and gauge connections, with flanged suction and discharge connections.
- .2 Pump impeller: Bronze, fully enclosed type. Impeller shall be dynamically balanced.
- .3 Shaft: alloy steel with bronze sleeve at bearing.
- .4 Seal assembly: Mechanical seal, spring with carbon against ceramic faces. Factory installed seal vent line from the seal area to the pump suction connection.
- .5 Motor: to NEMA MG 1 resilient mounted, drip proof, sleeve bearing, 1750 rpm, high efficiency motor.
- .6 Maximum operating pressure: 965 kPa. (140psi).
- .7 Maximum operating temperature: 121°C (250°F).
- .8 Capacities and electrical requirements as scheduled on the drawings.

2.3 Split Coupled Vertical In-Line Pump (7.5 hp and up)

- .1 Type: Cast iron, radially split, with tapped openings for venting, draining, and gauge connections, with ANSI 125 flanged suction and discharge connections.
 - .1 Maximum operating pressure: 690 kPa. (100psi).
 - .2 Maximum operating temperature: 149°C (300°F).
- .2 Type: Ductile iron, radially split, with tapped openings for venting, draining, and gauge connections, with ANSI 250 flanged suction and discharge connections.
 - .1 Maximum operating pressure: 1896 kPa. (275psi).
 - .2 Maximum operating temperature: 149°C (300°F).
- .3 Pump impeller: Bronze, fully enclosed type. Impeller shall be dynamically balanced.
- .4 Shaft: Stainless steel.
- .5 Seal assembly: Mechanical seal, stainless steel spring with carbon against silicone carbide faces, secondary Viton seal, factory installed flush line with manual vent.
- .6 Coupling: Rigid spacer type.
- .7 Motor: to NEMA MG 1, drip proof, sleeve bearing, 1750 rpm, high efficiency motor.
- .8 Capacities and electrical requirements as scheduled on the drawings.

3. EXECUTION

3.1 General

- .1 Install to manufacturer's instructions.

- .2 Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.
- .3 Decrease from line size with long radius reducing elbows or reducers. 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 102 mm (4 inches) and over.
- .4 Provide line sized shut-off valve and strainer or pump suction fitting on pump suction, and line sized soft seat check valve and balancing valve or combination pump discharge valve on pump discharge.
- .5 Install removable sections of pipe or 300 mm (12") spool pieces on the suction side of end suction pumps and where required for ease of maintenance
- .6 Provide drains for bases and seals, piped to and discharging into floor drains.
- .7 Install close coupled and base mounted pumps on concrete housekeeping base, with anchor bolts, set and level, and grout in place. Refer to Division 3 Cast In Place Concrete.
- .8 Ensure that pump body does not support piping or equipment. Provide stanchions or hangers for this purpose. Refer to manufacturer's installation instructions for details.
- .9 Install volute venting pet cock in accessible location.
- .10 Install pressure gauge test cocks.
- .11 Shave or replace pump impellers to meet actual operating conditions.
- .12 Provide spacer at inlet and outlet on vertical in-line pumps complete with screen diffuser.
- .13 Provide vibration isolation and seismic restraint in accordance with Section 23 05 48 Vibration and Seismic Control for Mechanical.
- .14 Install spool piece of discharge of vertical line pumps in accordance with manufacturer's instructions. In absence of instructions, spool pieces shall be as follows:
 - .1 2" – 3" pump outlet: 6" spool piece
 - .2 4" - 6" pump outlet: 12" spool piece
 - .3 8" and up pump outlet: 18" spool piece
- .15 Provide flexible pipe connections on all pumps with inlets/outlets 2" and up to isolate pump from piping.

3.2 Before Start-Up

- .1 In accordance with manufacturer's recommendations and the following:
 - .1 Verify that electric power is available and of the correct characteristics.
 - .2 Check rotation prior to start-up.
 - .3 Check and align pumps prior to start-up.
 - .4 Lubricate pumps before start-up.

3.3 Start-Up

- .1 In accordance with manufacturer's recommendations and the following:
 - .1 After starting pump, check for proper, safe operation.
 - .2 Check installation, operation of mechanical seals, packing gland type seals. Adjust as necessary.
 - .3 Check base for free-floating, no obstructions under base.

- .4 Run-in pumps for 12 continuous hours.
- .5 Verify operation of over-temperature and other protective devices under low- and no-flow condition.
- .6 Eliminate air from scroll casing.
- .7 Adjust water flow rate through water-cooled bearings.
- .8 Adjust flow rate from pump shaft stuffing boxes to manufacturer's recommendation.
- .9 Adjust alignment of piping and conduit to ensure true flexibility at all times.
- .10 Eliminate cavitation, flashing and air entrainment.
- .11 Adjust pump shaft seals, stuffing boxes, glands.
- .12 Measure pressure drop across strainer when clean and with flow rates as finally set.
- .13 Replace seals if pump used to degrease system or if pump used for temporary heat.
- .14 Verify lubricating oil levels.

3.4 In Line Circulators

- .1 Install as indicated by flow arrows.
- .2 Support at inlet and outlet flanges or unions.
- .3 Install with bearing lubrication points accessible. Install within 1.5 m (5ft) of finished floor.

3.5 Variable Frequency Drives

- .1 Comply with Section 23 05 14 Variable Frequency Drives.
- .2 Coordinate location of Variable Frequency Drive, mounting and support with all trades.
- .3 Ensure adequate clearance is allowed per code requirements.
- .4 Provide wiring between Variable Frequency Drive and pump in compliance with Division 26 requirements and pump motor manufacturer requirements.

3.6 Performance Verification (PV)

- .1 Comply with Section 23 08 00 Commissioning of Mechanical Systems and in addition the following:
- .2 Exclusions: 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):
 - .1 Application: measure NPSH for pumps, which operate on open systems and with water at elevated temperatures.
- .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 Record of point(s) of actual performance and design performance at maximum and minimum conditions and for single and parallel operation as finally set at completion of commissioning on pump curves.

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 Materials, components, equipment, and chemicals for cleaning, water treatment and maintenance for the following wet side hydronic systems and equipment:
 - .1 Hot water heating system (closed loop)
 - .2 Heat Pump loop system (closed loop)

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical
- .3 Section 23 21 13 – Hydronic Piping
- .4 Section 23 21 16 – Hydronic Piping Specialties

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
 - .1 Applicable Building Code - Refer to Section 21 05 01 – Common Work Results for Mechanical
 - .2 American Society for Testing and Materials International (ASTM)
 - .1 ASTM E202 Standard Test Methods for Analysis of Ethylene Glycols and Propylene Glycols.
 - .3 American Society of Mechanical Engineers (ASME)
 - .1 ASME Boiler and Pressure Vessel Code, Section VII.
 - .4 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).

1.4 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:
 - .1 Submit shop drawings with complete description of proposed chemicals, quantities, calculations, procedures, test kits, and equipment to be supplied. Along with product shop drawings, provide copies of data sheets, procedure instructions and analysis reports to be used on this project.
 - .2 Material Safety Data Sheets (MSDS) for all chemicals to be used.
 - .3 Provide written reports containing procedure of system cleaning and degreasing, giving times, dates, conditions of water, and problems and actions encountered.
 - .4 Submit written reports to the mechanical contractor and Consultant containing results of tests taken every seven days after completion of chemical treatment. Reports shall be done every seven days for a minimum time period of 35 days.
- .2 Provide seasonal site visits (4 minimum) within the warranty year to check the treatment, take samples, analyze, and recommend proper addition of treatment. Provide written reports to the owner after each visit with a copy to the Consultant.

1.5 General

- .1 Equipment, chemicals, testing, and service shall be provided by one supplier.
- .2 Chemical treatment agency shall provide equipment, chemicals, and site supervision so as to fully comply with all requirements and their intent contained within this specification section.
- .3 Perform the cleaning, degreasing operation and initial water treatment and submit written reports on all situations found, actions taken and final results. Reports shall be signed by the commissioning coordinator, and chemical treatment agency. Inform the Consultant and commissioning agency fifteen (15) working days prior to commencing of work.
- .4 Provide chemical treatment as specified herein and provide written reports. Reports shall be signed by the chemical treatment agency, mechanical contractor and commissioning agency.
- .5 Chemical treatment agency shall provide directive and assistance to the mechanical contractor in the degreasing, cleaning, and chemical treatment of all piping systems. Use of the permanent mechanical systems for pumping or heating of cleaning and dilution solutions is not permitted. Permanent systems shall be isolated and portable pumps and boilers utilized for the duration of the cleaning process. Permanent equipment shall be flushed, degreased, and chemically treated independent of the piping systems.
- .6 Confirm chemical treatment products are compatible with piping materials, seals, and gaskets used on this project prior to use.

2. PRODUCTS

2.1 Acceptable Manufacturers

- .1 Refer to Section 23 05 01 – Acceptable Manufacturers

2.2 General

- .1 Provide sufficient chemicals for the Owner to treat and test the systems for one year from the time of substantial completion of the building.
- .2 Materials which may contact finished areas shall be colourless and non-staining.
- .3 Chemicals used must comply with environmental and health standards applicable to the usage on this project.
- .4 Chemicals must be approved by governing authorities for release into Municipal sewer system.

2.3 Existing Treatment System

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

2.4 Characteristics of Control Chemicals:

- .1 Chemicals must be non-toxic when released to atmosphere, noncorrosive and non-staining if a leak occurs. Chemicals shall be compatible with all system components so that operation or life expectancy of the components is not affected by the application of the chemical treatment.
- .2 System Cleaner:

- .1 Liquid form alkaline type cleaner consisting of a concentrated blend of highly active penetrating agents and detergents with a 12.5 pH and specifically formulated to remove oil, mill scale, and oxides from piping and equipment.
- .3 Close System Treatment:
- .4 Sequestering agent to reduce deposits and adjust pH, with a Chromate free, nitrite/borate type corrosion inhibitor suitable for use with both ferrous and non-ferrous metals. Open System Treatment
 - .1 "Performax Millennium" Series #2395 corrosion inhibitor and deposit control in a drum type container;
 - .2 "Biocide T" slime control agent in a pail type container;
 - .3 "Biosphere 250" for control of bacteria, fungi, and algae, and supplied in pail or drum type containers as required.
- .5 Dispersant/Purging compound:
 - .1 As recommended by the Chemical Water Treatment company. Compounds shall not cause odours.

2.5 Cleaning Solutions:

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

2.6 Propylene Glycol

- .1 Provide a USP grade inhibited propylene glycol in sufficient quantity to charge the glycol heating system to the percentage scheduled in the contract drawings.
- .2 Ethylene glycol is not acceptable.
- .3 Provide sufficient product to charge the system, the system feeder storage tank, and the Owners stock of two (2) spare 20L pails of propylene glycol.

2.7 Hydronic System Feeder

- .1 System shall be a factory assembled and tested complete package with the following minimum criteria:
 - .1 Non-metallic storage/mixing tank with cover, 208 litre (55 US gallon) capacity
 - .2 Pump suction hose with inlet strainer.
 - .3 Pressure pump with thermal cut-out, 120V/1/60 with electrical cord and plug suitable for plug in to a standard electrical outlet.
 - .4 Integral pressure switch and check valve
 - .5 Low level pump cut-out.
 - .6 Pre-charged accumulator tank with EPDM diaphragm;
 - .7 Manual diverter valve for purging air and agitating contents of storage tank
 - .8 Pressure regulating valve adjustable 35 – 380 KPa (5 – 55 psig) complete with pressure gauge; built-in check valve and union connection
- .2 Provide a minimum NPS ½ flexible braided hose connection 900mm (36") long from package to system connection.
- .3 Pressure pump shall be capable of running dry without damage.

- .4 Unit shall be CSA approved.

2.8 Test Kits

- .1 Provide test kits as required to determine proper system treatment consisting of, but not limited to the following:
 - .1 Heating water test kit to determine proper treatment.
 - .2 Chilled water treatment test kits to determine proper treatment.
 - .3 Fluid cooler water treatment test kits to determine proper treatment and blowdown.
 - .4 Glycol systems treatment test kits to determine proper concentration and glycol inhibitor, this shall include a hydrometer type tester.
- .2 Provide test kits for hardness and chlorides in addition to those listed above.
- .3 Provide an electronic pH meter complete with three different calibration standard solutions.
- .4 All test kits shall be provided with adequate chemicals and reagents for one year of testing.
- .5 Turn test kits over to Owner at substantial completion.

2.9 Shipping/Feeding Chemical Containers

- .1 High density moulded polyethylene, with liquid level graduations, reusable cover.

3. EXECUTION

3.1 Manufacturer's Instructions

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

3.2 Chemical Feed Piping

- .1 Install crosses at changes in direction. Install plugs in unused connections.

3.3 Cleaning of Mechanical System

- .1 Systems shall be operational, hydrostatically tested, and with safety devices functional, before cleaning is carried out.
- .2 Retain a qualified water treatment specialist to perform system cleaning.
- .3 Install instrumentation such as flow meters, orifice plates, pitot tubes, flow metering valves only after cleaning is certified as complete by water treatment specialist.
- .4 Ensure that heat exchangers, coils, boilers, chillers and other equipment are isolated / bypassed during the flushing and cleaning process. Only after the piping system is substantially clean, shall water be allowed to circulate through equipment. Demonstrate system cleanliness to Consultant.
- .5 Cleaning procedures:
 - .1 Provide detailed report outlining proposed cleaning procedures at least 4 weeks prior to proposed starting date. Report shall include:
 - .1 Cleaning procedures, flow rates, elapsed time.
 - .2 Chemicals and concentrations used.
 - .3 Inhibitors and concentrations.
 - .4 Specific requirements for completion of work.

- .5 Special precautions for protecting piping system materials and components.
- .6 Complete analysis of water used to ensure water will not damage systems or equipment.
- .6 Conditions at time of cleaning of systems:
 - .1 Systems shall be free from construction debris, dirt and other foreign material.
 - .2 Control valves shall be operational, fully open to ensure that terminal units can be cleaned properly.
 - .3 Strainers shall be clean prior to initial fill.
 - .4 Install temporary filters on pumps not equipped with permanent filters.
 - .5 Install pressure gauges on strainers to detect plugging.
- .7 Report on Completion of Cleaning:
 - .1 When cleaning is completed, submit report, complete with certificate of compliance with specifications of cleaning component supplier.

3.4 Hydronic System Start Up

- .1 Fill system with water; ensure air is vented from system.
- .2 Fill expansion tanks 1/3 to 1/2 full, charge system with compressed air to at least 35 kPa (does not apply to diaphragm type expansion tanks).
- .3 Use water metre to record volume of water in system to +/- 0.5%.
- .4 Add chemicals under direct supervision of chemical treatment supplier.
- .5 Closed loop systems: circulate system cleaner at 60°C for at least 36 h. Drain as quickly as possible. Refill with water and inhibitors. Test concentrations and adjust to recommended levels.
- .6 Flush with velocity the system mains and branches to ensure removal of debris. System pumps may be used for circulating cleaning solution provided that velocities are adequate.
- .7 Add chemical solution to system.
- .8 Establish circulation, raise temperature slowly to 82°C minimum. Circulate for 12 h, ensuring flow in all circuits. Remove heat; continue to circulate until temperature is below 38°C. Drain as quickly as possible. Refill with clean water. Circulate for 6 h at design temperature. Drain and repeat procedures specified above. Flush through low point drains in system. Refill with clean water adding to sodium sulphite (test for residual sulphite).
- .9 Upon completion and verification of the installation performance, remove surplus materials, excess materials, rubbish, tools, and equipment.

3.5 Water Treatment Services

- .1 Provide water treatment monitoring and consulting services for period of one year after system start-up. Service to include:
 - .1 Initial water analysis and treatment recommendations.
 - .2 System start-up assistance.
 - .3 Operating staff training.
 - .4 Visit plant during period of operation and as required until system stabilizes, and advise on treatment system performance.
 - .5 Provide necessary recording charts and log sheets for one year operation.
 - .6 Provide necessary laboratory and technical assistance.

- .7 Provide clear, concise, written instructions and advice to operating staff.

3.6 Closed Loop Hydronic Water and Glycol Systems

- .1 Provide by-pass side stream filters complete with flow indicators and 5 micron filter cartridges between the supply and return of hot water heating and glycol heating circuits.
- .2 Provide sufficient filter elements for replacement once per week from commissioning to date of acceptance.
- .3 Provide one pot feeder for each individual system.
- .4 Install complete with isolating and drain valves and necessary piping. Install as indicated on schematics.
- .5 Treat closed systems with closed systems treatment introduced through pot feeder when required or indicated by test.
- .6 Provide one side stream 5 micron cotton wound filter cartridge per main circulation pump system, c/w isolation valves, unions.
- .7 Supply and add the chemical scale and corrosion inhibitor to the closed circuit heating or chilled water piping system under the direction of and according to the concentration recommended by the chemical water treatment company.
- .8 For glycol systems, test to prove concentration will prevent freezing to minus 40°C. Test inhibitor strength and include in procedural report. Refer to ASTM E202.

3.7 Commissioning

- .1 Commissioning Agency shall supervise water treatment sub-contractor.
- .2 Commence water treatment commissioning:
 - .1 After start-up deficiencies rectified.
 - .2 After start-up and before TAB of connected systems.
- .3 Pre-commissioning verification Inspections:
 - .1 Presence of test equipment, reagents, chemicals, details of specific tests performed, and operating instructions.
 - .2 Suitability of logbook.
 - .3 Required quality of treated water.
- .4 Commissioning procedures - applicable to Water Treatment Systems:
 - .1 Establish, adjust as necessary and record automatic controls and chemical feed rates.
 - .2 Monitor performance continuously during commissioning of connected systems and until acceptance of project.
 - .3 Establish test intervals, regeneration intervals.
 - .4 Record on approved report forms commissioning procedures, test procedures, dates, times, quantities of chemicals added, raw water analysis, treated water analysis, test results, instrument readings, adjustments made, results obtained.
 - .5 Establish, monitor, and adjust automatic controls and chemical feed rates as necessary.
 - .6 Visit project at specified intervals after commissioning is satisfactorily completed to verify that performance remains as set during commissioning.
- .5 Commissioning procedures - Closed Circuit Hydronic Systems:

- .1 Analyze water in system.
- .2 Record types, quantities of chemicals applied.
- .6 Training:
 - .1 Commission systems, perform tests in presence of, and using assistance of, assigned O&M personnel.

3.8 Owners Stock

- .1 Provide 1 year supply of each chemical for the Owner.
- .2 Provide 12 replacement DOE 5 micron cotton wound filter cartridges.
- .3 Provide two (2) spare 20L pails of propylene glycol
- .4 Obtain a receipt from the Owner and give one copy to the Consultant.

3.9 Testing

- .1 Chemical water treatment company shall provide a laboratory test report as required.
 - .1 Provide laboratory test reports confirming the correct chemical concentrations have been achieved.

3.10 Monitoring

- .1 Provide laboratory test reports and treatment recommendations for treated water samples taken by the Owner's operating personnel.
- .2 They will be sent to the chemical water treatment company monthly for the first three months, and once every three months thereafter for one year following the initial test.
- .3 Each analysis shall provide concentrations of significant components of each water sample. At minimum, these shall be:

Item	Reports Units (ppm)
Total Suspended Solids	ppm
Total Hardness	ppm
Total Dissolved Solids	ppm as calcium carbonate
pH	
Magnetite	ppm

- .4 The cost of the testing is to be borne by the Contractor.
- .5 The Chemical Water Treatment Company shall send to the Owner on a scheduled bases, properly identified sample bottles for each of the systems to be tested as required.
- .6 Test reports shall be sent as they occur to the owner.

3.11 Reports

- .1 A copy of all reports shall be sent to the Consulting Engineer.
- .2 Provide three (3) copies of written instructions for the chemical testing and treatment specific to this project for insertion into the operating and maintenance manuals.
- .3 Email electronic copy of all reports to the Owners maintenance department.

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 Materials and installation of low-pressure and high pressure metallic ductwork, flexible ductwork, underground ductwork, joints and accessories.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical
- .3 Section 23 33 00 – Duct Accessories

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
 - .1 National Fire Protection Association (NFPA)
 - .1 NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
 - .2 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).
 - .1 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
 - .2 SMACNA - HVAC Air Duct Leakage Test Manual.

1.4 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:
 - .1 Shop Drawings:
 - .1 Sealants, tapes, proprietary joints.

1.5 General Requirements

- .1 Duct sizes on drawings indicate clear inside dimensions. For acoustically lined or internally insulated ducts, maintain inside duct dimensions.
- .2 Where duct sizes are shown in nominal metric sizes, round and oval duct sizes may be supplied in nearest available sizes in equivalent imperial units.
- .3 Provide openings of correct size and locations through slabs and walls. Openings shall be planned to include installation of fire dampers at all rated fire separations.
- .4 Where ducts penetrate roofs, provide roof curbs with flashing, and counter flashing. Ensure that penetration details are coordinated with the Building Envelope Consultant and Architect.
- .5 The project drawings are diagrammatic and although efforts have been made to provide information regarding the number of offsets and transitions, not all are necessarily shown. Changes may be required in duct routings, elevation and duct shape to eliminate interference with structure and other services. All required adjustments shall be established when coordinating and field measuring the work prior to fabrication and must be provided as part of the contract and all associated costs must be considered and included.

- .6 Ductwork shall be clean and free from scale, corrosion, and deposits. Ductwork shall be degreased and wiped clean of all oil and other surface films with appropriate solvents prior to installation.
- .7 Ductwork shall be delivered clean to the site and maintained in clean condition. Dirty ductwork shall be removed from site.
- .8 Where welded ductwork is indicated, the welding shall be continuous. Tack welding is unacceptable, except as specifically noted. Paint damaged areas with zinc coating after welding.
- .9 In exposed ductwork installations, the contractor shall have a consistent ductwork fabrication methodology. Longitudinal seam ducts shall not be intermixed with spiral seamed ductwork. Slip joint seams shall not be intermixed with flanged type seams where practical. Shop drawing submittals shall also indicate the duct fabrication type - spiral seam versus longitudinal seam, and duct joining method etc.
- .10 The contractor shall allow for the design, supply, and installation of all transition fittings required to connect ductwork to all mechanical equipment (both inlet and outlet connections). Where feasible, the fittings shall be fabricated per SMACNA standards in terms of maximum angles of convergence and divergence. Flexible connections shall be provided for all equipment / duct connections.

2. PRODUCTS

2.1 Acceptable Manufacturers

- .1 Refer to Section 23 05 01 – Acceptable Manufacturers.

2.2 Ductwork and Plenum Pressures

- .1 Provide ductwork constructed, reinforced, sealed and installed to withstand 1½ times the working static pressure
- .2 Low Pressure Galvanized Steel Ductwork 500 Pa (2" W.G.) and under
 - .1 Supply ductwork and plenums on systems without terminal mixing boxes or air valves.
 - .2 Supply ductwork downstream from terminal mixing boxes or air valves.
 - .3 Outdoor air ductwork and plenums, unless noted otherwise.
 - .4 Return air ductwork and plenums, unless noted otherwise.
 - .5 Exhaust and relief air ductwork and plenums, unless noted otherwise.
- .3 Low Pressure Flexible Ductwork 500 Pa (2" W.G.) and under
 - .1 Connect outlet terminals to low pressure ducts with 900mm (36") maximum length of stretched flexible duct. Hold in place with strap or clamp, caulk sealed. Do not use flexible duct to change directions.
 - .2 Provide a flexible connection where low pressure ducts are connected to fan equipment, terminal boxes, or any other apparatus. Joint shall be screwed or bolted flexible gasketed joint, minimum 50mm (2") wide.
- .4 Medium Pressure Galvanized Steel Ductwork to 1000 Pa (4"W.G.)
 - .1 Supply air ductwork downstream from supply air handling units discharge, to terminal mixing boxes or air valves.
 - .2 Exhaust and return air ductwork downstream of return/exhaust air valves to the return/exhaust fans and discharge ductwork from the return/exhaust fans to the air handling units and/or relief opening.

- .3 Outdoor intake plenums in mechanical room(s).
- .4 Where flexible air ducts are used to connect terminal mixing boxes or air valves to metal ducts, the flexible air ducts shall be rated for 30.5 m/s (6000 fpm) velocity and 2500 Pa (10" W.G.). Maximum stretched length of flexible air duct shall be 300 mm (12"). Do not use flexible duct to change direction. Where flexible air ducts are attached to metal insulated duct, furnish flexible air ducts with fiberglass wool insulation and metalized jacket.

2.3 Duct Sealing Galvanized Steel.

- .1 Low Pressure Ductwork 500 Pa (2" W.G.) and under shall be SMACNA seal class A. Seal all supply, return and exhaust duct joints, longitudinal as well as transverse joints as follows:
 - .1 Slip Joints: Apply heavy brush-on high pressure duct sealant. Apply second application after the first application has completely dried out. Where metal clearance exceeds 1.5 mm (1/16") use heavy mastic type sealant.
 - .2 Flanged Joints: Soft elastomer butyl or extruded form of sealant between flanges followed by an application of heavy brush-on high pressure duct sealant.
 - .3 Other Joints: Heavy mastic type sealant.
- .2 Medium Pressure Ductwork to 1000 Pa (4"W.G.) shall be SMACNA seal class A. Seal all supply, return and exhaust duct joints, longitudinal as well as transverse joints as follows:
 - .1 Combination of woven fabrics and sealing compound followed by an application of high pressure duct sealant.
- .3 Duct tapes as sealing method are not permitted, except on residential ductwork – minimum 2 wraps of 2" wide (50mm) foil duct tape is acceptable.
- .4 Surfaces to receive sealant should be free from oil, dust, dirt, moisture, rust and other substances that inhibit or prevent bonding.
- .5 Do not insulate any section of the ductwork until it has been inspected and approved of duct sealant application, by the Consultant.

2.4 Rigid Ductwork - 500 Pa (2" W.G.) Static Pressure

- .1 Provide galvanized steel ductwork for system operating pressures 500 Pa (2" W.G.) and less. Ductwork shall be constructed, reinforced, sealed, and installed to withstand 1½ times the working static pressure.
- .2 Construct rectangular ductwork in accordance with SMACNA Duct Standards Section I.
- .3 Nomasco "Ductmate System, Lockformer TDC" or Exanno "Nexus System" may be used for rectangular duct joints.
- .4 Construct rectangular duct fittings in accordance with the SMACNA Duct Standards Section II.
- .5 Construct round ductwork in accordance with the SMACNA Duct Standards Section III, but excluding beaded crimp joints and snaplock seams.
- .6 Construct flat oval ductwork in accordance with the SMACNA Duct Standards Section III. Joints and seams shall be similar to those indicated for round ducts. Flat oval duct to be used for positive pressure application only.
- .7 Construct round and flat oval duct fittings in accordance the SMACNA Duct Standards Section III. Round elbows shall have a centreline radius of 1.0 times duct diameter. Sheet metal gauge of fittings and elbows shall be not less than the thickness of that specified for longitudinal seam straight duct. Adjustable elbows are not permitted.

2.5 Rigid Ductwork - 750 Pa (3") and Greater Static Pressure

- .1 Provide galvanized steel ductwork for system operating pressure over 500 Pa (2" W.G.). Ductwork shall be constructed, reinforced, sealed, and installed to withstand 1-1/2 times the working static pressure.
- .2 Construct rectangular ductwork in accordance with the SMACNA Duct Standards Section I.
- .3 Nomasco "Ductmate System", Exanno "Nexus System" or "Lockformer TDC, TDF system", may be used for rectangular duct joints.
- .4 Construct rectangular duct fittings in accordance with the SMACNA Duct Standards Section II.
- .5 Construct round ductwork in accordance with the SMACNA Duct Standards Section III.
- .6 Construct flat oval ductwork in accordance with the SMACNA Duct Standards Section III. Joints and seams shall be similar to those indicated for round duct. Flat oval duct to be used for positive pressure application only.
- .7 Construct round and flat oval duct fittings in accordance with the SMACNA Duct Standards Section III. Round elbows shall have a centreline radius of 1.5 times duct diameter. Construct 90 deg. elbows of not less than 5 tapered sections. All seams and joints in round or oval duct fittings and elbows shall be spot welded lap seams at not more than 50mm (2") spacing and all inside seams sealed with approved duct sealant. If the zinc coating is burned off the steel during welding, the joints shall be painted to prevent corrosion. Sheet metal gauges of fittings and elbows shall be not less than the thickness of that specified for longitudinal seam straight duct but suitably thick for welding methods used.

2.6 Metallic Fittings

- .1 Fabrication: to SMACNA HVAC Duct Construction Standards - Metal and Flexible, latest edition.
- .2 Radius elbows.
 - .1 Rectangular: standard radius with single thickness turning vanes Centreline radius: 1.5 times width of duct.
 - .2 Round: smooth radius piece.
 - .1 Centreline radius: 1.5 times diameter for ductwork 750 Pa (3" W.G.) and greater
 - .2 Centreline radius: 1 times diameter for ductwork 500 Pa (2" W.G.) and less.
- .3 Mitred elbows, rectangular:
 - .1 Install mitred elbows where space will not permit the use of full radius elbows.
 - .2 Provide single thickness turning vanes. Vanes in galvanized sheet metal ducts shall be constructed from galvanized steel, minimum thickness 0.76 mm (22 ga). Vanes shall be spaced at 40 mm (1½") centres and shall turn through 90 deg., with a radius of 50 mm (2"). Vanes shall not include a straight trailing edge. The maximum supported vane length shall be 750 mm (30"). Use multiple single thickness turning vane sections for wider ducts. Install vanes tangent to airflow. Refer to Figs. 2-3 and 2-4 of the SMACNA Duct Construction Standards. Vanes and runners in aluminum ducts shall be constructed from aluminum. Aluminum vanes shall be 0.86 mm (18 ga) thick.
- .4 Branches:
 - .1 Rectangular main and branch: with radius on branch 1.5 times width of duct and 45 degrees entry on branch.
 - .2 Round main and branch: enter main duct at 45 degrees with conical connection.

- .3 Provide volume control damper in branch duct near connection to main duct.
- .5 Transitions:
 - .1 In accordance with Fig. 2-9 of the SMACNA Duct Construction Standards.
 - .2 Diverging: 20 degrees maximum included angle.
 - .3 Converging: 30 degrees maximum included angle.
 - .4 Maximum divergence upstream of equipment to be 30 deg. and 45 deg. Convergence downstream.
- .6 Offsets:
 - .1 Short radius elbows.
 - .2 Obstruction deflectors: maintain full cross-sectional area.

2.7 Ductwork – Acoustically Lined

- .1 Where round ductwork is indicated to be acoustically insulated, it shall consist of two concentric round ducts with 25 mm (1") thick flexible fibrous glass duct liner between the two ducts. The inner duct shall be perforated and correspond to the duct diameter noted on the drawings. The outer duct shall be suitable for the static pressure and shall be sealed airtight where it joins the adjacent ductwork.

2.8 Ductwork – Outdoors

- .1 The internally or externally insulated supply, return and exhaust ducts (down stream of heat recovery coils) including silencers, located outdoors on the roof, shall be constructed watertight.
- .2 All joints shall be caulked with a water impervious sealant. TDC clips should be continuous on the top and sides of the ducts.
- .3 The top of the finished product (waterproof membrane) should be pitched to avoid pooling of water.

2.9 Hangers and Supports

- .1 Hangers and Supports: in accordance with Section 23 05 29 - Hangers and Supports for Mechanical Piping and Equipment.
- .2 Strap hangers: of same material as duct but next sheet metal thickness heavier than duct.
 - .1 Maximum size duct supported by strap hanger: 500 mm.
- .3 Hanger configuration: to SMACNA.
- .4 Hangers: galvanized steel angle with galvanized steel rods to SMACNA per the following table:

Duct Size (mm)	Angle Size (mm)	Rod Size (mm)
up to 750	25 x 25 x 3	6
751 to 1050	40 x 40 x 3	6
1051 to 1500	40 x 40 x 3	10
1501 to 2100	50 x 50 x 3	10
2101 to 2400	50 x 50 x 5	10
2401 and over	50 x 50 x 6	10

- .5 Upper hanger attachments:
 - .1 For concrete: manufactured concrete inserts.
 - .2 For steel joist: manufactured joist clamp.
 - .3 For steel beams: manufactured beam clamps.

3. EXECUTION

3.1 Ductwork Leakage Test

- .1 Leakage test all 750 Pa (3") and greater static pressure supply ductwork installed under this contract, as recommended in the SMACNA H.V.A.C. Air Duct Leakage Test Manual to a static pressure 500 Pa (2" W.G.) in excess of the specified ductwork design static pressure.
- .2 Use equipment capable of demonstrating leakage.
- .3 Test the first 30 m (100 ft) of installed ductwork in the presence of the Consultant.
- .4 Test a representative 30m (100ft) section of 500 Pa (2") static pressure ductwork, where complete systems over 30m (100 ft) long are installed.
- .5 The total allowable leakage for the entire system shall be not greater than 5 percent of the total system capacity.
- .6 Submit test reports for all ducts tested.

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 Materials and installation of low-pressure and high pressure metallic plenums, joints, and accessories.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical
- .3 Section 23 31 00 – HVAC Ducts and Casings
- .4 Section 23 33 00 – Air Duct Accessories

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
 - .1 National Fire Protection Association (NFPA)
 - .1 NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
 - .2 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).
 - .1 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

1.4 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:
 - .1 Shop Drawings: Sealants, Tapes, Proprietary Joints.

1.5 General Requirements

- .1 Plenum sizes on drawings indicate clear inside dimensions. For acoustically lined or internally insulated plenums, maintain inside plenum dimensions.
- .2 Plenums shall be clean and free from scale, corrosion, and deposits. Plenums shall be degreased and wiped clean of all oil and other surface films with appropriate solvents prior to installation.
- .3 Plenums shall be delivered clean to the site and maintained in clean condition. Dirty plenums shall be removed from site.
- .4 Where welded plenum work is indicated, the welding shall be continuous. Tack welding is unacceptable, except as specifically noted. Paint damaged areas with zinc coating after welding.
- .5 The contractor shall allow for the design, supply, and installation of all transition fittings required to connect plenum work to ductwork (both inlet and outlet connections). Where feasible, the fittings shall be fabricated per SMACNA standards in terms of maximum angles of convergence and divergence.

2. PRODUCTS

2.1 Plenum Pressures

- .1 Provide plenums constructed, reinforced, sealed and installed to withstand 1½ times the working static pressure
- .2 Low Pressure Galvanized Steel Plenums 500 Pa (2" W.G.) and under
 - .1 Supply plenums on systems without terminal mixing boxes or air valves.
 - .2 Outdoor air plenums, unless noted otherwise.
 - .3 Return air plenums, unless noted otherwise.
 - .4 Exhaust and relief air plenums, unless noted otherwise.

2.2 Plenum Sealing

- .1 Seal all plenums similar to that specified for ductwork of the same pressure class. Refer to Section 23 31 00 – HVAC Ducts and Casings

2.3 Plenums - 500 Pa (2") Static Pressure

- .1 Provide galvanized steel low pressure plenums suitable for 500 Pa (2" W.G.) positive or negative pressure.
- .2 Construct plenums in accordance with the SMACNA Plenum Standards Section VI.
- .3 Where the building structure does not form the bottom surface of a walk-in plenum, fabricate plenum floor panels of 1.78 mm (14 ga.) galvanized steel, with angle iron reinforcing such as to limit deflection of the floor panels to a maximum of 6.4 mm (1/4") under a concentrated load of 115 kg (250 lbs) at mid span.
- .4 Where plenum floors are internally lined, install a 1.47 mm (16 ga.) thick galvanized steel panel on top of the insulation.
- .5 Apply silicone sealant between plenum base angles and concrete or curbs before bolting together.
- .6 Reinforce all openings in plenum walls with 40 mm x 40 mm x 4.8 mm (1½" x 1½" x 3/16") angle iron, secured to the main vertical and horizontal reinforcing angles.
- .7 Construct access door and casing around door as per SMACNA standards, casing access doors, Provide angle iron frame sized to suit plenum wall. Doors constructed of 16 gauge metal.
- .8 Arrange access doors so that they open against the airflow and static pressure.
- .9 Weld all joints on condensate drain pans. Construct the pans from 1.45 mm (16 ga.) thick stainless steel type #302 or #304. Install a minimum of 32 mm (1 1/4") piping connection, complete with water seal at least 100 mm (4") deep, from the pan drain connection to the nearest building drain. Install drain connections so that they shall completely drain the pans.
- .10 Seal piping penetrations through plenum walls, with gland seals as detailed in SMACNA Duct Standards.

2.4 Plenum Insulation Covering

- .1 Sheet Metal
 - .1 Provide 0.76 mm (22 ga) galvanized sheet metal covering on acoustically lined plenum walls for a distance of 1.2 m (4 ft) downstream from cooling coils.
- .2 Perforated Metal

- .1 Provide 0.76 mm (22 ga) thick perforated galvanized sheet metal covering on all acoustically lined plenum walls (except immediately adjacent to downstream side of cooling coils).

3. EXECUTION

3.1 Plenum Installation

- .1 Where a plenum is to be internally insulated, enlarge the plenum so as not to reduce the plenum free area. Insulation is to be fibreglass free (use products such as Armacell or similar).
- .2 Cross-break or bead all metal plenum panels unless otherwise noted.
- .3 Do not cross-break bottom plenum panels when ductwork is handling moisture.
- .4 Roof mounted plenums shall have standing seams and shall be sealed weather tight.
- .5 Grade all plenum floors handling moisture, a minimum of 1:120 (1" in 10 ft) back to the source or at low points in the plenum, provide a 150 mm (6") deep drain sump and 32 mm (1 1/4") dia. drain connection with deep seal trap and pipe to drain.
- .6 Construct plenums handling moisture with three sided bottom sections and a separate top panel. Install the three sided bottom sections and internally seal the transverse joints with Silicone Sealant Then install the top panels and seal the top panel seams and joints.
- .7 Provide floor drains in outside air and humidifier sections with deep seal traps.
- .8 Provide moisture collection sections inside all louvres for outside air and exhaust air.
- .9 Arrange access doors so that they open against the airflow and static pressure.
- .10 Provide necessary baffling in manufactured or built-up mixed air plenums to ensure good mixed air temperature with variations of not more than \pm minus 5°C (23°F) under all operating conditions.
- .11 During construction, protect openings in all plenums, from dust infiltration, by covering with polyethylene, and protect floor outlet duct openings with metal caps.
- .12 Unless noted otherwise, line all builder's shafts and air plenums used as ducts and plenums with sheet metal.

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 Materials and installation for duct accessories including flexible connections, access doors, and collars.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical
- .3 Section 23 31 00 – HVAC Ducts and Casings
- .4 Section 23 32 00 – Air Plenums and Casings

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
 - .1 National Fire Protection Association (NFPA)
 - .1 NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
 - .2 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).
 - .1 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
 - .3 Underwriters Laboratories of Canada (ULC)
 - .1 CAN/ULC-S112, Fire Test of Fire Damper Assemblies.
 - .2 CAN/ULC-S112.2, Standard Method of Fire Test of Ceiling Firestop Flap Assemblies.
 - .3 ULC-S505, Fusible Links for Fire Protection Service.

1.4 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:
 - .1 Submit shop drawings for the following:
 - .1 Flexible connections.
 - .2 Duct access doors.
 - .3 Instrument test ports.
 - .4 Fire dampers and combination fire/smoke dampers
 - .5 Control dampers
 - .6 Balancing dampers
 - .7 Backdraft dampers

2. PRODUCTS

2.1 Acceptable Manufacturers

- .1 Refer to Section 23 05 01 – Acceptable Manufacturers

2.2 General

- .1 Manufacture in accordance with SMACNA - HVAC Duct Construction Standards.

2.3 Backdraft Dampers – Light Duty

- .1 Minimum Requirements:
 - .1 1.4 mm thick (16 ga) galvanized steel or aluminum channel frame.
 - .2 0.41 mm thick (24 ga) embossed aluminum blades.
 - .3 Full blade length shafts, brass bearings.
 - .4 Felt or neoprene anti-chatter blade strips.
 - .5 Maximum blade height per section, 610 mm (24"), uses multiple sections for larger dimensions.
 - .6 Maximum blade length of 460 mm (18"), use multiple sections for larger dimensions.
 - .7 Manufacturer's label.
 - .8 Where a balanced backdraft damper (BBD) is indicated, the damper shall incorporate an adjustable counterbalance weight and lever.
 - .9 Maximum pressure drop across damper at 4.06 m/s (800 FPM) shall be 35 Pa (0.14" w.g.).

2.4 Backdraft Dampers – Medium Duty

- .1 Minimum Requirements:
 - .1 1.4 mm thick (16 ga) galvanized steel or aluminum channel frame.
 - .2 1.2 mm thick (15 ga) aluminum blades, complete with stiffening ribs/bends.
 - .3 Full blade length shafts; brass, ball, or nylon bearings.
 - .4 Felt or neoprene anti-chatter blade strips.
 - .5 Blade connecting linkage with eyelet and pin bearings.
 - .6 Maximum blade length of 760 mm (30"), use multiple sections for larger dimensions.
 - .7 Manufacturer's label.
 - .8 Where a balanced backdraft damper (BBD) is indicated, the damper shall incorporate an adjustable counterbalance weight and lever.
 - .9 Maximum pressure drop across damper at 4.06 m/s (800 FPM) shall be 45 Pa (0.18" w.g.)

2.5 Balancing Dampers

- .1 Minimum Requirements:
 - .1 Rectangular ducts:
 - .1 Up to 300 mm (12") deep - single blade (butterfly type).
 - .2 330 mm (13") to 400 mm (16") deep - two opposed blades, mechanically interlocked with pivots at quarter points.
 - .3 430 mm (17") deep and over - multiple opposed blades, mechanically interlocked with blades not greater than 200 mm (8") deep and pivots equally spaced.
 - .2 Round Ducts:

- .1 Single blade (butterfly type).
- .3 Material:
 - .1 Minimum 1.47 mm (16 ga) thick galvanized steel blade on all butterfly dampers.
 - .2 Minimum 1.47 mm (16 ga) thick galvanized steel blades on multi-blade dampers with rigidly constructed galvanized steel frame (no frame required on single blade dampers).
 - .3 Minimum 1.14 mm (18 ga) thick stainless steel blades for fume exhaust ducts.
- .4 Bearings:
 - .1 End bearings on all low pressure single blade dampers above 300 mm (12") dia.
 - .2 Bearings on multiple blade dampers shall be bronze oilite type.
- .5 Operating Mechanism:
 - .1 Lockable quadrant type with end bearing on accessible rectangular ducts up to 400 mm (16") deep and on accessible round ducts.
 - .2 Wide pitch screw mechanism type with crank operator on accessible rectangular ducts 430 mm (17") and over in depth and on inaccessible rectangular and round ducts.
 - .3 Override limiting stops.
 - .4 No blade movement in set position.
- .6 Concealed Regulators:
 - .1 For all drywall ceilings, which do not have access panels, provide concealed balancing damper regulators embedded in the finished ceiling, mounted behind grilles, on or inside plenum slot diffusers and various types of diffusers. Concealed damper regulator to be connected to balancing damper by means of flexible cable and to be installed flush with ceiling. Cover plate to be held in place with 2 screws and to be easily removed for damper adjustment.
 - .2 Optional concealed regulator shall be either remotely accessible as coordinated on the drawings, or accessible at the face of the diffuser/grille to meet installation requirements of the concealed regulator.

2.6 Duct and Plenum Access

- .1 Locations: Refer to Part 3 (Execution).
- .2 Dimensions:
 - .1 Doors:
 - .1 500 mm (20") wide x 1370 mm (54") high.
 - .2 Head of door 1780 mm (70") above floor.
 - .2 Panels:
 - .1 380 mm x 500 mm (15"x20").
 - .2 Where the far corners of the duct are closer than 500 mm (20") and the equipment within the duct is closer than 300 mm (12") the size may be reduced to 400 mm x 300 mm (16"x12") or 450 mm x 250 mm (18"x10") elliptical.
 - .3 Where space will not permit the above dimensions to be attained they should be matched as closely as possible and where necessary additional access be provided.

- .3 Products:
 - .1 Doors - construct in accordance with SMACNA Duct Standards. 40 mm (1½") thick insulation.
 - .2 Panels:
 - .1 Non-Insulated Duct: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.7 mm (22 ga) thick complete with sheet metal angle frame.
 - .2 Insulated Duct: as above with 25 mm (1") thick insulation.
 - .3 Gaskets - neoprene or foam rubber.
- .4 Hardware:
 - .1 Panels up to 400 mm x 300 mm (16"x12") - 2 Cam locks complete with safety chain.
 - .2 Panels - 380 mm x 500 mm (15"x20") - 4 Cam locks complete with safety chain.
 - .3 Doors - piano hinge and Ventlok 310 latches c/w front and inside handles and front door pull.

2.7 Duct Connectors – Thermal breaks

- .1 Provide flexible duct connections to provide thermal breaks in all sheet metal ducts and plenums passing through or terminating at the exterior of the building. Install inside the building.
- .2 Minimum Requirements:
 - .1 Pre-assembled 75 mm (3") long thermal barrier with 75 mm (3") long, 0.61 mm (24 ga) galvanized steel duct connectors on each side of the thermal break.
 - .2 Thermal break – heavy duty glass fabric with elastomer coating.

2.8 Duct Connectors – Vibration Isolation

- .1 Provide flexible duct connections to provide vibration isolation at all duct and plenum connections to fan and air handling units. See Figure 2-19 SMACNA Duct Standards.
- .2 Minimum Requirements:
 - .1 Pre-assembled 75 mm (3") minimum long flexible connection with 75 mm (3") long 0.62 mm (24 ga) galvanized steel duct connectors on each side of the flexible connection. Flexible connector - fiber glass fabric with elastomer coating.
 - .2 Fire resistant, self extinguishing, neoprene coated glass fabric, temperature rated at minus 40 degrees C to plus 90 degrees C, density of 1.3 kg/m².
- .3 Centrifugal fans with 900 mm (36") diameter and larger fan wheels, use 150 mm (6") long flexible connection.
- .4 Do not install connectors on perchloric acid fume exhaust systems.

2.9 Fire Dampers

- .1 Minimum Requirements:
 - .1 Fire dampers shall be U.L.C. or Warnock Hersey tested and shall bear the testing agency's label.
 - .2 Fire dampers shall meet requirements of the National Building Code and authorities having jurisdiction.
 - .3 All fire dampers shall be "dynamic", rated to close under airflow.

- .4 Mild steel, factory fabricated for fire rating requirement to maintain integrity of fire separation.
- .5 Fusible link actuated, weighted to close and lock in closed position when released or having negator-spring-closing operator for multi-leaf type in horizontal position with vertical airflow.
- .6 Fire dampers in low-pressure ductwork may be multi blade or curtain type.
- .7 Fire dampers in medium and high-pressure ductwork shall be curtain type.
- .8 Curtain fire dampers shall have blades retained in a recess so free area of connecting ductwork is not reduced. Style “A” is NOT acceptable.
- .9 Fusible links: U.L.C. approved with a melting point of 74°C (165°F) on supply, return and exhaust air systems. Use fusible links with a melting point of 141°C (286°F) on all return and exhaust air systems if used for smoke venting.

2.10 Instrument Test Ports

- .1 1.35 mm (16 ga) thick steel zinc plated after manufacture.
- .2 Cam lock handles with neoprene expansion plug and handle chain.
- .3 25 mm (1”) minimum inside diameter. Length to suit insulation thickness.
- .4 Neoprene mounting gasket.

2.11 Spin-In Collars

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

2.12 Control Dampers

- .1 Unless otherwise specified elsewhere, shall be as follows.
- .2 Type: Control dampers shall be the parallel or opposed-blade type as specified below or as scheduled on drawings or as per the following:
 - .1 Outdoor and return air mixing dampers and face-and-bypass dampers shall be parallel-blade and shall direct airstreams toward each other.
 - .2 Other modulating dampers shall be opposed-blade.
 - .3 Two-position shutoff dampers shall be parallel- or opposed-blade with blade and side seals.
- .3 Frame: Damper frames shall be 2.38 mm (13 gauge) galvanized steel channel or 3.175 mm (1/8 in.) extruded aluminium with reinforced corner bracing.
- .4 Blades: Damper blades shall not exceed 20 cm (8 in.) in width or 125 cm (48 in.) in length. Blades shall be suitable for medium velocity (10 m/s (2000 fpm)) performance. Blades shall be not less than 1.5875 mm (16 gauge).
- .5 Shaft Bearings: Damper shaft bearings shall be as recommended by manufacturer for application, oil impregnated sintered bronze, or better.
- .6 Seals: Blade edges and frame top and bottom shall have replaceable seals of butyl rubber or neoprene. Side seals shall be spring-loaded stainless steel. Blade seals shall leak no more than 50 L/s·m² (10 cfm per ft²) at 1000 Pa (4 in. w.g.) differential pressure. Blades shall be air foil type suitable for wide-open face velocity of 7.5 m/s (1500 fpm).
- .7 Sections: Individual damper sections shall not exceed 125 cm × 150 cm (48 in. × 60 in.). Each section shall have at least one damper actuator.

- .8 Modulating dampers shall provide a linear flow characteristic where possible.
- .9 Linkages: Dampers shall have exposed linkages.
- .10 Sizing and Selection: Refer to Control Damper Schedule.
- .11 Control dampers subjected to outdoor air conditions, including but not limited to outdoor air intake, exhaust air and relief air dampers shall be provided complete with thermally insulated blades and thermally broken frames, suitable for operation to -40°C.

2.13 Coil End Covers

- .1 Provide coil end casings to eliminate coil frame air leakage.
- .2 Provide for cooling coil ends to drip condensate to the coil drain pan. Insulate the inside of the coil end casing to prevent casing condensation and provide closure panels to retain insulation.

2.14 Wire Mesh Screens

- .1 Provide wire mesh screens in all air intake openings where noted on the drawings.
- .2 Screens shall be constructed from aluminum wire 1.3 mm diameter (16 ga).
- .3 Screen mesh shall be 15 mm (½”).
- .4 Mount screens in 0.66 mm thick (20 ga) folded aluminum frames.

2.15 Counter Flashings

- .1 Counter Flashings – galvanized sheet steel of 0.8 mm (22 ga) minimum thickness.
- .2 Counter flashings are attached to mechanical equipment and lap the base flashings on the roof curbs.
- .3 All joints in counter flashings shall be flattened and solder double seam. Storm collars shall be adjustable to draw tight to pipe with bolts. Caulk around the top edge. Storm collars shall be used above all roof jacks.
- .4 Vertical flange section of roof jacks shall be screwed to face of curb.

3. EXECUTION

3.1 Manufacturer's Instructions

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

3.2 Balancing Dampers

- .1 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's recommendations.
- .2 Provide balancing dampers at points on low pressure supply, return and exhaust systems where branches are taken from larger duct as required for proper air balancing.
- .3 Provide balancing dampers at each run out to a grille or diffuser. Install damper as close to branch take-off as possible.
- .4 Identify the airflow direction and blade rotation and open and closed position.

- .5 On all round ductwork larger than 300 mm (12") diameter and on externally insulated rectangular ductwork, provide sheet metal bridge to raise quadrant type operators above the insulation thickness (coordinate with Duct Insulation Section 23 07 13). Provide an open end bearing where bridges are used. Bridges on uninsulated round ducts shall be at least 25 mm (1") high.
- .6 Where quadrant type operators are used, the lever shall be arranged parallel with the damper blade.
- .7 Where balancing dampers are located above hard-ceilings (e.g. drywall), provide access panels or a remote operating device actuated by a socket or screwdriver.
- .8 Coordinate the installation of all dampers with the balancing contractor to ensure all dampers are accessible for system balancing.

3.3 Backdraft Dampers

- .1 Install backdraft dampers on all exhaust and relief openings through the building walls and roof on all exhaust fans where control dampers are not called for or indicated.

3.4 Control Dampers – Automatic

- .1 Packaged equipment specified to be complete with control dampers, shall include control dampers as normally supplied by the equipment manufacturer unless otherwise noted.
- .2 All other automatic control dampers shall be provided and installed under this Section.
- .3 Damper submittals shall be coordinated for type, quantity, and size to ensure compatibility with sheet metal design.
- .4 Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting. Duct openings shall measure 6 mm (¼ in.) larger than damper dimensions and shall be square, straight, and level.
- .5 Individual damper sections, as well as entire multiple section assemblies, must be completely square and free from racking, twisting, or bending. Measure diagonally from upper corners to opposite lower corners of each damper section. Both dimensions must be within 3 mm (1/8 in.) of each other.
- .6 Follow the manufacturer's instructions for field installation of control dampers. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.
- .7 Install extended shaft or jackshaft according to manufacturer's instructions. (Typically, a sticker on the damper face shows recommended extended shaft location. Attach shaft on labeled side of damper to that blade.)
- .8 Damper blades, axles, and linkage must operate without binding. Before system operation, cycle damper after installation to ensure proper operation. On multiple section assemblies, all sections must open and close simultaneously.
- .9 Support ductwork in area of damper when required to prevent sagging due to damper weight.
- .10 After installation of low-leakage dampers with seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.
- .11 The indicated size of control dampers is the dimension outside the frame. Oversize the ductwork to include the depth of the damper frame if the pressure drop across the damper exceeds 25 Pa (0.1" w.g.).
- .12 Control damper frames shall be fitted tightly into ductwork and sealed airtight.
- .13 Check that dampers are installed square and true. Ensure that damper end linkages are easily accessible.

- .14 Do not install control dampers within the thickness of any wall unless otherwise indicated.

3.5 Duct and Plenum Access

- .1 Locations: Provide access doors and panels as follows:
 - .1 Doors: where shown on the drawings.
 - .2 Panels:
 - .1 Every 12 m (40 ft) on all ductwork.
 - .2 At the base of each duct riser.
 - .3 Both sides of equipment blocking the duct e.g.
 - .1 Air flow measuring stations
 - .2 Coils
 - .4 At or to one side of other equipment in duct e.g.
 - .1 Backdraft dampers (counter weight side)
 - .2 Balance dampers serving multiple outlets/inlets
 - .3 Bearings (fans/motors)
 - .4 Control dampers
 - .5 Control sensors
 - .6 Fire dampers (rectangular ducts and round ducts 330 mm (13") dia. and larger - latch side)
 - .7 Heat detectors (upstream from device)
 - .8 Smoke dampers (operator side)
 - .9 Smoke detectors (upstream from device)
 - .5 Panels need not be provided where access is available through a door or a register mounted on the side of the duct.
 - .6 Kitchen exhaust access requirement specified under "Ductwork - Kitchen Exhaust".
 - .3 Patches:
 - .1 Where required for cleaning and where access panels are not specified, e.g. on both sides of turning vanes.
 - .4 Flexible duct - on round duct and round fire dampers up to 300 mm (12") dia.
- .2 Seal frames airtight.
- .3 Install so as not to interfere with airflow.
- .4 Install to provide easiest possible access for service and cleaning.
- .5 Do not use sheet metal screws for attaching access panels to ductwork.
- .6 Round ducts 330 mm (13") dia. and larger shall include a short collar for the installation of access panels.
- .7 Small rectangular ducts shall be transitioned to a minimum dimension across the duct of 330 mm (13") for the installation of access panels.

3.6 Duct Connectors – Vibration Isolation

- .1 Install in the following locations:

- .1 Inlets and outlets to supply air units and fans.
- .2 Inlets and outlets of exhaust and return air fans.
- .3 As indicated.
- .2 Ensure flexible duct connectors do not reduce free area on suction side of fans.
- .3 Ducting on sides of flexible connection to be in alignment.
- .4 Ensure slack material in flexible connection.

3.7 Ductwork – Flexible

- .1 Installed lengths shall be limited to 6 times duct diameter but not longer than 900 mm (3 ft). Do not use for changes in direction greater than 60°.
- .2 Connect to ductwork and diffusers with stainless steel worm drive clamps or Panduit adjustable clamps or Thermaflex duct strap applied over two wraps of duct tape. Use stainless steel clamps on connections to fire dampers.
- .3 Minimum centreline radius of flexible ductwork bends shall be 1.5 times the duct diameter, alternatively, sheet metal elbows may be used at branch takeoffs and boot/diffuser connections. Very sharp turns and reduction in the area of the duct will not be permitted.
- .4 Support with 25 mm x 0.76 mm (1"x22 ga) galvanized steel straps at a maximum of 600mm (24"). Straps shall completely encircle duct. Support to prevent sagging of duct.
- .5 Support clear of ceiling assembly, light fixtures, and hot surfaces.
- .6 Do not use flexible ductwork in secure areas.

3.8 Fire Dampers

- .1 Install in accordance with the SMACNA Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, NFPA 90A, conditions of the ULC listing and per manufacturer's instructions.
- .2 Maintain integrity of the fire separation.
- .3 Fire damper sleeves must not extend more than 75 mm (3") from wall on each side.
- .4 Fire dampers must be installed within wall thickness of fire separation.
- .5 Wall openings sized to allow sleeve/damper expansion.
- .6 Arrange dampers so that linkages and locking catches are accessible from the access side of fire damper.
- .7 Install access door adjacent to each damper.
- .8 Install so as to close in the direction of normal airflow.
- .9 Size so that the free area of duct is maintained through the assembly.
- .10 Install in galvanized steel sleeve, retained in place with retaining angles on all four sides at each face of wall.
- .11 Connect ductwork to damper sleeves using break-away duct joints on all faces.

3.9 Instrument Test Ports

- .1 Locate to permit easy manipulation of instruments.
- .2 Install insulation port extensions as required.
- .3 Locations:
 - .1 For traverse readings:

- .1 Ducted inlets to roof and wall exhausters.
- .2 Inlets and outlets of other fan systems.
- .3 Main and sub-main ducts.
- .4 As indicated.
- .2 For temperature readings:
 - .1 At outside air intakes.
 - .2 In mixed air applications in locations as approved by the Consultant.
 - .3 At inlet and outlet of coils.
 - .4 Downstream of junction of two converging air streams of different temperatures.
 - .5 As indicated.
- .3 In addition to the locations specified, install instrument test ports in ductwork as directed by the Testing and Balancing Contractor. Test port covers are to be installed after the balancing is complete, however insure the insulation is repaired at test port locations. Install heavy duty locking quadrant handles at all balancing dampers (except splitter dampers). Ensure handles are marked in the final set position by the Testing and Balancing Contractor.

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 Section Includes:
 - .1 Materials, components, and installation for heat reclaim devices.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Section 21 05 01 Common Work Results for Mechanical
- .3 Section 23 33 00 Duct Accessories.

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
 - .1 Applicable Building Code - Refer to Section 21 05 01.
- .2 Air Movement and Control Association (AMCA)
 - .1 AMCA 210, Laboratory Method of Testing Fans for Aerodynamic Performance Rating (ASHRAE).
- .3 American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)
 - .1 ANSI/ASHARE Standard 62.1 - Ventilation for Acceptable Indoor Air Quality.
 - .2 ANSI/ASHRAE 84, Method of Testing Air-to-Air Heat/Energy Exchangers.
 - .3 ANSI/ASHARE Standard 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings.
- .4 American National Standards Institute/Air-Conditioning, Heating and Refrigeration Institute (ANSI/AHRI)
 - .1 ANSI/AHRI Standard 260 - Sound rating of Ducted Air Moving and Conditioning Equipment.
 - .2 ANSI/AHRI Standard 1060 – Performance Rating of Air-to-Air Heat exchangers for Energy Recovery Ventilation Equipment.
- .5 Canadian Electrical Code C22.2 No. 13-15 – Fans and Ventilators.
- .6 Canadian General Standards Board (CGSB)
 - .1 CAN/CGSB 1.181, Ready-Mixed Organic Zinc-Rich Coating.
- .7 NFPA 90A - Standard for the Installation of Air Conditioning and Ventilation Systems.
- .8 Underwriter's laboratory (UL) 1812 - Standard for Ducted Heat Recovery Ventilators.

1.4 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals.
- .2 Manufacturer shall submit a copy of the installation instruction to the contractor. Include a copy in the O&M manual.
- .3 Manufacturer shall provide the following information with each shop drawing/product data submission:

- .1 Each component of the unit shall be identified and mechanical specifications shall be provided for unit and accessories describing construction, components, and options.
- .2 Construction Details for the following components:
 - .1 Cabinet interior and exterior construction, including connection details.
 - .2 Floor, including connection details.
 - .3 Doors, hinges, latch, viewing port.
 - .4 Fans, motor and drive, mounting and isolation.
 - .5 Coil section.
 - .6 Pipe and conduit penetration through casing or floor.
 - .7 Drain pan.
 - .8 Heat recovery section and bypass
- .3 Materials of construction: Indicate material and gauge of all construction components.
- .4 All performance data, including, as a minimum, the following:
 - .1 Energy recovery performances
 - .2 Cooling performances
 - .3 Heating performances
- .5 Fan curves shall be provided for fans with the design operating points indicated. Data shall be corrected to actual operating conditions, temperatures, and altitudes.
- .6 Filter data shall be provided including media type, efficiency rating, velocity, pressure drop, mounting method and arrangement.
- .7 Vibration isolation shop drawings
- .8 Wiring diagrams showing factory installed wiring
- .9 A schedule detailing necessary trap height shall be provided for each air-handling unit. Schedule shall detail unit tag, unit size, appropriate trap schematic with recommended trap dimensions, and unit supplied base rail height. Contractor shall be responsible for additional trap height required for trapping and insulation beyond the unit supplied base rail height by adequate housekeeping pad.
- .10 Sound data shall be provided using AHRI 260 test methods. Unit discharge, inlet, and radiated sound power levels in dB shall be provided for 63, 125, 250, 500, 1000, 2000, 4000 and 8000Hz.

1.5 Quality Assurance

- .1 Submit following in accordance with Division 1 - Submittal Procedures.
 - .1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - .2 Catalogued or published ratings shall be those obtained from tests carried out by manufacturer or those ordered by him from independent testing agency signifying adherence to codes and standards.
 - .3 Instructions: submit manufacturer's installation instructions.
- .2 HRV:
 - .1 The fixed plate Heat recovery core must be AHRI certifies for the 1060 standard. Noncertified product will not be considered.

- .2 The unit must be tested as per ANSI/UL 1995 and CAN/CSA C22.2 No. 236, Fourth Edition, October 14, 2011.
- .3 The unit must be ETL certified.
- .4 The insulation shall comply with NFPA 90A requirements for flame spread and smoke generation.
- .5 Unit must be free of fabrication defect and maintain proper operation under normal use for a period of two years from purchasing date.
- .6 Unit must be fully tested before delivery.

1.6 Delivery, Storage and Handling

- .1 Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.
- .2 Units shall ship fully assembled up to practical shipping and rigging limitations. Units not shipped fully assembled shall have tags and airflow arrows on each section to indicate location and orientation in direction of airflow. Shipping splits shall be clearly defined on submittal drawings. Cost associated with non-conformance to shop drawings shall be the responsibility of the manufacturer. Each section shall have lifting lugs and shipping skid for lifting and forklift transport to allow for field rigging and final placement of section.
- .3 Deliver units to jobsite with fan motor(s), sheave(s), and belt(s) completely assembled and mounted in units.
- .4 Unit shall be shipped in a clear shrink-wrap or stretch-wrap to protect unit from in-transit rain and debris per ASHRAE 62.1 recommendations.
- .5 Installing contractor shall be responsible for storing units in a clean, dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.7 Maintenance

- .1 Extra Materials
 - .1 Provide maintenance materials in accordance with Section 01 78 00 Closeout Submittals.
 - .2 Provide list of individual manufacturer's recommended spare parts for equipment such as bearings and seals, and addresses of suppliers, together with list of specialized tools necessary for adjusting, repairing, or replacing, for placement into operating manual.
 - .3 Spare filters: in addition to filters installed immediately prior to acceptance by Consultant, supply 1 complete set of filters for each filter unit or filter bank.

2. PRODUCTS

2.1 Heat Recovery Ventilator – Fixed Plate Type

- .1 General
 - .1 Packaged Air-to-Air Fixed Plate Heat Recovery Ventilator (HRV) from the Advance series manufactured by Aldes.
 - .2 HRV must include the following components:
 - .1 a fixed plate air-to-air Heat recovery core;
 - .2 a fresh air blower;

- .3 an exhaust air blower;
- .4 filters ahead the core in both fresh and exhaust air circuits;
- .5 an insulated cabinet for an outdoor installation;
- .6 sensors and microprocessor controls for an autonomous operation.
- .3 The HRV must be capable of transferring both sensible energy.
- .4 The HRV must be designed to be used as a stand-alone unit or as a component in a dedicated HVAC system or as complete ventilation/HVAC unit with optional conditioning.
- .5 The unit must be complete, fully assembled with gauges and controls, ready to be field wired.
- .2 Unit Cabinet
 - .1 The cabinet must have a double-wall construction using Aldes HSF™ technology.
 - .2 The cabinet must have 2 inches thick fiberglass insulation.
 - .3 The floor of the unit must be insulated 2 inches thick with fiberglass.
 - .4 **The interior of the entire unit shall be stainless steel lined, suitable for a corrosive environment. No Exceptions.**
 - .5 The exterior wall of the unit must be made of prepainted steel 22 ga. The paint must be made of a silicone-based polyurethane and withstand 150 rubs (back and forth) with methyl ethyl ketone (MEK) when tested as per ASTM-D5402.
 - .6 The interior wall must be designed to support the structural loads of the cabinet.
 - .7 The structural base of the unit must be constructed with 11-gauge galvanized steel.
 - .8 The peripheral base must be equipped with lifting lugs.
 - .9 The access doors must be made with the same material and thicknesses than the cabinet and be equipped with ¼ turns handles with integrated locks.
 - .10 The access doors must be equipped with 180° hinges.
 - .11 The cabinet must allow access to all inside components and allow access for maintenance on one side of the unit; no clearance is needed on the back side.
 - .12 The cabinet must be constructed in a manner that there are no screw tips inside the unit.
 - .13 Every joint must be sealed with polyurethane-based high strength elastomeric sealant that contains no solvents or isocyanates.
 - .14 Cabinet shall include stainless steel drain pan.
- .3 Fixed Plate Heat Recovery Core
 - .1 The Heat recovery section must be of the fixed plate air-to-air type.
 - .2 The heat recovery fixed plated core must be made of polypropylene to recover sensible heat.
 - .3 The fixed plate air-to-air Heat recovery core must be easily cleanable.
 - .4 The core efficiency must be rated as per AHRI-1060 and certified by AHRI.
- .4 Fans

- .1 The Supply and exhaust fans must be double width double inlet with centrifugal forward curved blades.
 - .2 The bearings must be sealed and permanently lubricated.
 - .3 The fans must be dynamically and statically balanced.
 - .4 The fan/motor/drive assembly must be mounted on an 11-ga galvanized steel base.
 - .5 The fan/motor/drive assembly must be mounted on spring vibration isolators with 1 inch deflexion.
 - .6 **Fan and fan mounting bases shall be epoxy coated.**
 - .7 The fan outlet must be connected to the unit's casing with a flexible connector to minimize vibration dispersion.
 - .8 The performances of the fans must be tested as per AMCA-210 standard
- .5 Motors
- .1 **Motors must have a Totally Enclosed Fan Cooled (TEFC) high efficiency (EPACT), inverter rated 10:1 with a service factor 1.15. ODP not acceptable.**
 - .2 The motors must be mounted on an adjustable base to adjust the fan belt bending and alignment.
 - .3 The fan drive must be by pulley and trapezoidal belt with a fixed pitch driving pulley and a variable pitch driven pulley.
 - .4 Motors must be Premium efficiency (when applicable).
- .6 Filters
- .1 Each air circuit must have 4 inches thick pleated and replaceable filters.
 - .2 Filters must be installed ahead the Heat recovery core in both air stream to protect the core against dust and airborne contaminant that may reduce its efficiency.
 - .3 Fresh air circuit filters must be MERV8 rated when tested as per ASHRAE 52.2 standard.
 - .4 Exhaust air circuit filters must be MERV8 rated when tested as per ASHRAE 52.2 standard.
- .7 Electrical Wiring
- .1 The unit must have a single point power connection.
 - .2 The unit voltage must be 575 V/3 Φ /60 Hz.
 - .3 The unit must be equipped with a non-fused disconnect NEMA 4.
 - .4 The electrical data must be 10A FLA, 12.5A MCA, 15 MOP.
- .8 Controls
- .1 The unit shall be provided with factory mounted and factory wired microprocessor controls and sensors.
 - .2 The unit controller shall be controlled by a BACnet link complete with BACnet Controller.
 - .3 Unit must be able to provide a 24VAC 20VA power supply for external accessories.
 - .4 Every component shall be properly protected against current overload.

- .5 Each motor must have its own magnetic contactor and thermal overload.
- .9 Accessories
 - .1 Frost Control Option:
 - .1 Freezing of the core must be avoided by using a face and bypass damper.
 - .2 A temperature sensor will modulate the face and bypass damper in order to maintain an evacuated air temperature above freezing.
 - .2 Hydronic Post-heating:
 - .1 The air conditioning must be made using a hot water post-heating coil and maintain an adjustable temperature.
 - .2 The hot water post-heat coil must be installed inside the unit.
 - .3 Water coil performances must be tested and certified as per AHRI 410 standard requirements.
 - .3 Dirty Filters Contacts:
 - .1 Each set of filters in the unit must be equipped with an air pressure drop switch that closes when the filters are dirty.
 - .4 Motorized Damper, Fresh Air:
 - .1 Motorized damper on the fresh air duct made of extruded aluminum insulated and activated with an actuator. Dampers must be low leaks and have integrated thermal breaks.
 - .5 Motorized Damper, Exhaust Air:
 - .1 Motorized damper on the exhaust air duct made of extruded aluminum insulated and activated with an actuator. Dampers must be low leaks and have integrated thermal breaks.
 - .6 Backdraft Damper, Exhaust Air:
 - .1 Non insulated backdraft damper made of extruded aluminum on the exhaust air opening.
 - .7 Face and Bypass Damper:
 - .1 A modulating bypass damper will be used for free cooling.
 - .8 VFD on Motors:
 - .1 Each motor speed must be controlled with variable frequency drive.
 - .2 Each motor will be modulated via a 0-10VDC external signal.
 - .9 Independent Blower Control:
 - .1 Each motor can be started/stopped individually with external dry contacts.
 - .10 Free-Cooling Management:
 - .1 The unit will monitor the outside air temperature and automatically set the unit into free-cooling mode when the outside air temperature allows it.
 - .11 Roof Curb:
 - .1 **The unit must come with a 14-inches high non-insulated, vibration isolated seismic roof curb, allowed up to 1” deflection.**

3. EXECUTION

3.1 Manufacturer's Instructions

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

3.2 Heat Recovery Ventilators Installation

- .1 Install in accordance with manufacturer's recommendations.
- .2 Support independently of adjacent ductwork. Install flexible connections at unit inlet and outlets.
- .3 Ensure adequate clearance for servicing and maintenance.
- .4 The Mechanical Contractor shall be responsible to coordinate ALL of his installation requirements with the Owner and the General Contractor to ensure that a complete installation for each unit is being provided. Coordination efforts shall include such items as unloading and hoisting requirements, field wiring requirements, field piping requirements, field ductwork requirements, requirements for assembly of field-bolted or welded joints, and all other installation and assembly requirements.
- .5 Where applicable the manufacturer shall provide all screws and gaskets for joining of sections in the field.
- .6 Where applicable, install fan sheaves required for final air balance.
- .7 Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.
- .8 Start-up Heat Recovery Ventilators in accordance with manufacturer's start-up instructions. Provide start-up report to the Consultant, and include in O & M manual.

END OF SECTION

1. GENERAL

1.1 Related Sections

- .1 Section 21 05 01 – Common Work Results for Mechanical
- .2 Section 23 05 48 Vibration and Seismic Control for Mechanical.
- .3 Section 23 33 00 Duct Accessories.

1.2 References

- .1 Air-Conditioning, Heating, & Refrigeration Institute (AHRI)
 - .1 AHRI Standard 410 - Forced Circulation Air-Cooling and Air-Heating Coils.
 - .2 AHRI Standard 430 - [2014], Performance Rating of Central Station Air-Handling Unit Supply Fans.
- .2 Canadian General Standards Board (CGSB)
 - .1 CAN/CGSB 1.181- [99], Ready-Mixed Organic Zinc-Rich Coating.
- .3 ANSI/ASHRAE Standard 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
- .4 ANSI/ASHARE Standard 62.1 - Ventilation for Acceptable Indoor Air Quality.
- .5 ANSI/ASHARE Standard 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings.
- .6 ANSI/NEMA MG 1 - Motors and Generators.
- .7 ANSI/UL 900 - Standard for Safety Air Filter Units.
- .8 ANSI/AHRI Standard 260 - Sound rating of Ducted Air Moving and Conditioning Equipment.
- .9 ASHRAE Standard 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems.
- .10 NFPA 90A - Standard for the Installation of Air Conditioning and Ventilation Systems.
- .11 UL 1995 - Standard for Safety Heating and Cooling Equipment

1.3 Quality Assurance

- .1 It is the intent of this specification that the manufacturer provides exterior enclosures for the pre-heat sections and pumps designed and manufactured specifically to the requirements of this project. Overall dimensions and configuration are to be as shown on the plans and/or as described in the specifications.
- .2 Unit construction shall be per the construction details as described herein.
- .3 Airflow rates, external static pressures, water flow rates, coil face velocities, filter face velocities, water and air side pressure drops shall be the same or better than specified for alternate selections.
- .4 All components, paints, and lining shall have a flame spread rating of not over 25 without evidence of continued progressive combustion and a smoke developed rating no higher than 50.

1.4 Shop Drawings and Product Data

- .1 Submit shop drawings and product data in accordance with Section 21 05 01 - Submittal Procedures.

- .2 AHU manufacturer shall provide the following information with each shop drawing/product data submission:
 - .1 Each component of the unit shall be identified and mechanical specifications shall be provided for unit and accessories describing construction, components, and options.
 - .2 Construction Details for the following components:
 - .1 Side panels, including connection details.
 - .2 Top panel, including connection details.
 - .3 Floor, including connection details.
 - .4 Doors, hinges, latch.
 - .5 Coil section.
 - .6 Pipe and conduit penetration through casing or floor.
 - .7 Drain pan.
 - .8 Damper, linkage and drive construction and mounting
 - .3 Materials of construction: Indicate material and gauge of all construction components.
 - .4 Filter data shall be provided including media type, efficiency rating, velocity, pressure drop, mounting method and arrangement.

1.5 Delivery, Storage and Handling

- .1 Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.
- .2 Units shall ship fully assembled up to practical shipping and rigging limitations. Units not shipped fully assembled shall have tags and airflow arrows on each section to indicate location and orientation in direction of airflow. Shipping splits shall be clearly defined on submittal drawings. Cost associated with non-conformance to shop drawings shall be the responsibility of the manufacturer. Each section shall have lifting lugs and shipping skid for lifting and forklift transport to allow for field rigging and final placement of section.
- .3 Unit shall be shipped in a clear shrink-wrap or stretch-wrap to protect unit from in-transit rain and debris per ASHRAE 62.1 recommendations.
- .4 Installing contractor shall be responsible for storing AHU in a clean, dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.6 Start-Up and Operating Requirements

- .1 Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters in place, bearings lubricated (if applicable), condensate properly trapped, piping connections verified and leak-tested, belts aligned and tensioned, all shipping braces removed, bearing set screws torqued, and fan has been test run under observation.

1.7 Warranty

- .1 AHU manufacturer shall provide, at no additional cost, a standard parts warranty that covers a period of one year from unit start-up or 18 months from shipment, whichever occurs first. This warrants that all products are free from defects in material and workmanship and shall meet the capacities and ratings set forth in the equipment manufacturer's catalogue and bulletins.

1.8 Extra Materials

- .1 Provide maintenance materials in accordance with Section 01 78 00 Closeout Submittals.

- .2 Provide list of individual manufacturer's recommended spare parts for equipment such as bearings and seals, and addresses of suppliers, together with list of specialized tools necessary for adjusting, repairing, or replacing, for placement into operating manual.
- .3 Spare filters: in addition to filters installed immediately prior to acceptance by Consultant, supply 1 complete set of filters for each filter unit or filter bank.

2. PRODUCTS

2.1 Rooftop Pre-Heat Section c/w Pump Enclosure – AHU-3-2020

- .1 General:
 - .1 Manufacturer to provide a full perimeter integral base frame for either ceiling suspension of units or to support and raise all sections of the unit for proper trapping. Base frame will either be bolted construction or welded construction. Refer to schedule for base height and construction type. Contractor will be responsible for providing a housekeeping pad when unit base frame is not of sufficient height to properly trap unit. Unit base frames not constructed of galvanized steel shall be chemically cleaned and coated with both a rust-inhibiting primer and finished coat of rust-inhibiting enamel. Unit base height to be included in total height required for proper trap height.
- .2 Unit Casing:
 - .1 Unit manufacturer shall ship unit in segments as specified by the contractor for ease of installation in tight spaces. The entire air handler shall be constructed of galvanized steel. Casing finished to meet ASTM B117 250-hour salt-spray test. The removal of access panels or access doors shall not affect the structural integrity of the unit. All removable panels shall be gasketed. All doors shall have gasketing around full perimeter to prevent air leakage. Contractor shall be responsible to provide connection flanges and all other framework that is needed to properly support the unit.
 - .2 Casing performance - Casing air leakage shall not exceed leak class 6 (CL = 6) per ASHRAE 111 at specified casing pressure, where maximum casing leakage (cfm/100 ft² of casing surface area) = CL X P^{0.65}.
 - .3 Air leakage shall be determined at 1.00 times maximum casing static pressure up to 8 inches w.g. Specified air leakage shall be accomplished without the use of caulk. Total estimated air leakage shall be reported for each unit in CFM, as a percentage of supply air, and as an ASHRAE 111 Leakage Class.
 - .4 Unit casing (wall/floor/roof panels and doors) shall be able to withstand up to 1.5 times design static pressure, or 8-inch w.g., whichever is less, and shall not exceed 0.0042 per inch of panel span (L/240).
 - .5 Floor panels shall be double-wall construction and designed to support a 300-lb load during maintenance activities and shall deflect no more than 0.0042 per inch of panel span.
 - .6 Unit casing panels shall be 2-inch double-wall construction, with solid galvanized exterior and solid galvanized interior, to facilitate cleaning of unit interior.
 - .7 Unit casing panels (roof, walls, floor) and doors shall be provided with a minimum thermal resistance (R-value) of 13 Hr*Ft²*°F/BTU.
 - .8 Unit casing panels (roof, walls, floor) and external structural frame members shall be completely insulated filling the entire panel cavity in all directions so that no voids exist. Panel insulation shall comply with NFPA 90A.

- .9 Casing panel inner liners must not extend to the exterior of the unit or contact the exterior frame. A mid-span, no-through-metal, internal thermal break shall be provided for all unit casing panels.
 - .10 Access panels and/or access doors shall be provided in all sections to allow easy access to drain pan, coil(s), motor, drive components and bearings for cleaning, inspection, and maintenance.
 - .11 Access panels and doors shall be fully removable without the use of specialized tools to allow complete access of interior surfaces.
- .3 Outdoor Unit Features:
- .1 Outdoor Casing Details - In addition to all other details specified within for air handling units, units that are installed outdoors shall also comply with the following -
 - .2 Factory Supplied Roofcurb - Roof curbs shall be provided where indicated on the plans and shall be galvanized steel. Roof curb shall support the full perimeter of the air handling unit, including pipe chases. A 2" x 4" nominal wood nailing strip shall be supplied attached to the roof curb. Wood nailing strip shall be of #4 Spruce or #4 Yellow Pine. Roof curb shall include frame work necessary to support supply and return duct installation prior to unit placement. Roof curb shall be shipped loose for field installation prior to unit placement.
- .4 Access Doors:
- .1 Access doors shall be 2-inch double-wall construction. Interior and exterior shall be of the same construction as the interior and exterior wall panels.
 - .2 All doors downstream of the cooling coil shall be provided with a thermal break construction of door panel and door frame.
 - .3 Gasketing shall be provided around the full perimeter of the doors to prevent air leakage.
 - .4 Door hardware shall be surface-mounted to prevent through-cabinet penetrations that could likely weaken the casing leakage and thermal performance.
 - .5 Handle hardware shall be designed to prevent unintended closure.
 - .6 Access doors shall be hinged and removable without the use of specialized tools.
 - .7 Door handle hardware shall be adjustable and visually indicate locking position of door latch external to the section.
 - .8 All doors shall be a 60-inch high when sufficient unit height is available, or the maximum height allowed by the unit height.
 - .9 Multiple door handles shall be provided for each latching point of the door necessary to maintain the specified air leakage integrity of the unit.
- .5 Coils:
- .1 Coils section header end panel shall be removable to allow for removal and replacement of coils without impacting the structural integrity of the unit.
 - .2 Install coils such that headers and return bends are enclosed by unit casing to ensure that if condensate forms on the header or return bends, it is captured by the drain pan under the coil.

- .3 Coils shall be manufactured with plate fins to minimize water carryover and maximize airside thermal efficiency. Fin tube holes shall have drawn and belled collars to maintain consistent fin spacing to ensure performance and air pressure drop across the coil as scheduled. Tubes shall be mechanically expanded and bonded to fin collars for maximum thermal conductivity. Use of soldering or tinning during the fin-to-tube bonding process is not acceptable due to the inherent thermal stress and possible loss of bonding at that joint.
 - .4 Construct coil casings of galvanized steel steel. End supports and tube sheets shall have belled tube holes to minimize wear of the tube wall during thermal expansion and contraction of the tube.
 - .5 All coils shall be completely cleaned prior to installation into the air handling unit. Complete fin bundle in direction of airflow shall be degreased and steam cleaned to remove any lubricants used in the manufacturing of the fins, or dirt that may have accumulated, in order to minimize the chance for water carryover.
 - .6 When two or more cooling coils are stacked in the unit, an intermediate drain pan shall be installed between each coil. The intermediate drain pan shall be designed being of sufficient size to collect all condensation produced from the coil and sloped to promote positive drainage to eliminate stagnant water conditions. The intermediate drain pan shall be constructed of the same material as the sections primary drain pan.
 - .7 The intermediate drain pan shall begin at the leading face of the water-producing device and be of sufficient length extending downstream to prevent condensate from passing through the air stream of the lower coil.
 - .8 Intermediate drain pan shall include downspouts to direct condensate to the primary drain pan. The intermediate drain pan outlet shall be located at the lowest point of the pan and shall be sufficient diameter to preclude drain pan overflow under any normally expected operating condition.
- .6 Filters:
- .1 Provide factory-fabricated filter section of the same construction and finish as unit casings. Filter section shall have side access filter guides and access door(s) extending the full height of the casing to facilitate filter removal. Construct doors in accordance with Section 2.04. Provide fixed filter blockoffs as required to prevent air bypass around filters. Blockoffs shall not need to be removed during filter replacement. Filters to be of size, and quantity needed to maximize filter face area of each particular unit size.
 - .2 Filter type, MERV rating, and arrangement shall be provided as defined in project plans and schedule.
 - .3 Manufacturer shall provide one set of startup filters.
- .7 Dampers
- .1 All dampers shall be internally mounted. Dampers shall be premium ultra low leak and located as indicated on the schedule and plans. Blade arrangement (parallel or opposed) shall be provided as indicated on the schedule and drawings. Dampers shall be Ruskin CD60 double-skin airfoil design or equivalent for minimal air leakage and pressure drop. Leakage rate shall not exceed 3 CFM/square foot at one inch water gauge complying with ASHRAE 90.1 maximum damper leakage and shall be AMCA licensed for Class 1A. All leakage testing and pressure ratings shall be based on AMCA Standard 500-D. Manufacturer shall submit brand and model of damper(s) being.

2.2 Rooftop Mechanical Enclosures – Pumps – AHU-04-2020 and AHU-05-2020

- .1 General:

- .2 Description: JST certified weatherproof steel housing, engineered to withstand wind loads of up to 100mph.
- .3 Approved Manufacturers:
 - .1 Johnson Thermal Systems – BC Representative Trane Northwest
- .4 Description: Pre-engineered enclosure with the following features:
 - .1 Structural Design and Anchorage: Comply with IBC standards and local jurisdiction, complying with appropriate snow, wind, floor, roof and live load requirements.
 - .2 Hinged Doors: Bolting hardware is stainless steel. Neoprene gasket single sealed around door perimeters. Rain lips over all doors.
 - .1 Single service doors with lockable recessed handles and leaf plated hinges
 - .2 Lift off hinges for removable doors
 - .3 Thermal Insulation: Fire retardant, thermally, and sound attenuating mineral wool, 2" thick.
- .5 Base Skid:
 - .1 Skid Construction: Structurally engineered base skid designed to IBC standards, local jurisdiction, and seismic requirements.
 - .1 I-beam or C-Channel perimeter members sized to meet loading requirements.
 - .2 Horizontal cross member to meet all loading requirements.
- .6 Wall Construction:
 - .1 Wall panels:
 - .2 Box and pan design, minimum 14 gauge galvaneal wall panels with stiffeners welded at 24" on center and tek-screwed together.
 - .3 Wall interior finished with 22 gauge perforated galvaneal
 - .4 Wall panels including door framing built as one unit, attached to skid, and fully sealed to prevent moisture from entering enclosure.
- .7 Roof Construction:
 - .1 Minimum 14 gauge galvaneal roof panels with stiffeners.
 - .2 Roof is single sloped pitched roof. Roof pitch is 1/4" rise for every 12" horizontal run.
- .8 Airflow through Enclosure: Provide airflow for cooling, while maintaining temperature rise of system components within required limits.
 - .1 Air intake and discharge louvers: Fixed, horizontal intake, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow. Bird screen to exclude birds and rodents.
- .9 Finishes
 - .1 All exterior enclosure surfaces will be solvent cleaned per SSPC – SP1;
 - .2 All exterior enclosure surfaces power tool cleaned per SSPC – SP3 and painted as follows:
 - .1 Primer –Epoxy Primer-Sealer (1.2 – 1.8 mils DFT)
 - .2 Finish – Polyurethane (2 – 2.5 mils DFT)
 - .3 All carbon steel surfaces sand blasted per SSPC – SP6 and painted as follows:
 - .1 Primer –Epoxy Primer-Sealer (1.2 – 1.8 mils DFT)

- .4 Finish – Polyurethane (2 – 2.5 mils DFT)
- .10 Warranty
 - .1 To be free from defects in material or workmanship that would make the enclosure or base unusable for its intended purpose for a period of 1 year from the date of manufacture as listed on the manufacturer’s label.

3. EXECUTION

3.1 Installation

- .1 Provide appropriate protection apparatus.
- .2 Install units in accordance with manufacturer's instructions and as indicated.
- .3 Ensure adequate clearance for servicing and maintenance.
- .4 The Mechanical Contractor shall be responsible to coordinate ALL of his installation requirements with the Owner and the Owner’s selected General Contractor to ensure that a complete installation for each unit is being provided. Coordination efforts shall include such items as unloading and hoisting requirements, field wiring requirements, field piping requirements, field ductwork requirements, requirements for assembly of field-bolted or welded joints, and all other installation and assembly requirements.
- .5 The AHU manufacturer shall provide all screws and gaskets for joining of sections in the field.

3.2 Leveling

- .1 The Mechanical Contractor shall level all unit sections in accordance with the unit manufacturer’s instructions. The Mechanical Contractor shall provide and install all necessary permanent shim material to ensure individual sections and entire assembled units are level.

END OF SECTION

1. GENERAL

1.1 Section Scope

.1 Section Includes:

- .1 Materials, components, and installation for packaged rooftop units, makeup air units and heating/ventilating units.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical
- .3 Section 23 05 48 - Vibration and Seismic Control for Mechanical
- .4 Section 23 33 00 - Duct Accessories

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
 - .1 Applicable Building Code - Refer to Section 21 05 01
 - .2 Air Movement and Control Association (AMCA)
 - .1 AMCA 210-16, Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating (ASHRAE Standard 51-16).
 - .3 American Society of Heating, Refrigeration and Air Condition Engineers (ASHRAE)
 - .1 ASHRAE 52.2-2017, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
 - .2 ASHARE Standard 62.1 - Ventilation for Acceptable Indoor Air Quality.
 - .3 ANSI/ASHRAE 90.1-2016, (I-P) Energy Standard for Buildings Except Low-Rise Residential Buildings.
 - .4 American National Standards Institute/Air-Conditioning, Heating and Refrigeration Institute (ANSI/AHRI)
 - .1 ANSI/AHRI 210/240-2017, Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment.
 - .2 ANSI/AHRI Standard 260 - Sound rating of Ducted Air Moving and Conditioning Equipment.
 - .3 AHRI 270-15, Sound Performance Rating of Outdoor Unitary Equipment.
 - .5 Canadian Standards Association (CSA)
 - .1 CSA B52-13, Mechanical Refrigeration Code
 - .2 CSA C22.1 HB-18, Canadian Electrical Code Handbook
 - .3 CSA C22.2 236-05, dated February 18, 2005, with revisions through July 30, 2009, Standard for Safety Heating and Cooling Equipment-Third Edition.
 - .4
 - .6 Canadian General Standards Board (CGSB)
 - .1 CAN/CGSB 1.181, Ready-Mixed Organic Zinc-Rich Coating

1.4 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals.
- .2 Product Data: For each type of outdoor roof mounted unit indicated. Include the following:
 - .1 Manufacturer's printed product literature, specifications and datasheet for packaged rooftop HVAC units.
- .3 Shop Drawings:
 - .1 Submit shop drawings to indicate project layout and dimensions; include:
 - .1 Equipment, piping, and connections, together with valves, strainers, control assemblies, thermostatic controls, auxiliaries and hardware, and recommended ancillaries which are mounted, wired and piped ready for final connection to building system, its size and recommended bypass connections.
 - .2 Piping, valves, fitting shipped loose showing final location in assembly.
 - .3 Control equipment shipped loose, showing final location in assembly.
 - .4 Dimensions, internal and external construction details, recommended method of installation with proposed structural steel support, mounting curb details, sizes and location of mounting bolt holes; include mass distribution drawings showing point loads.
 - .5 Certified fan-performance curves with system operating conditions indicated.
 - .6 Certified fan-sound power ratings.
 - .7 Certified heat pump and coil performance ratings with system operating conditions indicated.
 - .8 Motor ratings, electrical characteristics, and motor and fan accessories.
 - .9 Detailed composite wiring diagrams for control systems showing factory installed wiring and equipment on packaged equipment or required for controlling devices of ancillaries, accessories, controllers.
 - .10 Material gages and finishes.
 - .11 Filters with performance characteristics.
 - .12 Type of refrigerant used.
 - .4 Operation and Maintenance Data:
 - .1 Submit operation and maintenance data for each unit. Include a copy in the O&M manual.
 - .2 Submit startup and operating instructions for each unit.

1.5 Quality Assurance

- .1 Meet the requirements of CSA, CGA, Provincial and Municipal Codes and be CSA listed.
- .2 Units shall be products of manufacturers who provide local service personnel from factory representative, franchised dealer or certified maintenance service shop.
- .3 Provide start-up service and report.

1.6 Delivery, Storage and Handling

- .1 Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

- .2 Units shall ship fully assembled up to practical shipping and rigging limitations. Units not shipped fully assembled shall have tags and airflow arrows on each section to indicate location and orientation in direction of airflow. Shipping splits shall be clearly defined on submittal drawings. Cost associated with non-conformance to shop drawings shall be the responsibility of the manufacturer. Each section shall have lifting lugs and shipping skid for lifting and forklift transport to allow for field rigging and final placement of section.
- .3 Deliver units to jobsite with fan motor(s), sheave(s), and belt(s) completely assembled and mounted in units.
- .4 Unit shall be shipped in a clear shrink-wrap or stretch-wrap to protect unit from in-transit rain and debris per ASHRAE 62.1 recommendations.
- .5 Installing contractor shall be responsible for storing units in a clean, dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.7 Extra Materials

- .1 Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - .1 Filters: One set for each air-handling unit.
 - .2 Fan Belts: One set for each air-handling unit fan.

1.8 Warranty

- .1 Provide 1 year whole unit parts and labour warranty 12 months from date of start-up or 18 months from shipment to site, whichever comes first.
- .2 Refrigeration compressors to be warranted for five [5] years.

2. PRODUCTS

2.1 Packaged Rooftop Heating and Cooling Units

- .1 General:
 - .1 Unit(s) furnished and installed shall be water-source heat pump, packaged outdoor air unit (s) as scheduled on contract documents and these specifications. Unit(s) shall consist of insulated weather-tight casing with compressor(s), air-cooled condenser coil, condenser fans, evaporator coil, air filters, supply motors and unit controls.
 - .2 Before shipment, each unit(s) shall be leak tested, dehydrated, charged with refrigerant (R-410A) and compressor oil, and factory run tested for proper control operation.
 - .3 The condenser coils must be aluminum fin, mechanically bonded to copper tubing.
 - .4 Direct-drive, vertical discharge condenser fans must be provided with built-in thermal overload protection.
 - .5 Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.
 - .6 Wiring internal to the unit shall be colored and numbered for identification.
- .2 Cabinet:

- .1 Cabinet: Zinc-coated, heavy gauge, galvanized steel. Exterior surfaces shall be cleaned, phosphatized, and finished with a weather-resistant baked enamel finish. Unit's surface shall be tested 672 hours in a salt spray test in compliance with ASTM B45. Structural members shall be a minimum of 16 gauge with access doors and removable panels of minimum 20 gauge.
 - .2 Panels: 2" double-wall foamed panel construction throughout the indoor section of unit to provide nonporous, cleanable interior surfaces. All interior seams exposed to airflow shall be sealed.
 - .3 Insulation: 2" polyisocyanurate Foam metal encapsulated with no exposed edges. Initial R value of 6.6 per inch of thickness.
 - .4 Cabinet construction shall provide access panels for all parts requiring service.
 - .5 Cabinet top cover shall be one-piece construction or where seams exist, it shall be double-hemmed and gasket-sealed.
 - .6 Panels: Water- and air-tight hinged panels with handles shall provide access to filters, heating section; power exhaust fan section, supply air fan section, evaporator coil section, and unit control section. Door hardware shall be oriented to allow the door swing to be reversed.
 - .7 Latches with hold down hooks will be factory installed on hinged access doors.
 - .8 Unit shall include a motor operated outside air damper and optional return air damper assembly constructed of galvanized steel, and air foil blades with rubber edge seals. Damper blades shall be designed to have no more than 4 cfm of leakage per sq ft of damper area and shall exceed ASHRAE 90.1 requirements. Linkage shall be concealed out of airstream, within the damper frame to reduce pressure and noise. Damper assembly shall be controlled by a spring return two position or fully modulating actuator. Dampers shall not be sized for air velocities exceeding 2000 fpm.
 - .9 Type 430 Stainless steel drain pan sloped in two directions to ensure positive drainage. Pan shall have a minimum depth of 2". Seams exposed to standing water shall be welded liquid tight. Base of pan shall be insulated with 1" thick foam insulation.
 - .10 Provide openings either on side of unit or thru the base for power, control and gas connections.
 - .11 The base of the unit shall have provisions for forklift and crane lifting
- .3 Power Wiring:
- .1 Field wiring access to be provided thru unit base into isolated enclosure with removable cover.
 - .2 Power wiring to be single point connection.
 - .3 Unit shall be factory wired to field wiring terminal block mounted in isolated enclosure.
 - .4 Factory wired main power disconnect device, overcurrent and SCCA rated for total unit power connection.
 - .5 Factory installed safety barrier shall isolate all high voltage components, mounted inside electrical compartment, to protect service personnel from incidental contact.
 - .6 Factory wired Phase monitor shall be included as standard.
 - .7 Factory to mount and wire optional 120 volt convenience outlet. Field wiring of convenience outlet not acceptable.

- .4 Low Voltage Controls:
 - .1 Factory wired 24 volt control system complete with required transformers and fusing.
 - .2 Main Control Module (MCM) shall prevent simultaneous operation of any modes and shall enable operation in Dehumidification, Cooling, Heating or Economizer mode based on programmed settings for outdoor air conditions and discharge air temperature
 - .3 MCM shall accept separate setpoints for Occupied and Unoccupied states.
 - .4 MCM shall control based on dew point design settings for Dehumidification and Economizer modes, and sensible temperature settings for heating and cooling modes.
 - .5 MCM shall have onboard clock and scheduling function for occupancy.
 - .6 MCM shall include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.
 - .7 Factory installed and wired sensors shall monitor Outdoor Air (OA) temperature, humidity and evaporator leaving air temperature.
 - .8 Supply air sensor shall be furnished with unit. Installing contractor shall install remote mounted supply air sensor in supply air duct and field wire to the unit.
 - .9 Space temp and humidity sensor shall be furnished and field wired to unit by the installing contractor.
 - .10 Fully modulating hot-gas reheat shall be enabled in dehumidification mode and cooling mode with modulation controlled by MCM to maintain (supply air temperature / space temperature).
 - .11 System controls shall include anti-cycle timing and minimum compressor run/off-times.
 - .12 Systems controls shall be digital, programmable type with access via factory installed and wired touchscreen, or through portable computer connection. All setpoints, unit functions, and status shall be accessible via the touchscreen or portable computer.
 - .13 All low voltage field wiring connections shall be made at factory installed low voltage terminal strip.
- .5 Fans and Motors:
 - .1 Indoor fan shall be direct drive plenum fan, factory installed and wired to on-board Variable Frequency Drive and shall be equipped with slide out service access.
 - .2 All fan motors shall be premium efficiency ODP and meet the U.S. Energy Policy Act of 2005/10 (EPACT).
 - .3 All fan motors shall either be permanently lubricated and/ or have internal thermal overload protection. AHU-3 shall include a direct drive, EC driven fan. AHU-4 shall include direct drive, VFD driven fan.
 - .4 Provide shafts constructed of solid hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.
- .6 Evaporator Condensor and Reheat Coils:
 - .1 Evaporator and hot gas reheat coils shall be constructed of copper tubes mechanically bonded to a configured aluminum plate fin.
 - .2 Coils shall be leak tested at the factory to ensure pressure integrity. The evaporator coil, reheat coil and condenser coil shall be leak tested to 500 psig and pressure tested to 500 psig.

- .3 Evaporator coil shall have four interlaced rows for superior sensible and latent cooling with a maximum of 12 fpi.
- .4 The condenser coils shall be a coaxial "tube in tube" design. Water flows through the inner tube while refrigerant flows in the annulus between the inner and outer tubes. The coils have a convoluted multi-lead inner tube. The resulting convoluted tube has increased heat transfer surface area per unit length yet still permits full flow of both water and refrigerant around its entire periphery for improved performance. Turbulence imparted by the convolutions to both the water and refrigerant flows further enhances the thermal performance, while inhibiting the accumulation of deposits on the surfaces.
- .5 Reheat coil shall be fully integrated into the supply air and fan system and capable of delivering design supply air temperature.
- .6 To prevent re-hydration of condensate from evaporator coil, the evaporator coil face and the hot gas reheat coil face shall be separated a minimum of six inches.
- .7 Refrigerant Capacity Control:
 - .1 Capacity control for units equipped with digital scroll compressors, or variable speed compressors, shall be accomplished through a 0-10V signal by the MCM to the compressor controls.
- .8 Refrigeration System:
 - .1 Compressor(s): All units shall have direct-drive, hermetic, scroll type compressors.
 - .2 Motor shall be suction gas-cooled and shall have a voltage utilization range of plus or minus 10 percent of unit nameplate voltage.
 - .3 Internal overloads shall be provided with the scroll compressors.
 - .4 Each compressor shall have a crankcase heater to minimize the amount of liquid refrigerant present in the oil sump during off cycles.
 - .5 Each compressor shall be mounted on rubber vibration isolators, to reduce the transmission of noise.
 - .6 Provide each unit with hermetically sealed refrigerant circuit(s) factory-supplied completely piped with liquid line filter-drier, liquid line charging port, discharge, suction and liquid line pressure ports, sight glass, thermal expansion valve, 4-way reversing valve, suction line accumulator, and charge compensator.
 - .7 Provide each circuit with automatic reset high and low pressure switches for safety control.
- .9 Power Exhaust/Return Section – AHU-4-2020
 - .1 Provide, a factory installed power exhaust assembly that shall be designed to ventilate return air to atmosphere.
 - .2 Power exhaust shall include direct drive, VFD driven fan motor.
 - .3 Fan wheel shall be direct drive plenum.
 - .4 Fan mount to be fixed.
 - .5 Exhaust to ventilate through automatic louver located on both sides of unit cabinet.
- .10 Roof Curb:
 - .1 Contractor shall provide spring vibration isolation 14" tall roof curb, 18 gauge perimeter made of zinc coated steel with supply and return air gasketing and wood nailer strips, up to 1" deflection. Ship knocked down and provided with instructions for easy assembly.

- .2 Curb shall be manufactured in accordance with the National Roofing Contractors Association guidelines.

3. EXECUTION

3.1 General

- .1 Install units as indicated and to manufacturers' recommendations.

3.2 Rooftop Mounted Equipment Installation

- .1 Install as per manufacturers' instructions on factory built roof curb and in accordance with Roofing Contractors Association of BC (RCABC) Guidelines and Architectural and Structural details.
- .2 Maintain proper clearance around equipment to permit performance of service maintenance.
- .3 The Mechanical Contractor shall be responsible to coordinate ALL of his installation requirements with the Owner and the General Contractor to ensure that a complete installation for each unit is being provided. Coordination efforts shall include such items as unloading and hoisting requirements, field wiring requirements, field piping requirements, field ductwork requirements, requirements for assembly of field-bolted or welded joints, and all other installation and assembly requirements. Refer to Architectural and Structural documents for additional information.
- .4 Install in accordance with the gas code.
- .5 Ensure curb interior is insulated and-through-curb service connections are in place before placement of unit.
- .6 Ensure through-roof service connections (HWS & R pipes, gas pipe as applicable and electrical) are in place before placement of unit.
- .7 Connect units to ductwork with flexible connections.
- .8 Install fan sheaves required for final air balance.
- .9 Pipe from condensate drains to roof deck complete with 'P' trap.

3.3 Equipment Preparation and Start-Up

- .1 Provide services of manufacturer's field engineer to set and adjust equipment for operation as specified.
- .2 Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

3.4 Field Quality Control

- .1 Performance Verification:
 - .1 Rooftop Mounted Units:
 - .1 Set zone mixing dampers for full cooling, except that where diversity factor forms part of design set that % of zone dampers to full heating.
 - .2 Set outside air and return air dampers for minimum outside air.
 - .3 Set face and bypass dampers so face dampers are fully open and bypass dampers are fully closed.
 - .4 Check for smooth, vibration less correct rotation of supply fan impeller.
 - .5 Measure supply fan capacity.

- .6 Adjust impeller speed as necessary and repeat measurement of fan capacity.
 - .7 Measure pressure drop each component of air handling unit.
 - .8 Set outside air and return air dampers for the % of outside air required by design and repeat measurements of fan capacity.
 - .9 Reduce differences between fan capacity at minimum and maximum outside air less than [5] %.
 - .10 Set face and bypass dampers to full bypass and repeat measurement of fan capacity.
 - .11 Reduce difference between fan capacity with F BPD fully closed to bypass and fully open to bypass to less than [5] %.
 - .12 Reduce difference between fan capacity at full cooling and fan capacity at full heating to less than [5] %.
 - .13 OAD: verify for proper stroking, interlock with RAD.
 - .14 Measure DBT, WBT of SA, RA, EA.
 - .15 Measure air cooled condenser discharge DBT.
 - .16 Measure flow rates (minimum and maximum) of SA, RA, EA, relief air.
 - .17 Simulate maximum cooling load and measure refrigerant hot gas and suction temperatures and pressures.
 - .18 Simulate maximum heating load and verify temperature rise. Simulate minimum heating load and repeat measurements.
 - .19 Measure radiated and discharge sound power levels under maximum heating demand and under maximum cooling demand with compressors running.
 - .20 Verify operating control strategies. Refer to Sequence of Operations.
 - .21 Measure return fan capacity. Adjust impeller speed as necessary and repeat measurement of return fan capacity to ensure space pressure is maintained.
 - .22 Refer to other sections of these specifications for PV procedures for other components.
- .2 Verify accessibility, serviceability of components including motorized dampers, filters coils, fans, motors, operators, humidifiers, sensors, electrical disconnects.
 - .3 Verify accessibility, clean ability, drainage of drain pans for coils, humidifiers.
- .2 Commissioning Reports:
 - .1 In accordance with Section 23 08 00 - Commissioning of Mechanical Systems and 21 05 01 – Common Work Results for Mechanical.

3.5 Demonstration

- .1 Training: in accordance with Section 23 08 00 - Commissioning of Mechanical Systems and 21 05 01 – Common Work Results for Mechanical.

3.6 Cleaning

- .1 Perform cleaning operations as specified in Section 23 01 31 Air Duct Cleaning – HVAC Systems and in accordance with manufacturer's recommendations.
- .2 On completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 The supply and installation of hydronic coils.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical.
- .3 Section 23 05 01 – Acceptable Manufacturers.
- .4 Section 23 07 19 - HVAC Piping Insulation.
- .5 Section 23 31 00 - HVAC Ducts and Casings.
- .6 Section 23 33 00 - Duct Accessories.
- .7 Section 23 73 11 – Custom Air Handling Units.

1.3 References

- .1 The latest revisions of the following standards shall apply unless noted otherwise.
 - .1 Applicable Building Code - Refer to Section 21 05 01 – Common Work Results for Mechanical.
 - .2 ANSI/AHRI Standard 410.
 - .3 ASTM B88 Standard Specification for Seamless Copper Water Tube.
 - .4 Canadian Electrical Code (CEC) C22.1

1.4 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:
 - .1 Shop Drawings: Indicate coil and frame configurations, dimensions, materials, rows, fin spacing, connections, and rough in dimensions. Certify that coil capacities, hydronic flow rates and temperatures, air and water pressure drops, and selection procedures meet or exceed specified requirements.
 - .2 Submit manufacturer warranty and ensure forms have been completed in Owners name and registered with manufacturer.
 - .3 Closeout submittals: submit all maintenance requirements, test schedules, and reviewed shop drawings for incorporation into manual specified in Section 21 05 01 – Common Work Results for Mechanical.

1.5 Warranty

- .1 Provide one year manufacturer warranty for coil leakage.

2. PRODUCTS

2.1 Acceptable Manufacturers

- .1 Refer to Section 23 05 01 – Acceptable Manufacturers.

2.2 Hydronic Heating Coils

- .1 Tubes: 16 mm (5/8") OD seamless copper or brass arranged in parallel or staggered pattern, expanded into full length fin collars, brazed joints. Manufacturer shall optimize tube size to maintain a minimum of 0.76 m/s (2.5 fps) fluid velocity in tubes at 60% of design flow rate.
- .2 Fins: Aluminum continuous plate type with full fin collars or individual helical finned tube type wound under tension.
- .3 Casing: Galvanized steel frame with extruded tube sheet holes. Provide tube supports for coils longer than 1000 mm (40").
- .4 Headers: Seamless copper tube with silver brazed joints to ASTM B88.
- .5 Configuration: Drainable, with threaded plugs in headers for drain and vent, serpentine type with return bends on smaller sizes and return headers on larger sizes.
- .6 Rows and Fin Spacing: To meet the performance scheduled on the drawings.
- .7 Brazing: all joints brazed with high temperature copper based alloy.
- .8 Testing: Factory tested to a minimum of 2070 kPa (300 psi) dry air under water.
- .9 Certified under AHRI Standard 410 Certified.

3. EXECUTION

3.1 General

- .1 Install to manufacturers written instructions.
- .2 Install in ducts and casings to SMACNA HVAC Duct Construction Standards, Metal, and Flexible.
- .3 Support coil sections independent of piping on steel channel or double angle frames and secure to casings.
- .4 Provide common frames for a maximum three coil sections.
- .5 Provide airtight seal between coil and duct or casing.
- .6 Refer to Section 23 33 00 Duct Accessories for coil end covers.
- .7 Protect coils to prevent damage to fins and flanges. Comb out damaged or bent fins.
- .8 Make connections to coils with unions or flanges.
- .9 Insulate headers located outside air flow as specified for piping. Refer to Section 23 07 19 HVAC Piping Insulation.

3.2 Hydronic Coils

- .1 Pipe hydronic coils in a counterflow arrangement i.e. Connect hydronic supply to leaving air side of coil.
- .2 Provide an isolation valve on the supply line and lockshield balancing valve with memory stop on the return line.
- .3 Install supply piping connection at the bottom of a coil header and install return piping connection at top of a coil header.
- .4 Provide manual air vents at high points complete with stop valve.
- .5 Install cleanable/drainable tube coils with 1:50 pitch.
- .6 Ensure water coils are drainable and provide drain connection at low points.

- .7 Install cleanable/drainable tube coils with 1:50 pitch.
- .8 Make connections to coils with unions or flanges.

END OF SECTION

1. GENERAL

1.1 General

- .1 This Section specifies general conditions for Divisions 25 and is to be read, interpreted, and coordinated with all other sections of Division 25 and Section 21 05 01 – Common Work Results for Mechanical.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division-1 Specification Sections apply to work specified in this section.
- .3 Section 23 05 53 - Identification for Mechanical Piping and Equipment.
- .4 Section 23 08 00 – Commissioning of Mechanical Systems.
- .5 Division 26 – Electrical.

1.3 References

- .1 Work, materials, and equipment shall comply with the most restrictive of local, provincial, and National authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with current editions in effect 30 days prior to receipt of bids of the following codes:
- .2 British Columbia Codes:
 - .1 British Columbia Electrical Code
 - .2 British Columbia Safety Authority

1.4 General Scope

- .1 'Provide' shall mean 'supply and install'.
- .2 Provide complete, fully tested, and operational systems to meet the requirements described herein and in complete accord with applicable codes and ordinances.
- .3 Contract documents and drawings of this Division are diagrammatic and approximately to scale unless detailed otherwise. They establish scope, material, and installation quality but are not detailed installation instructions.
- .4 Follow manufacturers' recommended installation instructions, details, and procedures for equipment, supplemented by requirements of the Contract Documents.
- .5 Install equipment to provide: service access, maintain service clearances and for ease of maintenance.
- .6 Connect to equipment specified in other Sections and to equipment supplied and installed by other Contractors or by the Owner.

1.5 Coordination of Work

- .1 Products furnished but not installed under this division
 - .1 Division 23 – Heating, Ventilation and Air Conditioning
 - .1 Control Valves
 - .2 Flow Switches

- .3 Pressure and Temperature Sensor Wells and Sockets
- .4 Automatic Damper Actuators
- .2 Products installed but not furnished under this division
 - .1 Division 26 – Electrical
 - .1 Duct smoke detectors
- .3 Products not furnished or installed under but integrated with the work of this division
 - .1 Division 23 – Heating, Ventilation and Air Conditioning
 - .1 Boiler controls
 - .2 Rooftop air-handling equipment discharge air temperature control
 - .3 Rooftop air-handling equipment economizer control
 - .4 Variable frequency drives
 - .2 Division 26 – Electrical
 - .1 Fire alarm panel

1.6 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:
- .2 Provide submittals on all hardware, software, and installation. No work may begin on any segment of this project until submittals have been successfully reviewed for conformity with the design intent. Provide drawings as files on optical disk (file format: .dwg, .dxf, pdf, or comparable). 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 a complete bill of materials of equipment to be used indicating quantity, manufacturer, model number, and other relevant technical data and the following:
 - .1 BAS Hardware:
 - .1 Manufacturer's description and technical data, performance curves, product specification sheets, and installation/maintenance instructions for:
 - .1 Control Panels
 - .2 Transducers/Transmitters
 - .3 Sensors (including accuracy data)
 - .4 Actuators
 - .5 Valves
 - .6 Relays/Switches
 - .7 Operator Interface Equipment
 - .8 Wiring
 - .9 Other relevant items
 - .2 Wiring diagrams and layouts for each control panel. Show all termination numbers.
 - .3 Schematic diagrams for all field sensors and controllers. Provide floor plans of all sensor locations and control hardware.

- .2 Central System Hardware and Software:
 - .1 Manufacturer's description and technical data, product specification sheets and installation/maintenance instructions for:
 - .1 Central Processing Unit
 - .2 Monitors, Printers
 - .3 Interface Equipment between CPU and Control Panels
 - .4 Operating System Software and/or Operator Interface Software
 - .5 Color Graphic Software and/or Third-Party Software
 - .6 Other relevant items
 - .2 Provide a schematic drawing of the central system. Label all cables and ports with computer manufacturers' model numbers and functions. Show all interface wiring to the control system.
 - .3 Riser diagrams of wiring between central control unit and all control panels.
 - .4 A list of the color graphic screens to be provided. For each screen, provide a conceptual layout of pictures and data and show or explain which other screens can be directly accessed.
- .3 Controlled Systems
 - .1 A schematic diagram of each controlled system. The schematics shall have all control points labeled with point names shown or listed. The schematics shall graphically show the location of all control elements in the system.
 - .2 A schematic wiring diagram for each BAS. Each schematic shall have all elements labeled. Where a control element is the same as that shown on the BAS schematic, it shall be labeled with the same name. All terminals shall be labeled.
 - .3 An instrumentation list for each controlled system. Each element of the BAS shall be listed in table format. The table shall show element name, type of device, manufacturer, model number, and product data sheet number.
 - .4 A complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system.
 - .5 A point list for each system controller including both inputs and outputs (I/O), point number, the controlled device associated with the I/O point, and the location of the I/O device. Software flag points, alarm points, etc.
- .4 Quantities of items submitted shall be reviewed but are the responsibility of the Division 25 Contractor.
- .5 A description of the proposed process along with all report formats and checklists to be used in Section 25 08 00 "Commissioning of Integrated Automation "BAS Demonstration" and "BAS Acceptance."
- .6 Instrumentation and Data Point Summary Table. Contractor shall submit in table format with the following information for each instrument and data point. The table is to be reviewed and approved by the owner's representative prior to hardware and software installation and programming.
 - .1 Point name
 - .2 Point description: provide building designation, system type, equipment type, engineering units, and functionality; include a description of its physical location

- .3 Expected range (upper and lower limit)
- .4 Instrumentation (as applicable): manufacturer, model number, range, and accuracy specification
- .5 Type
 - .1 AI: analog input
 - .2 BI: binary input
 - .3 NAI: network analog input
 - .4 NBI: network binary input
 - .5 CP: Configuration Property
 - .6 P: Programmed (e.g., soft or virtual point in control sequence such as a PID input or output)
 - .7 C: Calculated value; a soft or virtual point. If calculated value, provide logic diagrams or code and any constants used in formula. If time-based integrated values are required, provide time periods: minutes, daily, weekly, monthly, and yearly. Also, indicate if it is a running average.
- .6 Input resolution
- .7 Graphic display resolution
- .8 Data trend interval
- .3 Provide Record drawings and maintenance data in compliance with Division 01 - Closeout Submittals and the following:
 - .1 Submit project record documents upon completion of installation. Co-ordinate quantity to suit number of O&M manuals required. The documents shall be submitted for approval prior to final completion and shall include:
 - .2 Project Record Drawings. As-built versions of the submittal shop drawings provided as files on optical media and as 11" x 17" prints.
 - .3 Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements of Section 25 08 00 Commissioning of Integrated Automation "BAS Demonstration" and "BAS Acceptance".
 - .4 Operation and Maintenance (O & M) Manual.
 - .5 As-built versions of submittal product data.
 - .6 Names, addresses, and 24-hour telephone numbers of installing contractors and service representatives for equipment and control systems.
 - .7 Operator's manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
 - .8 Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
 - .9 Graphic files, programs, and database on magnetic or optical media.
 - .10 List of recommended spare parts with part numbers and suppliers.
 - .11 Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.

- .12 Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
- .13 Licenses, guarantees, and warranty documents for equipment and systems.
- .14 Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

1.7 Acceptable Control System Primary Manufacturers

- .1 Quality Assurance
 - .1 Installer and Manufacturer Qualifications
 - .1 Installer shall have an established working relationship with BAS Manufacturer of not less than three years.
 - .2 Installer shall have successfully completed BAS control system training. Upon request, Installer shall present certification of completed training including hours of instruction and course outlines.

1.8 Identification

- .1 All components of the Building Management System shall be identification tagged. Comply with Section 23 05 53 - Identification for Mechanical Piping and Equipment.

1.9 Warranty

- .1 Warrant work as follows:
 - .1 Warrant labor and materials for specified BAS free from defects for a period of 12 months after final acceptance. BAS failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner's warranty service request.
 - .2 Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
 - .3 Provide updates to operator workstation software, project-specific software, graphic software, database software, and firmware that resolve Contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner's written authorization.
 - .4 Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of BAS designer's acceptance.
- .2 Special warranty on instrumentation:
 - .1 All instrumentation shall be covered by manufacturer's transferable [one-year] "No Fault" warranty. If manufacturer warranty is not available, the BAS installer shall provide the same.

1.10 Substantial & Total Performance

- .1 Comply with Section 21 05 01 Common Work Results for Mechanical – Substantial and Total Performance.

- .2 A certificate of Substantial Performance will not be granted unless the controls systems have been commissioned and are capable of operation with alarm controls functional and automatic controls in operation. Commissioning checklists must be submitted prior to the request by the Contractor to have a substantial completion inspection.

1.11 Ownership of Proprietary Material

- .1 Project-specific software and documentation shall become Owner's property. This includes, but is not limited to graphics, record drawings, database, application programming code, and documentation.

2. PRODUCTS

2.1 Not used

3. EXECUTION

3.1 Examination

- .1 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 Consultant for resolution before rough-in work is started.

3.2 Co-ordination

- .1 Coordinate and schedule work with all other work in the same area, or with work that is dependent upon other work, to facilitate mutual progress.
- .2 Coordinate final graphics floor plans, room names and numbering with Architectural drawings including any changes made during construction. These graphics should be provided to the Engineers and the Owner for sign off before the graphics are completed.
- .3 The contractor shall provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.
- .4 Duct smoke detectors required for air handler shutdown are supplied under Division 26. The 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 BAS specified in this section. These controls shall be integrated into the system and coordinated by this Contractor as follows:
 - .1 Each supplier of a controls product is responsible for the configuration, programming, start-up, and testing of that product to meet the sequences of operation described in this section.
 - .2 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 The contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
 - .4 The contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

3.3 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 Verify integrity of all wiring 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.
- .6 All work, materials, and equipment shall comply with the rules and regulations of applicable local, provincial, and federal codes and ordinances as identified in Part 1 of this specification.

3.4 Existing Equipment

- .1 Unless otherwise directed, the contractor is not responsible for the repairs or replacement of existing energy equipment and systems, valves, dampers, or actuators. Should the contractor find existing equipment that requires maintenance, the Consultant is to be notified immediately.
- .2 All redundant wiring and equipment as a result of this project, that is not identified for either salvage or reuse, shall be removed and become the property of the contractor, unless otherwise noted.
- .3 The mechanical system must remain in operation based on the Owner requirements within the building (i.e. between the hours of 6 a.m. and 6 p.m., Monday through Friday). Any interruptions to the operation of existing building systems must be co-ordinated with the Owner and the design team in advance of any interruptions.
- .4 The scheduling of fans through existing or temporary time clocks or BAS shall be maintained throughout the BAS installation.
- .5 Modify existing starter control circuits, if necessary, to provide hand/off/auto control of each starter controlled. If new starters or starter control packages are required, these shall be included as part of this contract.

3.5 Training

- .1 Provide training sessions period for personnel designated by the Owner. The number of training sessions required should be agreed with the Engineers and Owner prior to commencement of training
- .2 Provide two additional training sessions at 6 and 12 months following building's turnover. Each session shall be one day in length and must be coordinated with the building owner.
- .3 Train the designated staff of the owner to enable them to do the following:
 - .1 Day-to-day Operators:
 - .1 Proficiently to operate the system
 - .2 Understand BAS architecture and configuration
 - .3 Understand BAS system components
 - .4 Understand system operation, including BAS control and optimizing routines (algorithms)

- .5 Operate the workstation and peripherals
- .6 Log on and off the system
- .7 Access graphics, point reports, and logs
- .8 Adjust and change system set points, time schedules, and holiday schedules
- .9 Recognize malfunctions of the system by observation of the printed copy and graphical visual signals
- .10 Understand system drawings and Operation and Maintenance manual
- .11 Understand the job layout and location of control components
- .12 Access data from BAS controllers and ASCs
- .13 Operate portable operator's terminals
- .2 Advanced Operators:
 - .1 Make and change graphics on the workstation
 - .2 Create, delete, and modify alarms, including annunciation and routing of these
 - .3 Create, delete, and modify point trend logs and graph or print these both on an ad-hoc basis and at user-definable time intervals
 - .4 Create, delete, and modify reports
 - .5 Add, remove, and modify system's physical points
 - .6 Perform BAS field checkout procedures
 - .7 Perform BAS unit operation and maintenance procedures
 - .8 Perform workstation and peripheral operation and maintenance procedures
 - .9 Perform BAS diagnostic procedures
 - .10 Maintain, calibrate, troubleshoot hardware
 - .11 Adjust, calibrate, and replace system components
- .3 System Managers/Administrators:
 - .1 Maintain software and prepare backups
 - .2 Interface with job-specific, third-party operator software
 - .3 Add new users and understand password security procedures
- .4 These objectives will be divided into three logical groupings. Participants may attend one or more of these, depending on level of knowledge required.
- .5 Provide course outline and materials. The instructor(s) shall provide one copy of training material per student.
- .6 The instructor(s) shall be factory-trained instructors experienced in presenting this material.

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 Section includes commissioning process requirements for control systems, assemblies, and equipment.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Division 01 – Measurement and Verification Plan General Requirements
- .3 Section 21 05 01 – Common Work Results for Mechanical
- .4 Section 23 08 00 – Commissioning of Mechanical Systems
- .5 Section 25 09 01 - Controls Systems
- .6 Section 25 90 00 – Integrated Automation Control Sequences

1.3 References

- .1 Commissioning Agency (CxA)

1.4 Submittals

- .1 Comply with Division 01 – Submittal Procedures and Closeout Procedures, Section 21 05 01 Common Work Results for Mechanical – Submittals and in addition the following:
 - .1 Certificates of readiness.
 - .2 Certificates of completion of installation, prestart, and start-up activities.

1.5 Contractor's Responsibilities

- .1 Provide Project-specific construction checklists and commissioning process test procedures for actual control systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.
- .2 Perform commissioning tests
- .3 Hold construction phase controls coordination meeting.
- .4 Attend testing, adjusting, and balancing review and coordination meeting.
- .5 Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection.
- .6 Provide information requested by the CxA for the final commissioning documentation.
- .7 Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.6 CxA's Responsibilities

- .1 Attend construction phase controls coordination meeting.
- .2 Verify and participate in commissioning testing.
- .3 Verify testing, adjusting, and balancing of work are complete.

1.7 Commissioning Documentation

- .1 Provide the following information to the CxA for the inclusion in the commissioning plan:
 - .1 Plan for delivery and review of submittals, systems manuals, and other documents and reports.
 - .2 Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
 - .3 Process and schedule for completing construction checklists for controls systems, assemblies, equipment, and components to be verified and tested.
 - .4 Certificate of completion certifying that installation, start-up checks, and start-up procedures have been completed.
 - .5 Certificate of readiness, certifying that controls systems, subsystems, and equipment are ready for testing.
 - .6 Test and inspection reports and certificates.
 - .7 Corrective action documents.
 - .8 Documented verification of testing, adjusting, and balancing reports.

2. PRODUCTS (NOT USED)

3. EXECUTION

3.1 BAS Start-up Testing

- .1 All testing listed in this article shall be performed by the Division 25 contractor and shall make up part of the necessary verification of an operating BAS. 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 according to 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. DO NOT call for system demonstration prior to these detailed tests being completed and systems properly functioning as per the sequence of operations and design intent.
 - .7 Verify that all graphics are complete and meet the Owner's Representative's requirements. Add or adjust graphics to suit the specific project requirements and Owner's requests.

- .8 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.

3.2 BAS Demonstration

- .1 Prior to acceptance, the BAS shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests.
- .2 The tests described in this section are to be performed in addition to the tests that the contractor performs as a necessary part of the installation, start-up, and debugging process and as specified in “Start-up Testing” of this specification. The CxA will be present to observe and review these tests. The CxA 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 Article 1.10, “Submittals.” The approved checklists and forms shall be completed for all systems as part of the demonstration.
- .4 The contractor shall provide at least two persons equipped with two-way communication and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point and system. Any test equipment required to prove the proper operation shall be provided by and operated by the contractor.
- .5 As each control input and output is checked, a log shall be completed showing the date, technician’s initials, and any corrective action taken or needed.
- .6 Demonstrate compliance with Section 25 09 01 Control Systems - Part 1, “BAS Performance.”
- .7 Demonstrate compliance with Section 25 90 00 Integrated Automation Control Sequences through all modes of operation.
- .8 Demonstrate complete operation of operator interface.
- .9 Additionally, the following items shall be demonstrated:
 - .1 DDC loop response. The contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop’s response to a change in set point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.
 - .2 Demand limiting. The contractor shall supply a trend data output showing the action of the demand limiting algorithm. The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting set point, and the status of shed equipment outputs.

- .3 Optimum start/stop. The contractor shall supply a trend data output showing the capability of the algorithm. The change-of-value or change-of-state trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.
- .4 Interface to the building fire alarm system.
- .5 Operational logs for each system that indicate all set points, operating points, valve positions, mode, and equipment status shall be submitted to the architect/BAS designer. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats.
- .10 Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

3.3 BAS Acceptance

- .1 All tests described in this specification shall have been performed to the satisfaction of both the Consultant and CxA prior to the acceptance of the BAS 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 BAS designer. 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 Section 25 09 01 Control Systems, "Submittals."

END OF SECTION

1. GENERAL

1.1 Section Scope

- .1 Provide a complete system of manufacturer's packaged control systems, with provision for future connection to DDC system through BacNET interface. System to match or exceed the base building standard with regard to control devices, components, wiring and materials. All control work associated with the current project scope.

1.2 Related Requirements

- .1 This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
- .2 Section 21 05 01 – Common Work Results for Mechanical.
- .3 Section 25 05 00 – Common Work Results for Integrated Automation.

1.3 Code Compliance

- .1 All work shall comply with current editions of the National, Provincial and Municipal Building and Plumbing Codes, Standards, Acts and Bylaws and will meet the requirements of the Authority having jurisdiction.

1.4 Examination of Existing System

- .1 This project involves renovation to an existing control system. The contractor shall inspect the system prior to tender close and include in his bid all control components required to provide a fully operational system including replacement of existing defective components where noted in the project documents.
- .2 Refer to existing control sequences and points lists, attached at the end of this section, for additional information. Sequence from 2010 supersedes that from the original project in 1995.
- .3 Contractor to allow in their bid for connection to all available points through new equipment BACNet interface (to be included in the Contract Price for the supply and installation of each individual AHU or DH).

1.5 Design Requirements

- .1 Provide all control system components and programming to make a complete and operable system, except those supplied as part of packaged equipment controls, but including all auto-sequencing devices and electrical interlocks required to accomplish the sequences specified hereafter. Refer to the electrical equipment schedule, the electrical drawings, and the electrical specification, which describes the limits of the extent to the work in Division 26 serving mechanical systems. Materials, equipment, connections, and power not provided by Division 26 but required for the Control System shall be provided under this section.
- .2 Contractor shall not remove or override any manufacturer's safeties.
- .3 Note that the sequences in this section outline overall operational intent. Coordinate all interface requirements with equipment for the sequences in this section to be successfully executed.
- .4 Consult with the Mechanical Consultant during the shop drawing stage to finalize the control sequences for each system. The controls contractor shall submit the final sequence of operation during shop drawing phase.

1.6 Control Components

- .1 Provide control valves and damper actuators as required to meet the sequence of operation and meet the design intent. Valves and actuators shall match the base building standard unless noted otherwise. New control valve operation to be compatible with existing.
- .2 Where existing devices are re-used, verify operation, and re-calibrate as required.
- .3 Verify correct operation of controlled devices including existing control valves, etc. within the area of renovation.
- .4 Report any existing control device, which need replacement. Replacement will be by building management or via change order, at the discretion of the owner.

1.7 Programming Requirements

- .1 Provide all programming required to implement the control sequences and to make system operational, as well to meet design intent.
- .2 Programs shall be modular in nature and shall be as structured as the language will permit.
 - .1 Unconditional "GOTO" statements shall be used sparingly and shall always jump forwards. All jumps from the body of a module shall target the end of that module. Similarly, jumps from the body of a sub-module shall target the end of that sub-module.
 - .2 All conditional "GOTO" statements, which make a single choice from multiple choice sub-module options, shall form the opening lines of code of the module. Each succeeding conditional jump shall direct the execution of software to the relevant sub-module, which shall be in the reverse order of the conditional jump statement. The exit from each sub-module shall jump to the end of the module.
 - .3 All conditional "GOTO" statements, for "AND"/"OR" choices between sub-modules, shall form the opening line of code in each sub-module which the conditional statement controls.
 - .4 Do not use double negatives in programming language.
- .3 All programs must include a sufficient number of comments to allow another person to make changes to the strategies at a later time.
- .4 Additional programming may be provided by the Contractor as desired, so long as it does not affect the intended operation of the specified sequences. Ensure that all equipment will operate in a safe manner.
- .5 Programming required for equipment safety may be installed by the Contractor as necessary. The Owner shall be notified of these changes as soon as practical.
- .6 All deviations from the specified programming, except those related to equipment safety, must receive prior written approval from the Mechanical Consultant.
- .7 All control loops shall be tuned such that they are stable through all seasons and operating conditions including start-up.
- .8 All HVAC controls shall implement Building operating modes. Unit system description is modifications to the Building operation modes.
- .9 Staggered starting:
 - .1 Motors must not be allowed to start at the same time. Under all conditions of start-up, return from power failure or panel reset, there must be at least a 15 second delay between the time one motor starts and another is allowed to start.
- .10 Motor and equipment status:

- .1 All mechanical equipment motors that are enabled by the BMS shall be provided with status and alarm indication by a current sensor. This includes all pumps, fans, and electric motor driven devices.
- .2 Equipment status may also be indicated by flow switches as an alternate status indication, with prior acceptance by the Consultant, or where specifically indicated in the Contract Documents.
- .3 Exclude small unitary bathroom exhaust fans, domestic range hoods and manually operated fans and devices, unless noted otherwise.
- .4 Current sensors shall provide status and an out of range alarm.

2. EXECUTION

2.1 Revisions to Existing Sequences of Operation

- .1 In addition to the application of the existing sequences of operation for the new equipment, the following revisions/alterations are to be incorporated into the current scope:
 - .1 AHU-03-2020 is now a heat pump air handler, and as such now has cooling capacity. Control sequence is to be updated to include the ability to provide cooling to the spaces being served by this unit when called for by the space temperature sensors and/or thermostats. Heating elements within the unit and spaces associated with existing AHU-03 are to be locked out so that heating and cooling is not provided simultaneously, nor that cooling/reheat is allowed for this unit.
 - .2 Pump P-01R-2020 and associated control valve are to be modulated to maintain space temperature setpoint. Control valve is to modulate to by-pass extra flow not required to maintain pre-heat coil discharge air temperature setpoint per schedules to maximize heat pump efficiency.
 - .3 AHU-04-2020 is provided with a power exhaust in lieu of a dedicated return air fan. Contractor to modulate or control this component as required to maintain existing building pressure and airflow setpoints within the space.
 - .4 Pump P-02R-2020 is to be modulated to maintain space temperature setpoint and maximize heat pump efficiency.
 - .5 AHU-04-2020 no longer has an external condensing unit, so any requirements for cooling are to be met by this AHU through the work in this Contract. Delete alarm for old CU-1 Start/Run failure.
 - .6 AHU-05-2020 is now a heat recovery ventilator providing 100% outside air to the space and exhausting 100% outside, while recovering as much heat as possible off the exhaust stream when/if required, and by-passing the excess. It involves the re-ducting of EF-11 and EF-13 systems to the unit to incorporate those exhaust streams in the recovery volume. Delete alarms associated with deleted exhaust fans. Add alarm for AHU-05-2020 return/exhaust fan.
 - .7 Upon a call for unit start from the schedule, AHU-05-2020 dampers are to open 100%. Discharge temperature from post-heat coil to meet lowest setpoint within space, with existing unit heaters to supplement as required for those individual spaces.
 - .8 AHU-05-2020 dampers close when unit is commanded to shut down by schedule. Unit heaters will be commanded on to maintain minimum nighttime setback temperature as described in existing sequence of operation.
 - .9 Pump P-03R-2020 is to be modulated to maintain discharge setpoint temperature (adjustable).

- .10 DH-02-2020 is now a heat pump dessicant dehumidifier that controls the environment in arena 2, complete with packaged controls to modulate and control unit to maintain humidity and temperature setpoints. This contract to include all required sensors and controls components to meet system and control intent.
- .11 Pump P-201-2020 is to be modulated as required by DH-02-2020 in order meet humidity and/or temperature setpoints for the arena environment.

2.2 Pumps

- .1 Pumps P-13A-2020 and P-13B-2020:
 - .1 Pumps circulate through a cascade system and operate in parallel, speeding up and down together as required to maintain lowest temperature setpoint required to satisfy all equipment and spaces. Intent is to have the system water at or below 85 F at the connection to the refrigeration plant heat recovery in order to maximize the heat recovery capacity.
 - .2 System temperature setpoint to modulate between 70 F and 105 (adjustable) between heating and cooling seasons.
 - .3 Pumps to alarm to BMS.
- .2 Pumps serving individual AHUs:
 - .1 Refer to paragraph 2.1 above.
 - .2 Pump to alarm to BMS.
- .3 Pump P-202-2020:
 - .1 Pump circulates heat pump loop fluid through refrigeration heat recovery system.
 - .2 When heat is available from the refrigeration plants (ie. When the compressors are running), the fluid temperature at the heat recovery system is below 95 F (adjustable) and the underfloor heating system is not calling for heat, pump to modulate to recover as much heat as possible from the heat recovery system. Pump to turn off once pump return water temperature is at or below heat pump loop temperature.
 - .3 Controls system in this project is to include inputs from the refrigeration plant to determine compressor status and underfloor heating pumps status in order to meet item 2.2.4.2 above.
 - .4 When underfloor heating system is calling for heat, pump shall be off. Underfloor heating system is to take precedence.
 - .5 Pump to alarm to BMS.
- .4 Pump P-203-2020:
 - .1 Pump serves to inject hot water from boiler loop to heat pump loop to raise loop temperature to lowest temperature required to satisfy all equipment and spaces, maximizing heat recovery from refrigeration plant.
 - .2 Boiler injection to cycle on when loop temperature drops below 70 F and cycle off when loop temperature rises above 75.
 - .3 Should pump be at 100% (adjustable) and not maintain heat pump loop minimum supply temperature, boiler setpoint to be reset up as required. Boiler setpoint and this pump speed are to be as low as possible to satisfy setpoints and maximize efficiency/heat recovery.
 - .4 Pump to alarm to BMS.

END OF SECTION

OUTLINE SPECIFICATION

1.1 SECTION INCLUDES

- .1 The work also shall include but not be limited to the supply and installation of:
 - .a Air / vapour barrier membrane.
 - .b Rigid insulation.
 - .c Asphaltic Protection Board overlay for insulation.
 - .d Associated roof flashing and sheet metal.

1.2 RELATED SECTIONS (BY OTHERS)

- .1 Division 01
- .2 Section 02200 Patch and Make Good
- .2 Section 06100 Rough Carpentry
- .3 Section 07620 Sheet Metal Flashing.
- .4 Section 07900 Joint Sealants.
- .6 Division 15 - Mechanical (roof drains, plumbing vents, etc.)

1.3 REFERENCE STANDARDS

- .1 The latest edition (in effect at time of project) of the following reference standards and codes shall govern all roofing materials and work.
- .2 Roofing Practices Manual (RPM) as issued by the Roofing Contractors Association of British Columbia (RCABC).
- .3 CAN/CGSB 51.26-M86, thermal insulation, urethane and isocyanurate Board, Faced.
- .4 B.C. Building Code (BCBC) 2018.
- .5 Underwriters Laboratories of Canada, ULC-190 / ULC-580
- .6 Industrial Health and Safety Regulations of Work-Safe BC (WSBC).

to the Consultant that all roofing materials and components are compatible.

PRODUCTS + MATERIALS

2.1 ROOFING ASSEMBLY MATERIALS

- .1 General SBS membrane roof:

- .a Primer: PA 1125 primer by Siplast, or approved alternate, where required.
- .b Vapour Retarder: Paradiene 20 SA by Siplast or approved alternate.
- .c Insulation:
 - .i Rigid closed cell, polyisocyanurate foam with glass reinforced organic felt facers. Conforming to CGSB 51.26-M86 and CAN/ULC S704 and CAN/ULC S770 with Long Term Thermal Resistance (LTTR) of 6.0. RGC and FM approved. Minimum RSI value to be as noted on Architectural drawings, minimum compressive strength of insulation to be 20 psi except minimum 25 psi at paver locations. Approved Product: Johns Manville E'NRG'Y 2 Plus, IKO Therm, by IKO or approved equivalent.
 - .ii Apply in multiple layers to achieve thickness shown on the drawings. Maximum thickness per layer to be 38 mm. Maximum panel size 4' x 4' (1220 mm x 1220 mm). If acceptable to the RCABC warranty program and/or the roofing manufacturer's warranty.
- .d Overlay: IKO Thermaboard by IKO or Halboard by Hal Industries, or approved alternate.
- .e Base Sheet: Thermofused Paradiene 20 TGF, or approved alternate.
- .f Standard Cap Sheet: Paradiene 30 CR FR TG by Siplast, or approved alternate.

2.2 ACCESSORIES

- .1 Paradiene 20 SA (or approved alternate): a self-adhesive fire stop membrane composed of a glass fleece reinforced and SBS modified bitumen. Paradiene tape is a safety precaution and must be installed prior to the installation of any torch applied vapour barriers; membrane base sheets or torch applied stripping membranes. It is installed over substrate cracks, voids, angle changes at curbs, parapets, penetrations or any locations subject to back drafts or entrance of flame from the torch, protecting combustible materials in the system.

2.3 MISCELLANEOUS MATERIALS

- .1 Concealed Flashings: Shall be Alcan utility aluminum sheet .8 mm back painted with bituminous paint.
- .2 Screws, Bolts, Nails and Flashings: Of metal compatible with adjacent surfaces, size to be such to suit applicable conditions complying with CSA B111-1974 (R1998) Standard table 12. Fasteners in contact with pressure treated wood must be 304 or 316 stainless steel.
- .3 Approved Adhesives for Roofing Components above Steel Deck: Insta-Stik by Dow Chemical, Duotack by Soprema and Olybond as manufactured by Olyfast.
- .4 Cleats: Same metal but heavier gauge as sheet being anchored, 51mm wide, punched for 2 anchors.

- .5 Caulking Compound: Shall be one part polysulphide, conforming to CAN/CGSB-19.13-M87; and compatible with roofing membrane.
- .6 Bedding Compound: SBS modified plastic cement.
- .7 Wood blocking: ACQ treated plywood. (CCA treated plywood is not to be used without prior written permission from both the Owner and Consultant).

2.4 OVERLAY

- .1 Adhere overlay board to RCABC standards and tape butted joints with Paradiene 20 SA, or approved alternate.

INSTALLATION + TESTING

3.1 ROOFING

- .1 Install base and cap sheets and other materials in strict accordance with manufacturers instructions and to approved details.

3.2 PAINTING

- .1 Back Painting: Apply 1 coat bituminous anti-corrosive paint on all concealed metal flashing surfaces before installation.
- .2 Insulated Painting: Apply 2 coats bituminous anti-corrosive paint on each contacting surface between dissimilar metals.

3.3 CAULKING

- .1 Caulk all roof side joints in metal flashings, etc., including joints in coping flashings as required to provide fully watertight installation. Do not apply sealant at exposed locations without first consulting with the Consultant.
- .2 Where required behind caulking, provide non-staining type joint backing of expanded polyurethane cell foam, compressed to half its width in joint.

3.4 FLOOD TEST

- .1 Do not conceal waterproofing until inspection and testing are completed to satisfaction of the Consultant and the roofing inspector.
- .2 Temporarily plug drains and dam horizontal surface areas to be tested and flood with water to a minimum depth of 80 mm or as otherwise directed by the Consultant.
- .3 Maintain flooded depth for 24 hours.
- .4 If leak occurs, repair and retest.
- .5 Remove water at end of test.

END OF SECTION 07550

OUTLINE SPECIFICATION

1.1 DESCRIPTION OF WORK

- .1 Furnish all tools, plant, labour, materials, equipment and supervision required to complete the work of this section as specified herein and in accordance with the contract documents.
- .2 Selective demolition required to perform the work.
- .3 Remove and store for relocation, reuse, or recycle, items as noted on the drawings.
- .4 The work shall also include removal of demolition (except as noted above) material off site and disposal in a legal manner.
- .5 Demolition must be carefully scheduled to accommodate phasing and occupancy requirements.

1.2 RELATED SECTIONS (BY OTHERS)

- .1 Section 01740 Cleaning & Dust Control.
- .2 Section 01400 Quality Requirements.
- .3 Section 007550 SBS Modified Roofing.

1.4 QUALITY ASSURANCE

- .1 Codes and Regulations: Do all demolition work according to the requirements of the BC Building Code, Work-Safe BC and the Canadian Construction Safety Code.
- .2 Qualifications of Workers: Provide a Supervisor who shall be present at all times during the demolition work and who shall be thoroughly familiar with the work required and who shall direct all work. Provide one (1) person on site who is responsible for maintaining the safety barriers and protection of the workers and the public. Provide the name of this person to the Owner. Any changes in personnel must also be reported to the Owner.

1.5 EXISTING CONDITIONS

- .1 The Contractor shall accept the site as it exists and will be responsible for all demolition work as required.
- .2 The Contractor shall visit the site at his own expense prior to the submission of tenders and take whatever time is required to ascertain existing site conditions and surrounding features related to the proposed demolition and new construction work, and ensure himself that conditions are suitable for execution of the work. Access to site is restricted, refer also to Instructions to Bidders.

- .3 No additional sums of money will be allowed for any items resulting from lack of familiarity with the site conditions. Report any discrepancies to the Consultant.
- .4 Arrange for a site visit together with Consultant, to examine existing exterior and interior site conditions adjacent to demolition and new construction work. Take photographs of any existing damage and record same in writing to avoid any disputes at a later date. Photograph all rooms where partial demolition is to occur before work commences in order to provide a record of existing conditions.

1.6 PROTECTION

- .1 All smoke and heat detectors within the affected work area(s) are to be protected and sealed with polyvinyl and duct tape to prevent damage and false fire alarms due to demolition work in progress.
- .2 Take all the necessary precautions to fully protect the existing building equipment and furnishings against damage from water, dust or the like during installation of new work, cutting existing wall, etc. Dust screens and/or platforms shall be provided as specified above. Cover and protect existing furnishings, equipment, etc. by means acceptable to the Owner whenever Work is to be carried on, above or beside such existing items.
- .3 Where material or equipment is being transported within the existing building on carts or pallets, such carts or pallets shall have rubber tires.
- .4 The Contractor shall make good, at no expense to the Owner, any damage or disruption caused to the existing building and to the adjoining property utilities and services not called for as part of the Work of this contract. All repair work shall only be done after consultation with the Consultant, appropriate parties and authorities and to standards and codes of authorities having jurisdiction.
- .5 Damage of any nature done to existing building and contents, except where required by Work, shall be made good to the satisfaction of the Consultant and at no additional cost to the Owner.
- .6 Making good shall mean restoration to at least the original condition in terms of strength, safety, workmanship and appearance.

1.7 EMERGENCY EXITS

- .1 The Contractor shall maintain at all times, while the facility is open, emergency exits and keep such egress adequately lighted and free of any hazard which could cause obstruction in the event of an emergency.

1.8 MAKE GOOD

- .1 "Making Good" shall be defined as preparing new surfaces which are identical to adjacent surfaces with similar backing materials, and finished off in such a manner that there are absolutely no visible traces (at a distance of 600 mm / 2 feet), between existing work and the work of new patching. "Making good" therefore, extends to the complete re-finishing of entire surface areas as is necessary, to junction points or inside or outside corners of walls, partitions and ceilings.
- .2 "Making good" for painting refers to satisfactorily preparing finish surfaces for paint, so that newly patched surfaces are indistinguishable from immediately adjacent existing finishes of similar materials.
- .3 All alteration and restoration required to be performed shall be done whether or not shown on the drawings or specified. (Example, where wall is indicated to be removed, make good at floor, ceiling and junction with other walls). Thus whenever existing assemblies are removed or altered, the Scope of Work of the Contract will include all remedial work and "making good" of services and finishes that are affected by the removal or alteration.
- .4 Where existing items are removed, "make good" to existing surfaces if they are to remain exposed.

2.0 PRODUCTS

2.1 MATERIALS

- .1 Materials resulting from the demolition not needed for reinstallation or indicated to be turned over to the Owner shall become the property of the Contractor and shall be removed from the site and disposed of in a legal manner.
- .2 Make Good: Materials shall be either recycled or new, structurally sound and matching in dimensions of the profile, colour and character of the existing construction.

3.0 EXECUTION

3.1 EXAMINATION

- .1 Examine the work as it relates to existing features and services to be removed, capped and sealed-off.
- .2 Examine the area and surfaces adjacent to the demolition area and record any damages to avoid later disputes.

3.2 PREPARATION

- .1 Shut-off, disconnect, cap-off and seal all plumbing, mechanical, and electrical services, slated for demolition, in accordance with the requirements of the authorities having jurisdiction, before starting demolition. Do not disturb active or energized utilities designated to remain undisturbed. Arrange for temporary power as required.

3.3 HAZARDOUS MATERIAL REMOVAL

- .1 Should additional suspected asbestos or other hazardous material be encountered, stop work immediately and notify the Owner and Consultant.

3.4 DEMOLITION

- .1 Demolish and remove portions of existing building only as required to perform the Work.
- .2 Carry out all demolitions and making good. Patch and make good to a standard at least equal to that of adjacent surfaces when related work is completed including deficiencies. The Contractor shall assume responsibility for all existing surfaces and be responsible for making good same.
- .3 Remove materials from demolition promptly as the demolition work progresses. Materials shall not be sold or burned at the site. The Contractor will be assumed to have allowed for any credit he may obtain for such materials. Materials from demolition are not to be used as backfill.
- .4 No temporary stockpiling of demolished materials not designated for reuse is permitted on site. All demolition materials must be removed from site daily. Dispose of materials in a legal manner.
- .5 The work described in this section shall include the items as shown on the drawings and other related Contract Documents and obvious from site investigations.
- .6 No heavy equipment causing excessive vibrations to the existing structure are permitted.
- .7 Prevent overloading of any part of the building. Do not cut, drill or otherwise sleeve a structural member without written approval of the Consultant.
- .8 Make cuts clean, true, smooth edges. Saw cut all concrete to sharp smooth lines. Make patches inconspicuous in final assembly.
- .9 Locate and make holes through floor slabs for review by the Consultant prior to commencement of cutting.
- .10 At locations where reinforcing bars have been cut or exposed during demolition, notify Consultant and Structural Engineer, paint ends of bars with zinc-rich paint.

- .11 Carry out all necessary temporary bracing and supporting to structure as required during building demolitions.

3.5 ITEMS TO BE SALVAGED

- .1 Any items identified by the Owner during the Tender or Pre-Construction period- affected by scope of work
- .2 Other items as noted on drawings, including specific Mechanical and Electrical items.

3.6 PROTECTION

- .1 Protect adjacent work from damage, staining, disfigurement caused by the work of this section.
- .2 Promptly as the work proceeds, and on completion keep the premises clean and free from rubbish, debris, surplus materials and equipment.
- .3 At the end of each day's work, leave work in safe condition so that no parts are in danger of toppling or falling.

3.7 CLEAN-UP

- .1 Upon the completion of all demolition work, remove all equipment, material and debris and leave the area clean.

END OF SECTION